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Main Office	Regional Office, Sørlandet	Regional Office, Østlandet	Regional Office, Vestlandet	Akvaplan-NIVA A/S
P.O. Box 69, Korsvoll	Televeien 1	Rute 866	Breiviken 5	Søndre Tollbugate 3
N-0808 Oslo 8	N-4890 Grimstad	N-2312 Ottestad	N-5035 Bergen - Sandviken	N-9000 Tromsø
Norway	Norway	Norway	Norway	Norway
Phone (47 2) 23 52 80	Phone (47 41) 43 033	Phone (47 65) 76 752	Phone (47 5) 95 17 00	Phone (47 83) 85 280
Telefax (47 2) 95 21 89	Telefax (47 41) 44 513	Telefax (47 65) 78 402	Telefax (47 5) 25 78 90	Telefax (47 83) 80 509

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Abstract: Olive oil industry wastewater (Alpechine) samples are coagulated with a range of organic polymers with different chemical compositions, molecular weights and cationic natures. Nearly 100% particle removals are possible to achieve with organic polymers. The viscosity of polymer solution is found as a limiting factor, thus low molecular weight and strongly cationic polymers are recommended. The CST value (which may be an indicator for filterability) is decreased with selected polymers. The polymers result in good sedimentation properties, while a combination with flocculants does not improve it further.

4 keywords, Norwegian

1. Oliven olje
2. Industriavløp
3. Koagulering
4. Polymer

4 keywords, English

1. Olive oil
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3. Coagulation
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Project leader

Harsha Ratnaweera

For the Administration

Bjørn Olav Rosseland

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PREFACE

The Olive oil industry wastewater treatment plant at Alacalà la Real (Jaèn) in Spain consists with a coagulation / floc separation stage prior to an ultrafiltration and a reverse osmosis process. The coagulant in use today, Chitosan, has reported to result in poor total solids removal and causing difficulties in the ultrafiltration stage.

Ticon Industrier AS of Norway, the producer of the coagulation / floc separation stage at the treatment plant has requested the Norwegian Institute for Water Research (NIVA) to evaluate other possible coagulants suitable to the process to overcome the above problems. A research project jointly financed by NIVA and Ticon Industries AS was commenced at the beginning of April 1992. A number of polymers from different producers and representing different characteristics were selected and evaluated in this project. A brief description of experiments and a discussion of results are presented in this report.

Norwegian Institute for Water Research
Harsha Ratnaweera, dr.ing.
27.4.92

Table of contents

SUMMARY

Coagulation of Olive oil industry wastewater (Alpechine) is studied with organic polymers as coagulants. 13 polymers with different molecular weights, cationic strengths and chemical compositions are investigated. Chitosan (polymer in use at present) and a polyaluminium chloride are also used as coagulants for comparison.

Low molecular weight (LMW) and highly cationic polymers resulted highest total solids reductions. The application of high MW (HMW) polymers are restricted by their high viscosities in solutions > 1%, a concentration which is practically required.

Capillary Suction Time (CST) is reported to correlate with the filterability of coagulated suspensions and LMW polymers resulted the lowest CST values at applicable polymer dosages.

After coagulation a TS concentration of 4.8% is measured. The dissolved solids which are impossible to remove by coagulation assumed to represent this TS amount (or TDS).

The addition of flocculants did not influence coagulation, flocculation or sedimentation process significantly.

1. Introduction

Alpechine is a wastewater from the Olive oil industry. It is a dark red coloured suspension consisting between 5%-13% of total solids, and has a COD of 60-175 g/l. The wastewater is required to be treated for a consequent discharge.

The Alpechine treatment plant at Alcalà la Real (Jaèn) consists with a coagulation/flotation stage, a sand filtration stage, an ultrafiltration(UF) unit and a reverse osmosis(RO) stage. The coagulation/flotation stage is designed to remove particles from the wastewater, while the UF and RO is designed to remove the dissolved organic matter.

Chitosan (C1), an organic polymer, was used as the main coagulant. Despite the extremely good results from preliminary experiments this coagulant was found to be resulting poor treatment levels at the treatment plant and also causing difficulties in the UF & RO stages.

Upon a request from Ticon Industrier AS of Norway, The Norwegian Institute for Water Research (NIVA) has proposed to evaluate some other coagulants on Alpechine. The results and discussions are presented in this report.

2. Materials and methods

A range of organic polymers from various producers were selected. One inorganic coagulant was also used for comparison. Their details and the dosages used are given in Table 1.

