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Poly aluminium chloride as an alternative coagulant

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AFFORDABLE WATER SUPPLY AND SANITATION

Poly aluminium chloride as an alternative coagulant

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ALUMINIUM SULPHATE COMMONLY known as alum is widely used as a coagulant in water treatment plants. Generally large sludge volumes are produced with alum which requires frequent desludging operations at the treatment plants causing increased wastage of water. There is also possibility of aluminium carry over in water treated with alum. High levels of aluminium in potable water is reported to cause Alzheimer's disease, a form of senility. However uptill now there is no clear evidence to suggest a link between aluminium & Alzheimer's disease (Cole, 1990). Poly aluminium chloride (PAC) has been developed as an alternative coagulant for alum by an Indian manufacturer.

PAC hydrolyses with great ease as compared to alum, emitting polyhydroxides with long molecular chains & greater electrical charge in the solution, thus contributing to maximise the physical action of the flocculation. Better coagulation is obtained with PAC as compared to alum at medium & high turbidity waters. Floc formation with PAC is quite rapid. The sludge produced by PAC is more compact than that produced by alum.

Preparation of coagulant solution

The working alum solution was freshly prepared by dissolving 10g of alum in one litre of distilled water. For making 1% solution of PAC the dilution of PAC was done with distilled water on daily basis.

Jar test equipment

All the laboratory tests were carried out using Phipps & Bird Multiple Stirring Device(Jar tester) equipped with stirring paddles & provisions for controlled mixing.The floc size & its settleability were observed with the illuminating device at the base of the apparatus.

Test conditions

Measured volumes (500 ± 10 mL) of samples were flocculated using the jar test apparatus in 600mL beakers. The beakers were placed in position in the jar tester. The motor of the stirrer paddles was started after addition of coagulant in each beaker simultaneously, rapid mix was maintained at 90 ± 10 rpm for 0.5 minutes followed by slow mix for high turbidity samples at 40 ± 5 rpm for 9.5 minutes. In case of low turbidity samples, after rapid mix & after addition of PAC or alum, slow mix was done at 25 ± 5 rpm for 9.5 minutes. At the end of the stirring period, the beakers were removed slowly from the jar tester platform & the contents of the beakers were allowed to settle for 20 minutes. For each series, jar tests were repeated & average value of turbidity recorded to eliminate subjective errors. The criteria used for the evaluation of the efficiency of the coagulants were settled water turbidity & visual appearance of flocs.

Floc size index & flocculation

The floc size during jar tests were observed visually & recorded arbitrarily as per the following classification:

Floc Size Index (FSI)	Indication
1	No flocculation
2	Pin Point floc
3	Small floc
4	Large floc
5	Lump floc

The above classification was made by the author throughout the sets & observations were tabulated for each set of jar test conducted for comparison of floc size for PAC & alum.

The comparative performance of alum & PAC at four turbidity levels viz. 150 NTU, 550 NTU, 800 NTU and 2200 NTU are tabulated in

Tables 1 to 4 and summarised under Table 5. The results of sludge volume produced by alum & PAC are tabulated in Tables 6 & 7. The experiments on sludge volume were performed using Imhoff cones. Results of residual aluminium with alum & PAC are tabulated in Table 8. Aluminium analysis was performed colorimetrically using ECR method (Standard Methods, 1992)

Summary and conclusion

PAC is an effective & useful substitute for solid alum which is conventionally used as a coagulant in most of the water treatment plants in India. It can cause rapid coagulation of water at different turbidities, produces less sludge & leaves less amount of residual aluminium.

Table 1. Comparative performance of alum and PAC.

Source : Wainganga river
Turbidity : 150 NTU

Alum, mg/L	0	5	10	15	20	30	40
Residual Turbidity,NTU	148	102	16	13	10	6	4
Reduction %	0	31.1	89.2	91.2	93.2	95.9	97.3
FSI	1	2	3	3	4	4	4
pH	8.2	8.0	7.8	7.6	7.5	7.4	7.2
Alkalinity mg/L as $CaCO_3$	168	164	160	159	158	152	148
PAC, mg/L	0	4	8	12	16	20	30
Residual Turbidity,NTU	152	106	33	18	13	11	4
Reduction %	0	30.3	78.3	88.1	91.4	92.8	97.4
FSI	1	2	3	4	5	5	5
pH	8.2	8.2	8.2	8.2	8.1	8.1	8.1
Alkalinity mg/L as $CaCO_3$	168	166	165	164	162	160	156

Table 2. Comparative performance of alum and PAC.

