



Poly Aluminum Chloride

TPP-100 PAC 18%

Pale Yellow Liquid





Why Coagulation & Flocculation?

Various sizes of particles in raw water

Particle diameter (mm)	Type	Settling velocity
10	Pebble	0.73 m/s
1	Course sand	0.23 m/s
0.1	Fine sand	0.6 m/min
0.01	Silt	8.6 m/d
0.0001 (10 micron)	Large colloids	0.3 m/y
0.000001 (1 nano)	Small colloids	3 m/million y

Gravity settling

Colloids – so small: gravity settling not possible

What is coagulation? What is flocculation?

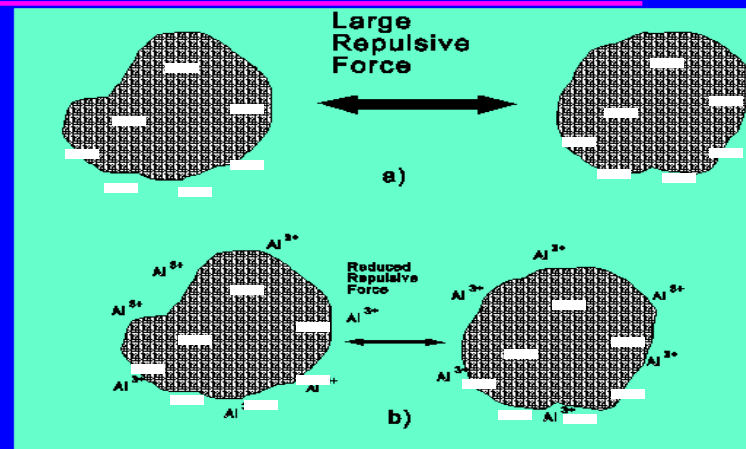
- ❑ **Coagulation** is the destabilization of colloids by addition of chemicals that neutralize the negative charges
- ❑ The chemicals are known as coagulants, usually higher valence cationic salts (Al^{3+} , Fe^{3+} etc.)
- ❑ Coagulation is essentially a chemical process

Flocculation is the agglomeration of destabilized particles into a large size particles known as flocs which can be effectively removed by sedimentation or flotation.

- Gentle mixing or **flocculation**, then causes the destabilized (reduced charge) colloids to cluster.
- Another method of enhancing agglomeration is to add organic polymers.
- These compounds consist of a long carbon chain with active groups such as amine, nitrogen, or sulfate groups along the chain.



Charge neutralization



Dose calculation-Jar testing

The jar test – a laboratory procedure to simulate the coagulation and flocculation processes to

- ❑ Determine the most effective chemical
- ❑ Determine the most effective dosage
- ❑ Determine the optimum point of application
- ❑ Determine the optimum PH
- ❑ Evaluate polymers





Choice of coagulants

A number of parameters must be considered:

- ☐ Water temperature,
- ☐ Characteristics of raw water (including calcocarbonic balance).
- ☐ Physico-chemical parameters to include or eliminate priority (turbidity and / or Organic Materials).
- ☐ Operations management (stocks, automation, etc ...)
- ☐ Product cost,

Parameters affecting Coagulation and flocculation

- ☐ Water quality (physico-chemical characteristics especially Alkalinity & Turbidity)
- ☐ Nature and structure of colloids
- ☐ Nature and implementation of used product (Coagulant type).
- ☐ PH
- ☐ Pretreatments
- ☐ Mixing conditions, dose, size & shape of the flocs.



Types of coagulants

Inorganic Coagulants

These are often considered to be more cost-effective than their organic counterparts, and they can be applied to a wide variety of water treatment operations including food and drink manufacturing and oil purification. Most commonly used ones are:

- ❑ Ferric Chloride (**FC**)
- ❑ Aluminum Sulphate (**Alum**)
- ❑ Poly Aluminum Chloride (**PACL**)

Organic Coagulants

These are typically used for solid-liquid separation when a reduction in sludge generation is required. Organic coagulants can be based on two types of chemistries:

- ❑ Polyamines and PolyDADMAC
- ❑ Melamine formaldehydes and tannins



Coagulants-Other classification





Coagulating Power of Inorganic Electrolytes

Electrolyte	Relative power of coagulation	
	Against positive colloids	Against negative colloids
NaCl	1	1
Na ₂ SO ₄	30	1
Na ₃ PO ₄	1000	1
BaCl ₂	1	30
MgSO ₄	30	30
AlCl ₃	1	1000
Al ₂ (SO ₄) ₃	30	1000
FeCl ₃	1	1000
Fe ₂ SO ₄	30	1000
PAC	>30	>10000

POLY ALUMINIUM CHLORIDE APPLICATIONS



Storms water and Dams



STP, IWTP



Desalination plants



Advantages of PAC:

PH

- ❑ Wide range
- ❑ Negligible variation of solution PH when PAC is used
- ❑ Very low need to correct or adjust PH value in case of using PAC. This will dramatically decrease OPEX.

Alkalinity consumption & Corrosion causes

- ❑ Compared to conventional inorganic coagulants, Alkalinity will not be consumed, PH value will not be highly decreased and hence corrosion problems shall not arise.

Water TDS & Pre chlorination

- ❑ When applying PAC dosage, TDS is not increased
- ❑ There is much decrease of pre chlorination if PAC was used.



Advantages of PAC:

Flocs. & Sludge

- ☐Fast formation.
- ☐Large sized.
- ☐Dense & compact.

Residual Aluminum

- ☐Very negligible .
- ☐Diseases Prevention.

Un-Dissolved TOC Removal

- ☐Very Effective

Iron Fouling Prevention

- ☐PAC contains no Iron radicals, this helps with Iron fouling prevention in case of being used in RO pr-treatment.



Advantages of PAC:

Low water Temperatures

- ❑ Unlike conventional inorganic coagulants, PAC is still very effective at lower temperatures.

OPEX & CAPEX

- ❑ Cost effective.
- ❑ Much OPEX & CAPEX saving.
- ❑ Footprint saving.

Handling, Shipping & Storage

- ❑ Very easy to handle.
- ❑ Much shipping & Storage cost saving.



PACL VS. CONVENTIONAL INORGANIC COAGULANTS

Criteria	PACL	FC	Alum
PH range	Wide (4-8.5)	Wide (4-9)	Small (3.5-6.5)
PH Variation (After usage)	Negligible	Very high decrease	Very high decrease
PH of solution ($\approx 50\%$)	3.5	2	2
Optimum PH range	5-6.5	4.5-5.5	5.5 – 6.5
Need to adjust PH	Low	Very high	Very igh
Alkalinity consumption	Very low	Very high	Very high
Cationic strength	Very high	High	High
Corrosion problems (when used)	Very low	Very high	Very high
Increase of water TDS	Very low	High	High
Increasing Sulphate	Not adding more	Not adding more	Highly increase



PACL VS. CONVENTIONAL INORGANIC COAGULANTS

Criteria	PACL	FC	Alum
Increasing Sulphate conc.	Not adding more Sulphates	Not adding more Sulphates	Highly increase
Floc formation	Fast	Slow	Slow
Floc. Size	Large	Medium	Medium
Sludge amount	Small	Very Much	Very Much
Sludge density	More dense and more compact	Less dense and less compact	Less dense and less compact
Residual Aluminum	Negligible	No residuals	Much amount
Increase of Iron Conc.	No Increase	High increase	No Increase
Coloring water solutions	Nope	High coloration	Nope
Low Temperatures	Still very effective	Very ineffective	Very ineffective
Un -dissolved TOC removal	Very effective	Not effective	Not effective



PACL VS. CONVENTIONAL INORGANIC COAGULANTS

Criteria	PACL	FC	Alum
DOC removal	Not effective	Effective	Effective
Organic Colloids removal	High effective	Not effective	Not effective
Dose	Very small	Very high	Very high
Unit Price	Expensive	Cheap	Cheap
Needed CAPEX	Less $\approx$ (20%-30% Saving)	High	High
Power consumption	Low	High	High
OPEX	Low $\approx$ (20%-30% Saving)	High	High
Footprint needed	Low $\approx$ (30%-40% Saving)	High	High
Handling, Shipping & Storage	Easier & much lower cost	Harder & much higher cost	Harder & much higher cost



Switching cautions !!!!!

Replacement of Conventional Inorganic coagulants with PACL requires to consider:

- ☐ Complete elimination of the old chemicals (FC or Alum) from all tanks & pipelines in order to avoid Aluminum jelly formation (chemical interaction must be avoided)
- ☐ Dosing system must be investigated to make sure It's not corroded.
- ☐ Flush the old system with water before you apply PACL.
- ☐ System must be checked for any leakages.