Table 1. Coagulants and their dosages

Code	Producer	Type	Charge	MW	Dosages used
A1	CPS Chemicals(US)	DMA/ECH	++++	120 000	.05-1 ml/l
A2	CPS Chemicals(US)	pDMDAC	++++	200 000	.05-2 ml/l
A3	CPS Chemicals(US)	pDMDAC	+++	V. Low	.05-1 ml/l
C1	Protan (N)	Chitosan	+++(?)	High (?)	.0025-.4 g/l
F1	Floreger (F)	pDMDAC	+++	Ultra low	.3-.8 ml/l
F2	Floreger (F)	pDMDAC	+++	V. low	.01-5 ml/l
H1	Henkel-Nopco	?	?	?	2-4 ml/l
H2	Henkel-Nopco	?	+	?	2-4 ml/l
K1	Kemira (S)	PAC	?	?	2-20 ml/l
P1	Stockhausen (D)	PAA	+++	ca. 7 mln	.005-.2 ml/l
P2	Stockhausen (D)	PAA	+	ca. 7 mln	.05-.4 g/l
P3	Stockhausen (D)	PAA	+++	ca. 7 mln	.1-.4 g/l
P4	Stockhausen (D)	PAA	+++(?)	ca. 7 mln	.005-.2 g/l
P5	Stockhausen (D)	PAA	++	ca. 7 mln	.7-3 ml/l
P6	Stockhausen (D)	PAA (?)	+++(?)	ca. 7 mln	.005-.8 ml/l

Cationic charge: + slight, ++ medium, +++ strong, ++++ very strong.

In order to evaluate the role of flocculants, five chemicals were selected.

Table 2. Details and dosages of flocculants

Code	Producer	Dosage
PP1	Stockhausen (D)	.5-1 mg/l
PP2	Stockhausen (D)	.5-1 mg/l
FF1	Floreger (F)	.5-2.5 μl/l
FF2	Floreger (F)	.5-2.5 μl/l
$CaCl_2$	Merck (D)	.5-1 mmole/l

A semi-automatic jar-test apparatus (Kemira flocculator 90) with 12 jars was used. The mixing and resting procedures were possible to select individually for each jar, which increased the accuracy and effectiveness of the experiments. The mixing and resting procedures are given in Table 3.

Table 3. Jar-test experiments

		Rapid mixing		Slow mixing		Sedimentation, min	
		rpm	min	rpm	min	first	additional
Coagulant only	After coag.	400	2	50	15	30	40, 60, 90
Coag.& flocculant	After coag.	400	2	50	5	none	
	After floccu.	200	2	50	10	30	40, 60

The Total Solids (TS) were analysed (at least) after 24 hours at 105°C.

The CST was analysed using a Triton Type 92 CST meter.

The sugar content was analysed using a field refractrometer type Bellingham+Stanley Ltd, with a sugar scale from 1974.

The samples were filtered using a 1 μm glassfiber filter type Whatmann GF/C, and centrifuged for 15 min, where necessary.

3. Results

Results of the experiments are given in the appendix.

3.1 Experiments with Alpechine from 10.3.92

A preliminary jar-test was conducted using a 20 l batch of Alpechin. Three coagulants were used: F1, H1 and H2. Only F1 indicated any flocculation, and therefore selected for the tests with further dosages.

The results showed a good sludge separation by sedimentation after coagulation. The TS was reduced from 5.5% from 5.0% of raw Alpechine.

A filtration through a 1 μm glass-fiber filter did not reduce the solids content significantly (reduced only < 0.06%). This indicates a dissolved nature of TS, and therefore, TDS=TS is assumed after good coagulation/sedimentation.

Supernatant after centrifugation indicated a further TS reduction by 0.15%.

3.2 Coagulation experiments with Alpechine from 20.3.92

The majority of experiments were conducted with the Alpechine collected on 20.3.92. (The 450 l of Alpechine which was sent from Spain included samples also from 19.3.92).

The experimental results (see appendix) indicate the relatively good performance of low molecular weight (LMW) strong cationic polymers. A1, A3, F1 and F2 resulted in the best TS removals and the best sludge separations. The inorganic coagulant K1 was also performed well, however the flotation and the large sludge volumes were problems at high concentrations.

Nearly all the other polymers indicated no flocculation. However, clumps of polymers/flocs were found sticked to the propellers of mixers at higher dosages. These situations also resulted in lower TS contents (with P1-P6 polymers).

3.3 Coagulation/flocculation experiments with Alpechine from 20.3.92

From the results found in chapter 3.2, polymers A3 and F1 were selected and used to investigate the flocculation efficiencies of five flocculants.

At the dosages used, none of the flocculants significantly affected the sludge volume, sedimentation speed or TS reduction. CST was possible to reduce from 17.9 to 14.1 sec at high dosages (2.5μl/l) of FF1.

3.4 Analysis of samples collected during 15-19.02.92

For the reference purposes, the samples collected in parallel with the Spanish authorities were analyzed and the results are presented in the appendix.

4. Discussion

4.1 Total Solids Content

In Table 5 a wide variation of TS in different Alpechines are indicated. Unfortunately, the Alpechine given for the current study seemed to be not very representative (very low TS% in raw Alpechine).