Source : Narmada river
Turbidity : 550 NTU

Alum, mg/L	0	10	20	30	40	50
Residual Turbidity,NTU	570	75	14	10	5	5
Reduction %	0	86.8	97.5	98.2	99.1	99.1
FSI	1	2	3	4	4	4
pH	7.7	7.3	7.2	7.1	7.0	6.9
Alkalinity mg/L as $CaCO_3$	85	84	82	81	80	78
PAC, mg/L	0	5	10	20	30	40
Residual Turbidity,NTU	565	129	44	24	10	4
Reduction %	0	77.2	92.2	95.7	98.2	99.2
FSI	1	3	4	4	5	5
pH	7.7	7.7	7.6	7.5	7.4	7.3
Alkalinity mg/L as $CaCO_3$	85	84	84	82	82	82

Table 3. Comparative performance of alum and PAC.

Source: Narmada river
Test water turbidity: 800 NTU

Alum, mg/L	0	10	20	40	60	80
Residual Turbidity,NTU	770	294	93	16	8	5
Reduction %	0	61.8	87.9	97.9	98.9	99.3
FSI	1	2	3	4	4	4
pH	8.0	7.9	7.5	7.4	7.2	7.1
Alkalinity mg/L as $CaCO_3$	88	85	80	78	76	74
PAC, mg/L	0	5	10	20	30	40
Residual Turbidity,NTU	780	331	79	17	9	5
Reduction %	0	57.6	89.9	97.8	98.8	99.3
FSI	1	3	4	5	5	5
pH	8.0	8.0	7.9	7.8	7.7	7.6
Alkalinity mg/L as $CaCO_3$	88	88	87	86	84	84

Table 4. Comparative performance of alum and PAC.

Source: Kanhan river
Test water turbidity :2200 NTU

Alum, mg/L	0	20	30	40	50	60	70
Residual Turbidity,NTU	2250	80	29	28	17	9	4
Reduction%	0	96.4	98.7	98.7	99.2	99.6	99.8
FSI	1	3	4	4	4	4	4
pH	7.9	7.6	7.5	7.5	7.4	7.4	7.3
Alkalinity mg/L as $CaCO_3$	120	98	85	80	75	70	65
PAC, mg/L	0	10	20	30	40	50	
Residual Turbidity,NTU	2270	200	29	8	5	5	
Reduction %	0	91.2	98.7	99.6	99.8	99.8	
FSI	1	3	4	5	5	5	
pH	7.9	7.9	7.7	7.7	7.6	7.6	
Alkalinity mg/L as $CaCO_3$	120	110	105	100	95	90	

Table 5. Comparative dose to bring down the turbidity to 5 NTU.

S. No.	Turbidity NTU	Alum mg/L	PAC mg/L	% PAC Consumption against % Alum Consumption
1.	150	35	25	71.4
2.	550	40	35	87.5
3.	800	80	40	50.0
4.	2200	65	40	61.5

Table 6. Residual Aluminium with PAC/alum.

S. No.	Dose of Alum/PAC mg/L	Aluminium Concn. after treatment with,mg/L		Resultant pH	
		Alum	PAC	Alum	PAC
1.	0	0.05	0.05	8.0	8.0
2.	200	0.10	0.05	6.5	7.3
3.	300	>0.80	0.05	5.0	7.1
4.	400	>0.80	0.05	4.8	7.0

References

1) Cole, H; Asian Water and Sewage, p.53, 1990

2) Standard Methods for the examination of water and waste water, 18th edition, published jointly by American Public Health Association, American Water Works Association, Water Environment Federation, p.3-44, 1992

Table 7. Sludge volume produced by alum & PAC.

Raw water turbidity - 2010 NTU, pH -8.0, volume - 1 L
Source : Narmada river

S. No.	Time (min.)	Sludge Volume, mL	
		Alum dose 80 mg/L	PAC dose 50 mg/L
1.	0	0	0
2.	5	35	30
3.	10	27	21
4.	15	24	15
5.	20	20	16
6.	30	19	15
7.	45	17	14
8.	60	14	12
9.	90	14	12
10.	120	13	11
11.	150	13	10.5
12.	180	12.5	10
13.	240	11	9.5
14.	300	10.5	9.5
15.	1260	9	9.0
16.	1440	8.5	8.5

Table 8. Sludge volume produced by alum & PAC.

Raw water turbidity - 1250 NTU, pH - 8.1, volume - 1 L
Source: Solapur water works (raw water)

S. No.	Time (min.)	Sludge Volume, mL	
		Alum dose 120 mg/L	PAC dose 80 mg/L
1.	0	0	0
2.	30	35	31
3.	60	31	27
4.	90	28	24
5.	120	26	21
6.	150	25	20
7.	180	23	20
8.	210	20	18