Case Studies- KSA

Storm water and Dams





CHARACTERIZATION AND EVALUATION

Surface water treatment - Storm water /dams

Case Study 1
Marabah
WTP 75,000m3/day

Case Study 2
BEASH
WTP
200,000 m3/day

Case Study 3
Hali
WTP
100,00 m3/day

Specification standard	After sand filters outlet	Raw water	Specs	
5	0.52	6.3	Turbidity NTU	1
6.5-8.5	6.9	7.46	PH	2
-	--	--	T.S.S	3
5	4.75	12.8	TOC	4
1000	--	--	TDS	5
15	2	62.13	Color Unit	6
250	--	87.5	Sulphate	7
0.2	0.029	--	Al+++ Residuals	8
0.5-1	0.7		Free Cl Residuals	9
0.5	0.037	0.349	Mn++	10
0.3	--	0.015	Fe +++	11



CHARACTERIZATION AND EVALUATION

Surface water treatment - Storm water /dams

Reducing

- 45% Reducing Caustic Soda consumption plus more water Production quantities by 25%

Reducing

- pumps replacements and maintenance and network corrosion as well @ PH 7.3.



CHARACTERIZATION AND EVALUATION

Surface water treatment - Storm water /dams

Reducing

- **Chlorine gas consumption by 55% to 60%**

Reducing

- **Sulfuric acid by 20%**

• **Feasibility**

- **48%cost reduction**



Poly aluminum chloride applications

Desalination



CHARACTERIZATION AND EVALUATION

Surface water treatment - Storm water /dams

Case
Study 1

DHUBA
Desalination plant 5,000
m3/day

Case
Study 2

Alwejah
Desalination Plant
5,000 m3/day

Case
Study 3

AMLOJ
Desalination plant
5,000 m3/day

المؤسسة العامة لتحلية المياه المالحة
Saline Water Conversion Corporation
www.swcc.gov.sa

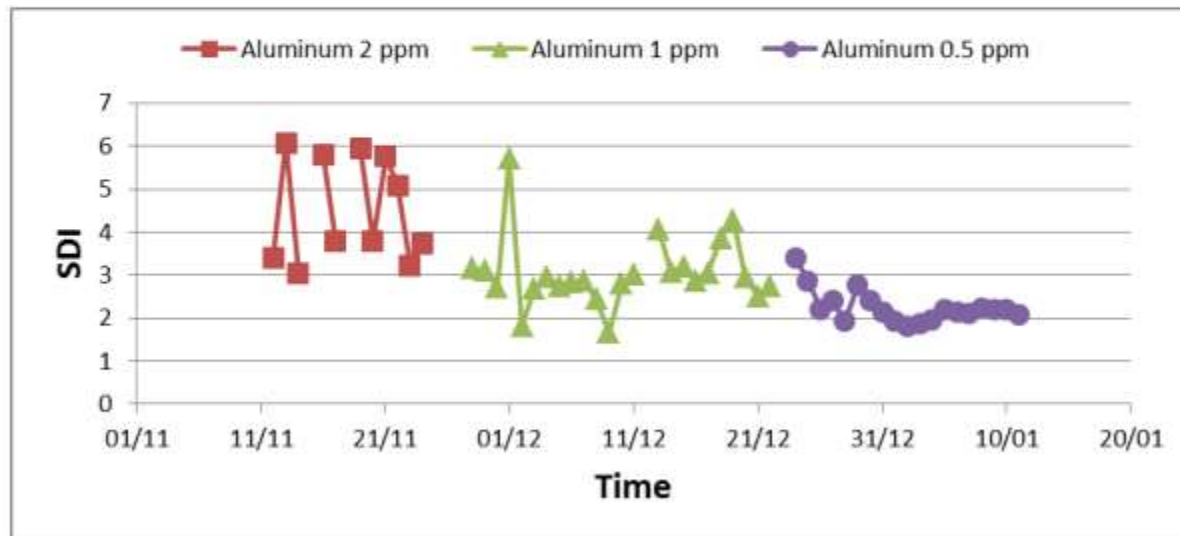


معهد أبحاث تقنيات التحلية

ص.ب : 8328 الجبيل 31951 - المملكة العربية السعودية
هاتف: (013) 3433477 - فاكس: (013) 3431615