Table 5. Total Solids of Alpechine

Date/source	TS%	TS% after coagulation (best results)
10.3.92 (chapter 3.1)	5.5%	5.0%
20.3.92 (chapters 3.2-3.3)	5.5%	4.8%
15.2.92 (chapter 3.4)	8.0%	4.7%
18.2.92 (chapter 3.4)	8.5%	6.9%
19.2.92 (chapter 3.4)	8.3%	7.6%
21.2.92 (chapter 3.4)	7.7%	4.5%
31.1.91 (Hans Kristiansen)	11.3%	1.1% (?)
5/7.2.91 (Hans Kristiansen)	12.6%	3.6% (?)
From a plant (Italian study)	13.2%	7.8%
From a settling tank (Ital...)	5.5%	4.1%

When a suspension is stored over a period, some of the particles sedimentate. This is the reason for the differences in observations in the Italian study (Massignan *et al*). The smaller particles (colloids), however, may not settle even after a few months. During coagulation, particles agglomerate in to larger and easy to sedimentate flocs. The colloids are also removed during coagulation due to the destabilization of colloidal system. The dissolved organic compounds as sugar is impossible to remove by coagulation. The COD reduction observed after a coagulation stage is reasoned by the removal of particulate organic materials.

Therefore in the situations where a good coagulation / floc separation were achieved, one can assume that the TS=TDS. TDS is usually not possible to reduce further by coagulation to an appreciable levels. Thus, at optimum dosages, any **effective** coagulant should achieve equal or better TS removals given in Table 5. A difference may be observed in many parameters as sludge volume, chemical costs, dosage, filterability, sedimentation characterestics, CST *etc.*, **but not in the maximum TS reduction,** with different coagulants.

The sugar concentrations in coagulated samples, which were measured by a field refractometer, were almost constant despite TS reductions up to 0.7% in §3.2. This observation confirms the assumption of TS=TDS in coagulated water.

If we assume that raw Alpechine consisted with 0.7% of particulate material > 1μm (suspended solids), and 4.8% of TDS, Fig. 1 can be constructed. The results are maximum removals, and therefore, dosages are different for each coagulant. A3, A1, F1 and F2 resulted good sludge separation. Although P1-P6 and C1 also resulted good SS removals, polymer clumps were observed sticking to the propellers of mixers. Flocculation, sedimentation or flotation were not observed during these experiments.

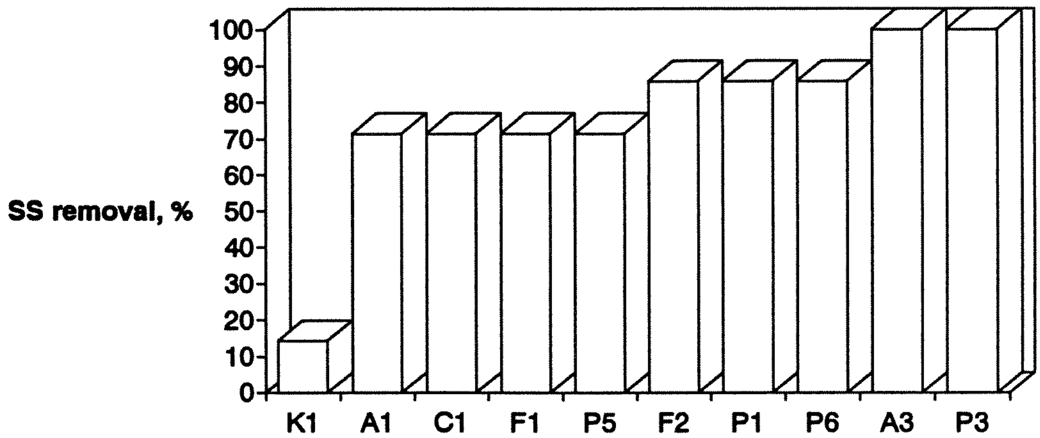

Figure 1. Suspended solids removal (maximum values) with different polymers.

4.2 The high efficiency of LMW & strong cationic polymers

From the analysis given in chapter 3.2, the Alpechine used in the experiments had approx. 0.8% TS which was removable by coagulation. This amount is approx. 10-20 times higher than in a typical municipal wastewater. If there is a direct relationship between the TS and necessary polymer dosage, one would need to apply 100-400 mg/l of polymer to remove TS. With A3 and F1 it was necessary to apply approx. 100-400 mg/l (assuming 50% dry polymers in stock solutions), which is in good agreement with the latter statement.

A polymer dosage of 100-400 mg/l equals to 4-8 μl/l of 5-10% solutions of above polymers, which are LMW. High molecular weight polymers are usually required to apply from 0.01%-0.05% solutions, which is practically not applicable in this case. During these experiments HMW solutions of 0.5%-1% were used which has definitely reduced their effectiveness. However, if the Alpechine is diluted by 10 times, HMW polymers are expected to function even better than LMW polymers.

Therefore, the conclusion from chapter 3.2 is to use LMW polymers. The strongest cationic coagulant will most effectively destabilize colloids in Alpechine, which are negatively charged. The amount of polymer for coagulation is less with strong cationic polymers than with less cationic polymers.

The dosage of coagulant may be possible to reduce further by optimizing the mixing procedures.

4.3 Capillary Suction Time (CST)

The CST values can be used to compare the filterability in a batch of samples. CST is a relative measure, and therefore can not be compared with CST results from the other experiments.

During our experiments, the raw Alpechine had a CST>62 sec. With best coagulants and dosages, it was reduced down to 17 sec. The distilled water indicated a 7 CST sec, which probably represents the resistance of the filter paper. According to the theory, if the CST values are not limited by the filter-paper resistance, they are acceptable. Thus, all the CST values given in this report can be considered as acceptable.

The lowest CST values observed with each polymer are shown in Fig. 2. The polymer dosages are different. At higher dosages of polymers CST may be reduced even to 14.1 sec. However, these situations must be evaluated with other factors as TS removal, chemical costs, sludge volumes *etc.* for an optimum operation.

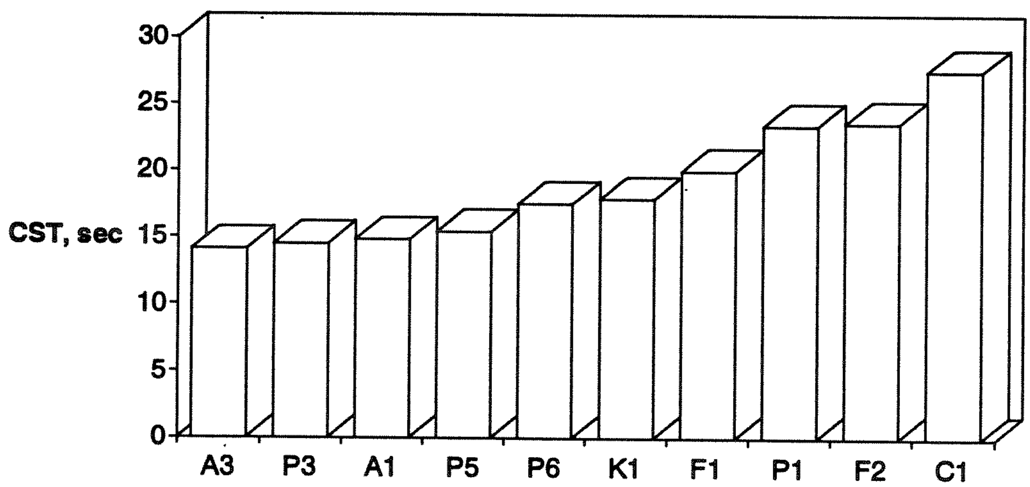

Figure 2. Lowest CST values achieved by different coagulants.

The Alpechine collected during 15-21.2.92 (chapter 3.4) were reported to have a poor filterability. After sand filtration, they had CST values 58-309 sec. Comparing these results, the Alpechine coagulated with A3 or F1 should result in significantly better filterabilities.

The jar-tests with Chitosan were not very successful due to it's HMW nature. The CST measurements indicated values of 28-35 sec, which were relatively high.

It should be mentioned, however, that the relationship between CST and membrane filtration was not evaluated here, and therefore, one should be careful in drawing direct conclusions.

4.4 The role of flocculants

As it was mentioned earlier (chapter 3.3), no appreciable effect of flocculants were observed. A certain improvement in CST results is achievable, at the cost of extra chemicals and instruments. Furthermore, the flocculants which aid flotation may function differently, but such an investigation was beyond the scope of this project. The $CaCl_2$ addition did not improve the CST in our experiments, in contrast to the results reported in a similar study (Massignan *et al.*).

The sedimentation speed and sludge volume, which are usually affected by flocculants, seemed not to be the case with Alpechine. Any differnce was hardly observed.

4.5 Other

COD was measured in few samples where a good TS reduction were observed. COD was reduced from 91.8 g/l to 75.6 g/l (by 18%).

The conductivity was remained almost constant with all organic coagulants, while K1 (polyaluminium chloride) increased it by 20%.

5. Recommendations for further research

A series of jar-tests with representative Alpechine samples (TS>10%, collected directly from the plant) should be conducted to confirm the coagulation and CST results reported here.

The selection of a polymer and it's optimization (mixing, dosage etc) should be conducted in combination with a UF process.

A series of jar-tests combined with a laboratory scale UF will be the preferable method. Otherwise, one can establish a correlation between the CST values and UF Flux for Alpechines with different TS concentrations. This correlation can then be used in usual jar-tests.

Some polymers have negative influence on UF, and the optimum polymer dosage should be thoroughly observed with them. One should, therefore, either select an automatic polymer dosing system based on the raw Alpechine quality, or find a polymer which functions equally good at underdosages or overdosages.