Desalination Technologies Research Institute

PO Box 8328, Al Jubail 31951, KSA
Tel: (+966) 013-343-3477; Fax: (+966) 013-343-1615
E-Mail: rdc@swcc.gov.sa





CHARACTERIZATION AND EVALUATION

Surface water treatment - Storm water /dams

Case
Study 1

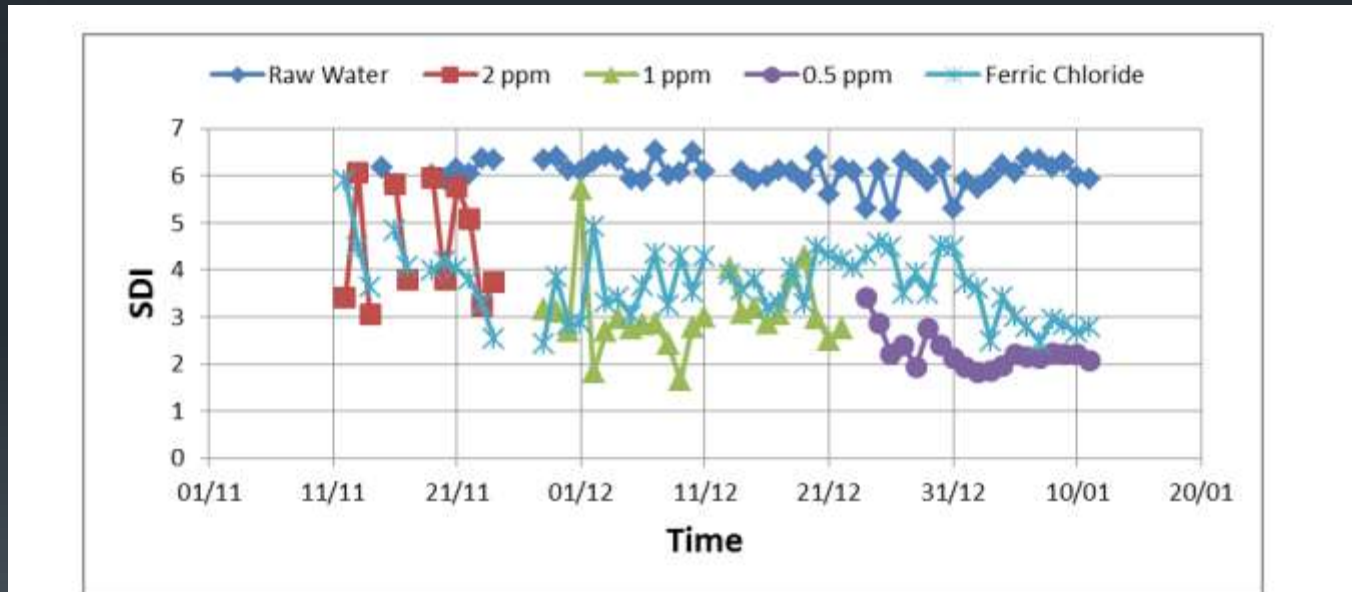
DHUBA
Desalination plant 5,000
m3/day

Case
Study 2

Alwejah
Desalination Plant
5,000 m3/day

Case
Study 3

AMLOJ
Desalination plant
5,000 m3/day



Performance comparison between PAC TPP-100 and ferric chloride



CHARACTERIZATION AND EVALUATION IN DESALINATION PRETREATMENT

Reduce
chemicals
loads

- **0.5 ppm of Al^{3+} concentration in the feed seawater has best performance. Mostly, it gave average SDI value about 2.2.**

• Aluminium
Residuals
almost Zero

- **Al^{3+} residual after filtration was lower than Fe^{3+} residual with averages of 0.027 and 0.052 respectively.**