One should also investigate the possibility of application and efficiency of HMW polymers. (The solvents other than water may result in less viscose polymer solutions).

6. Conclusions

Low Molecular Weight (LMW) and strongly cationic polymers are the most suitable coagulants for Alpechine treatment. High Molecular Weight polymers may also be applicable, if it is possible to use them in concentrated solutions (5-10%).

The CST seemed to be significantly improved after coagulation with LMW & strong cationic polymers. Therefore, a better filterability (or UF Flux) is expected after coagulation with them, compared with Chitosan.

The applicable coagulant dosage is strictly dependent on the TS of raw Alpechine, and expected to vary between 0.4-2.0 l/m^3 Alpechine.

A good sedimentation was observed (between 30-60 min) with LMW polymers, without any flocculant addition. No evidence for flotation was observed during the experiments.

When flocculants were added (these were not specifically designed for flotation) the sedimentation and the sludge volume were not affected. However, the sludge may be further conditioned by polymers after separation.

A series of jar-tests with Alpechine including TS>10% is strictly recommended for the confirmation of the conclusions given in this report.

Alpechine from 10-March-92						COAGULANTS:						
Jar-test experiments (500ml):							F1					
rapid mix: 2 min (400 rpm)			RAW ALP., TS=5.5%				H1					
slow mix: 15 min (50 rpm)							H2					
sedimentation: 30, 60 & 90 min												
Coagulant	H1	H1	H1	F1	F1	F1	F1	F1	F1	F1	H2	H2
Coag. conc.	100%	100%	100%	10%	10%	10%	10%	10%	10%	10%	100%	100%
dosage (dil.) ml/l	1	2	5	0.5	1.5	2	3	5	7	10	1	2
dosage, ml/l	2	4	10	0.1	0.3	0.4	0.6	1	1.4	2	2	4
Sludge Volume, ml/l:												
after 30 min					400	780	920	860	960	450	880	920
after 60 min				980	240	640	860	740	880	600	600	
after 90 min					220		700	600		400		
TS%					5.2		5.0					
TS(filtrate),%	5.6	5.5	5.5	4.8	5.2	5.0	4.9	4.8	5.0	4.8	5.5	4.9
TS(centrif.), %					5.0		4.8					
SS%					0.36	0.06	0.06	0.04		0.06		

Alpechine from 20-March-92						
Jar-test experiments:						
rapid mix: 2 min (400 rpm)						
slow mix: 15 min (50 rpm)						
sedimentation: 30, 40 & 60 min						
Coagulant	A1					
Coag. conc.	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
dosage (dil.) ml/l	1	5	7.5	10	15	20
dosage, g/l						
dosage, ml/l	0.05	0.25	0.375	0.5	0.75	1
Sludge Volume, ml/l:						
after 30 min		380	760	900	930	910
after 40 min		340	600	810	870	850
after 60 min		300	510	660	730	700
CST (avg. of 2-3 measur.)		21.8	25.6	14.8	16.9	14.5
Sugar, %		6.1	6.1	6.1	6.0	6.0
TS%		5.0	5.1	5.0	5.0	5.0
Conductivity, mS/cm		8.6	9.2	9.0	8.8	9.3
COD, g/l			81.6			
Remarks	no fl.					

Alpechine from 20-March-92					
Jar-test experiments:					
rapid mix: 2 min (400 rpm)					
slow mix: 15 min (50 rpm)					
sedimentation: 30, 40 & 60 min					
Coagulant	A2				
Coag. conc.	5.00%	5.00%	5.00%	5.00%	5.00%
dosage (dil.) ml/l	1	5	10	20	40
dosage, g/l					
dosage, ml/l	0.05	0.25	0.5	1	2
Sludge Volume, ml/l:					
after 30 min					
after 40 min					
after 60 min					
CST (avg. of 2-3 measur.)					
Sugar, %					
TS%					
Conductivity, mS/cm					
COD, g/l					
Remarks	no fl.	no fl.	no fl.	no fl.	no fl.

Alpechine from 20-March-92									
Jar-test experiments:									
rapid mix: 2 min (400 rpm)									
slow mix: 15 min (50 rpm)									
sedimentation: 30, 40 & 60 min									
Coagulant	A3								
Coag. conc.	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%			
dosage (dil.) ml/l	1	3	5	8	10	20			
dosage, g/l									
dosage, ml/l	0.05	0.15	0.25	0.4	0.5	1			
Sludge Volume, ml/l:									
after 30 min	150	400	580	880	950	970			
after 40 min	120	320	410	670	810	880			
after 60 min	11	300	390	550	710	800			
CST (avg. of 2-3 meas	21.9	21	18	17.9	18.7	14.1			
Sugar, %	6	6	6.2	6	6	6			
TS%	5.2	5.0	5.0	4.8	4.9	4.9			
Conductivity, mS/cm	9.01	9.13	9.15	9.19	8.99	9.12			
COD, g/l				77.9					
Remarks									

Alpechine from 20-March-92									
Jar-test experiments:									
rapid mix: 2 min (400 rpm)									
slow mix: 15 min (50 rpm)									
sedimentation: 30, 40 & 60 min									
Coagulant	C1								
Coag. conc.	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	1.00%	1.00%	
dosage (dil.) ml/l	0.5	1	2	5	20	40	30	40	
dosage, g/l									
dosage, ml/l	0.0025	0.005	0.01	0.025	0.1	0.2	0.3	0.4	
Sludge Volume, ml/l:									
after 30 min									
after 40 min									
after 60 min									
CST (avg. of 2-3 measur.)				27.5			35.2	33.2	
Sugar, %				6.2			6.1	6.1	
TS%				5.0	6.0		5.3	5.2	
Conductivity, mS/cm				8.9	8.8				
COD, g/l							90.7	90.6	
Remarks	no fl.	no fl.	no fl.			no fl.			

Alpechine from 20-March-92									
Jar-test experiments:									
rapid mix: 2 min (400 rpm)									
slow mix: 15 min (50 rpm)									
sedimentation: 30, 40 & 60 min									
Coagulant	F1								
Coag. conc.	10.00%	10.00%	10.00%						
dosage (dil.) ml/l	3	5	8						
dosage, g/l									
dosage, ml/l	0.3	0.5	0.8						
Sludge Volume, ml/l:									
after 30 min	100	190	420						
after 40 min	100	250	370						
after 60 min	90	190	290						
CST (avg. of 2-3 meas	26.3	20	21.7						
Sugar, %	6.1	6.1	5.8						
TS%	5.8	5.1	5.0						
Conductivity, mS/cm	9.16	9.24	9.18						
COD, g/l			87.7						
Remarks									

Alpechine from 20-March-92									
Jar-test experiments:									
rapid mix: 2 min (400 rpm)									
slow mix: 15 min (50 rpm)									
sedimentation: 30, 40 & 60 min									
Coagulant	F2								
Coag. conc.	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%
dosage (dil.) ml/l	0.1	0.3	0.6	1	3	5	12	18	50
dosage, g/l									
dosage, ml/l	0.01	0.03	0.06	0.1	0.3	0.5	1.2	1.8	5
Sludge Volume, ml/l:									
after 30 min						60	290	410	50
after 40 min						90	280	400	40
after 60 min							260	320	
CST (avg. of 2-3 measur.)						29.5	25	24.6	23.6
Sugar, %						6.3	5.9	5.9	5.9
TS%						5.8	5.1	4.9	5.2
Conductivity, mS/cm						9.12	9.03	8.88	8.5
COD, g/l							81		
Remarks	no fl.	no fl.	no fl.	no fl.	no fl.				

Alpechine from 20-March-92						
Jar-test experiments:						
rapid mix: 2 min (400 rpm)						
slow mix: 15 min (50 rpm)						
sedimentation: 30, 40 & 60 min						
Coagulant	K1					
Coag. conc.	100%	100%	100%	100%	100%	100%
dosage (dil.) ml/l	2	5	7.5	10	15	20
dosage, g/l						
dosage, ml/l	2	5	7.5	10	15	20
Sludge Volume, ml/l:						
after 30 min			100	700	950	
after 40 min				500		
after 60 min						
CST (avg. of 2-3 measur.)			25.4	17.9		
Sugar, %		6	6	6	6.1	
TS%		5.4	5.6	5.5	6.0	
Conductivity, mS/cm		10.26	10.57	11.74	12.1	
COD, g/l				78.8		
Remarks	no fl.					flot.

Alpechine from 20-March-92					
Jar-test experiments:					
rapid mix: 2 min (400 rpm)					
slow mix: 15 min (50 rpm)					
sedimentation: 30, 40 & 60 min					
Coagulant	P1				
Coag. conc.	0.50%	0.50%	0.50%	0.50%	0.50%
dosage (dil.) ml/l	1	5	10	20	40
dosage, g/l					
dosage, ml/l	0.005	0.025	0.05	0.1	0.2
Sludge Volume, ml/l:					
after 30 min					
after 40 min					
after 60 min					
CST (avg. of 2-3 measur.)			50		23.4
Sugar, %					6
TS%			4.9	5.3	4.7
Conductivity, mS/cm			8.82	8.19	8.92
COD, g/l					
Remarks	no fl.	no fl.	clumps	cl.	cl.

Alpechine from 20-March-92				
Jar-test experiments:				
rapid mix: 2 min (400 rpm)				
slow mix: 15 min (50 rpm)				
sedimentation: 30, 40 & 60 min				
Coagulant	P2			
Coag. conc.	1.00%	1.00%	1.00%	1.00%
dosage (dil.) ml/l	5	10	20	40
dosage, g/l	0.05	0.1	0.2	0.4
dosage, ml/l				
Sludge Volume, ml/l:				
after 30 min				
after 40 min				
after 60 min				
CST (avg. of 2-3 measur.)				
Sugar, %				
TS%				
Conductivity, mS/cm				
COD, g/l				
Remarks	no fl.	no fl.	no fl.	no fl.