Poly aluminum chloride applications STP'S AND IWTP'S





CHARACTERIZATION AND EVALUATION

Industrial waste water treatment

Case Study 1

Modon - Riyadh 2nd industrial City - Tawzea
Desalination plant 45,000 m³/day

Case Study 2

Modon – Damam 3rd
Industrial zone- Sudio-Kiko
25,000 m³/day

Case Study 3

MEPCO – Middle east Paper company - Jeddah IWTP
8,000 m³/day

Pollutant	Primary Clarifier	Splitter Box	Secondary Clarifier
pH	7-8.5	7.2-8.5	6-8.5
BOD5 (mgO ₂ l ⁻¹)	100	50	12.5
COD (mgO ₂ l ⁻¹)	1500 (1100)	900 (650)	34(49)
Turbidity (NTU)	None measured	None measured	None measured
TSS (mg l ⁻¹)	2000 (1800)	2700-4000	8(12)

TSS efficient Results and COD reductions



CHARACTERIZATION AND EVALUATION IN DESALINATION PRETREATMENT

Max coagulant
Concentration

- **18% Alum conc. Is more effective than 9% Aluminium sulfate max Liquid solution**

• Poly
coagulant
efficiency

- **Effective with TSS of chemicals and biological loads**



Case Studies- Egypt

- ☐ River Nile
- ☐ Swimming Pools
- ☐ Agricultural Waste Water
- ☐ SWRO Pre-treatment
- ☐ Industrial Waste Water



Comparative study between TPP -100 PAC 18% versus Alum

Coagulant	TPP-100 PAC 18%	Alum(liquid 50%)
Date	20/06/2022	
Sample type	Nile River “Giza Governorate “	
Initial Turbidity (NTU)	7.2	
Concentration (%)	0.5	1
Volume (ml)	0.5	2
Dose (ppm)	2.5	20
Ratio as Alum 50%	1	8
Final Turbidity (NTU)	2.28	2.71
Volume (ml)	0.6	3
Dose (ppm)	3	30
Ratio as Alum 50%	1	10
Final Turbidity (NTU)	2.07	1.66

The optimum dose of TPP-100 PAC 18% is 3 ppm whereas the optimum dose of Alum is 30 ppm.

The best ratio between TPP-100 PAC 18% and Alum (50%) is 1:9



Comparative study between TPP -100 PAC 18% versus Alum

Coagulant	TPP-100 PAC 18%	Alum(liquid 50%)
Date	15/07/2022	
Sample type	Swimming pool	
Initial Turbidity (NTU)	8	
Concentration (%)	0.5	1
Volume (ml)	0.2	1
Dose (ppm)	1	10
Ratio as Alum 50%	1	10
Final Turbidity (NTU)	1.75	1.97



Comparative study between TPP -100 PAC 18% versus Alum

Coagulant	TPP-100 PAC 18%	Alum(liquid 50%)
Date	08/02/2022	
Sample type	Agricultural wastewater	
Initial Turbidity (NTU)	35.6	
Concentration (%)	0.5	1
Volume (ml)	1	2
Dose (ppm)	5	20
Ratio as Alum 50%	1	4
Final Turbidity (NTU)	1.71	1.65



Comparative study between TPP -100 PAC 18% versus Alum

Coagulant	TPP-100 PAC 18%	Alum(liquid 50%)
Date	12/01/2022	
Sample type	Sewage wastewater	
Initial Turbidity (NTU)	210	
Concentration (%)	0.5	1
Volume (ml)	5	25
Dose (ppm)	25	250
Ratio as Alum 50%	1	10
Final Turbidity (NTU)	2.02	1.99



Comparative study between TPP -100 PAC 18% versus Alum

Coagulant	TPP-100 PAC 18%	Alum(liquid 50%)
Date	05/07/2022	
Sample type	Sea water	
Initial Turbidity (NTU)	3.3	
Concentration (%)	0.5	1
Volume (ml)	0.1	1
Dose (ppm)	1	10
Ratio as Alum 50%	1	10
Final Turbidity (NTU)	1.3	1.01



Comparative study between TPP -100 PAC 18% versus Alum

Coagulant	TPP-100 PAC 18%	Alum(liquid 50%)
Date	15/03/2022	
Sample type	Industrial wastewater (Textile factory)	
Initial Turbidity (NTU)	250	
Concentration (%)	100	50
Volume (ml)	0.120	2ml
Dose (ppm)	120	1000
Ratio as Alum 50%	1	8
Final Turbidity (NTU)	1.5	1.74



<http://www.tpfindustry.com/>

Reach us at:

Amr_shalaby@tayseerint.com
amr4shalaby@gmail.com

+20 1228974311