Alpechine from 20-March-92			
Jar-test experiments:			
rapid mix: 2 min (400 rpm)			
slow mix: 15 min (50 rpm)			
sedimentation: 30, 40 & 60 min			
Coagulant	P3		
Coag. conc.	0.50%	0.50%	0.50%
dosage (dil.) ml/l	20	40	80
dosage, g/l	0.1	0.2	0.4
dosage, ml/l			
Sludge Volume, ml/l:			
after 30 min			
after 40 min			
after 60 min			
CST (avg. of 2-3 measur.)			14.5
Sugar, %			6
TS%			4.8
Conductivity, mS/cm			8.21
COD, g/l			75.6
Remarks			cl.

Alpechine from 20-March-92				
Jar-test experiments:				
rapid mix: 2 min (400 rpm)				
slow mix: 15 min (50 rpm)				
sedimentation: 30, 40 & 60 min				
Coagulant	P4			
Coag. conc.	0.50%	0.50%	0.50%	0.50%
dosage (dil.) ml/l	1	5	10	40
dosage, g/l	0.005	0.025	0.05	0.2
dosage, ml/l				
Sludge Volume, ml/l:				
after 30 min				
after 40 min				
after 60 min				
CST (avg. of 2-3 measur.)				
Sugar, %				
TS%				
Conductivity, mS/cm				
COD, g/l				
Remarks	no fl.	no fl.	no fl.	cl.
Alpechine from 20-March-92				
Jar-test experiments:				
rapid mix: 2 min (400 rpm)				
slow mix: 15 min (50 rpm)				
sedimentation: 30, 40 & 60 min				
Coagulant	P5			
Coag. conc.	100%	100%	100%	100%
dosage (dil.) ml/l	0.7	1	2	3
dosage, g/l				
dosage, ml/l	0.7	1	2	3
Sludge Volume, ml/l:				
after 30 min				
after 40 min				
after 60 min				
CST (avg. of 2-3 measur.)				15.4
Sugar, %	6	5.9	5.9	5.8
TS%	5.4	5.4	5.3	5.0
Conductivity, mS/cm	9.22	9.02	8.86	8.9
COD, g/l				81.1
Remarks	no sedi.	no sedi.	cl.	

Alpechine from 20-March-92									
Jar-test experiments:									
rapid mix: 2 min (400 rpm)									
slow mix: 15 min (50 rpm)									
sedimentation: 30, 40 & 60 min									
Coagulant	P6								
Coag. conc.	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	10.00%		
dosage (dil.) ml/l	0.5	1	2	5	10	30	8		
dosage, g/l									
dosage, ml/l	0.0025	0.005	0.01	0.025	0.05	0.15	0.8		
Sludge Volume, ml/l:									
after 30 min					40	80	140		
after 40 min							130		
after 60 min									
CST (avg. of 2-3 measur.)					34.9	20.7	17.5		
Sugar, %					6.2	6.1	6.1		
TS%					5.4	4.9	5.2		
Conductivity, mS/cm					8.92	8.89	9.08		
COD, g/l						90.5			
Remarks	no fl.	no fl.	no fl.	no fl.	flot.	flot.			
Alpechine from 20-March-92									
Jar-test experiments:									
rapid mix: 2 min (400 rpm)									
slow mix: 15 min (50 rpm)									
sedimentation: 30, 40 & 60 min									
Coagulant	RAW ALPECHINE								
Coag. conc.									
dosage (dil.) ml/l									
dosage, g/l									
dosage, ml/l									
Sludge Volume, ml/l:									
after 30 min									
after 40 min									
after 60 min									
CST (avg. of 2-3 meas	68		62						
Sugar, %	6.1	6.1	6.1						
TS%	5.3	5.5	5.6						
Conductivity, mS/cm	9.05	9.1	9.05						
COD, g/l	91.3		92.3						
Remarks									

Alpechine from 20-March-92												
Jar-test experiments:												
rapid mix: 2 min (400 rpm) + slow mix: 5 min (50rpm)												
flocculant + rapid mix: 2 min (200 rpm) + slow mix: 10 min (50 rpm)												
sedimentation: 30, 40 & 60 min												
Coagulant	NONE	A3	A3	A3	A3	A3	A3	A3	A3	A3	A3	A3
Coag. conc.		5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
dosage (dil.) ml/l		8	8	8	8	8	8	8	8	8	8	8
dosage, ml/l		0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
flocculant		CaCl2	CaCl2	FF1	FF1	FF1	FF2	FF2	FF2	PP1	PP1	PP2
floc. conc.		1M	1M	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.10%	0.10%	0.05%
dosage (dil.), ml/l		0.5	1	0.1	0.2	0.5	0.1	0.2	0.5	0.5	1	1
dosage, mg/l										0.5	1	0.5
dosage, µl/l		0.5 µM/l	1µM/l	0.5	1	2.5	0.5	1	2.5			
Sludge Volume, ml/l:												
after 30 min		870	820	830	810	730	740	860	840	850	760	890
after 40 min		700	630	670	620	560	560	640	670	660	670	760
after 60 min		530	490	510	490	450	460	510	490	500	520	560
CST (avg. of 2-3 meas	70	23.8	19.1	30	70	14.1	42.4	17.9	15.5	21	20.1	15.8
Sugar, %	6.1	6	5.9	6	6	6.1	6.1	6	6	5.9	6	6
TS%	5.5	4.8	4.9	4.7	5.5	4.8	5.0	4.9	4.8	4.8	4.8	4.9
Conductivity, mS/cm	8.52	9.29	9.25	9.17	8.36	9.15	8.42	9.16	8.85	9.19	8.73	8.82
Remarks												

Alpechine from 20-March-92												
Jar-test experiments:												
rapid mix: 2 min (400 rpm) + slow mix: 5 min (50rpm)												
flocculant + rapid mix: 2 min (200 rpm) + slow mix: 10 min (50 rpm)												
sedimentation: 30, 40 & 60 min												
Coagulant	NONE	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1	F1
Coag. conc.		10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
dosage (dil.) ml/l		8	8	8	8	8	8	8	8	8	8	8
dosage, ml/l		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
flocculant		CaCl2	CaCl2	FF1	FF1	FF2	FF2	PP1	PP1	PP2	PP2	NONE
floc. conc.		1M	1M	0.50%	0.50%	0.50%	0.50%	0.10%	0.10%	0.05%	0.05%	
dosage (dil.), ml/l		0.5	1	0.1	0.2	0.1	0.2	0.5	1	1	2	
dosage, mg/l								0.5	1	0.5	1	
dosage, µl/l		0.5 µM/l	1 µM/l	0.5	1	0.5	1					
Sludge Volume, ml/l:												
after 30 min		490	530	480	500	430	500	420	530	400	480	390
after 40 min		400	430	390	410	380	410	380	420	360	400	340
after 60 min		320	350	310	340	300	330	300	330	300	320	320
CST (avg. of 2-3 meas	70	24	25	17.9	20.3	21.7	19.1	20.6	19.1	19.8	22.4	17.2
Sugar, %	6.1	5.9	6.1	5.9	5.9	5.9	6	6	6	6.1	5.9	6.1
TS%	5.5	4.9	4.9	5.0	4.9	4.9	4.9	4.9	4.9	4.9	4.9	5.0
Conductivity, mS/cm	8.52	9.22	9.28	8.84	9.19	8.99	9.2	9.16	8.94	9.23	8.93	8.82
Remarks												

	ALPECHINE FROM 15-19 FEB. 1992 (collected by Jan Knudsen)					
	TS%	15.Feb.92	18.Feb.92	19.Feb.92	21.Feb.92	
A	from Alpechin plant	8.0	8.1	7.9	10.3	
B	to treatment plant	8.0	8.5	8.3	7.7	
C	to flotation (chitosan+ no polym.)	7.3	8.1	8.4	6.1	
D	fom flotation	5.3	6.9	7.7	5.0	
E	from sandfilters	4.7	6.9	7.6	4.5	
F	from ultrafiltration	6.4	8.3	8.6	6.8	
G	from RO (effluent)					
H	sludge from flotation					
I	washwater - sandfilter	6.1	6.6	7.0	5.3	
J	concentrate UF	6.1	7.8	8.6	5.8	
K	concentrate RO	4.4	13.3	13.4	11.5	
		Conduct.				
G	from RO	**1:10**	**COD**	**BOD**	**CST**	
	diff. membranes	**µS/cm**	**g/l**	**g/l**	**sec**	
G1	15.Feb.92	101.8	2.66			
G2	18.Feb.92	229	6.34			
G3	19.Feb.92	151.5	4.96			
G4	21.Feb.92	101	2.43			
G4 ii	21.Feb.92	180.5				
G4 iii	21.Feb.92	72.8				
G5	22.Feb.92	101	2.76	2.28		
G5 i	22.Feb.92	88				
G5 ii	22.Feb.92	145				
G5 iii	22.Feb.92	91.6				
G iv	22.Feb.92	98.5				
E3	from sandfilters, 19.Feb.92		>100 (?)		309 (?)	
E4	from sandfilters, 21.Feb.92		58.3		60.6	
F3	from ultrafiltration, 19.Feb.92		67.2		15.7	
F4	from ultrafiltration, 21.Feb.92		46.6		12.9	
Hans Kristiansen, NIVA.						

Norwegian Institute for Water Research NIVA

P.O.Box 69, Korsvoll N-0808 Oslo, Norway
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