POTABLE WATER COAGULANT TRIALS UTILIZING POLYALUMINIUM CHLORHYDRATE

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ABSTRACT

This paper describes the trial and subsequent introduction of Polyaluminum Chlorhydrate as a replacement primary coagulant for liquid Alum Sulphate in the potable water treatment process at the Glenmore Water Treatment Plant.

Glenmore Water Treatment Plant is managed and operated by the Rockhampton Regional Council Water Group, which is located in Rockhampton on the Tropic of Capricorn in Central Queensland Australia.

1.0 INTRODUCTION

Raw Water for the Glenmore Water Treatment Pant is sourced from the Fitzroy River, which has a catchment size greater than twice the area of Tasmania and comprising some 4,880 kilometres of waterways.

The Fitzroy River Barrage was commissioned in 1970 to provide a freshwater storage for Rockhampton.

The Barrage separates the downstream saltwater from the freshwater. The freshwater behind the Barrage is treated at the Glenmore Water Treatment Plant to make it suitable for drinking. The untreated water enters the system through an intake structure four kilometres upstream from the Barrage.

Its openings are covered with mesh screens to keep debris from being drawn in. The water is then gravity fed to a pump station and pumped into the Treatment Plant where a number of treatment processes are involved including Coagulation, Flocculation, Sedimentation, Activated Carbon Treatment (when required), Filtration, pH Correction and Disinfection.

The Plant treats on average 50-55 ML/day and is hydraulically capable of 140 ML/day.

Table 1: ***Typical Raw Water Analysis***

Parameter	Range
pH	6.8-7.4
Alkalinity - mg/L	20-190
Total Hardness - mg/L as CaCO3	20-240
True Color - Hazen Units	<5 - >70
Turbidity - NTU	20-5000

2.0 DISCUSSION

Typically in the past Rockhampton Regional Council has utilised Aluminium Sulphate as the primary coagulant in the potable water treatment process at Glenmore Water

Treatment Plant, Rockhampton.
In November 2002 Fitzroy River Water (a commercial business unit of the then Rockhampton City Council) investigated the use of an alternate primary coagulant called Polyaluminium Chlorhydrate to Aluminium Sulphate in the potable water treatment process with properties that would allow better performance when raw water conditions created the problem of post flocculation (aluminium hydroxide precipitation – exhibited by white cloudiness in the treated water).

Post-flocculation occurred in 2002 when low alkaline raw water with high turbidity needed to be treated. To overcome this problem Fitzroy River Water initially budgeted $50,000 for a lime pre-dosing unit.

This was untried technology with these waters and previous trials at Glenmore Water Treatment Plant had not seen success. Consequently, an alternate approach was considered.

Poly aluminium chloride has been approved for use in potable water treatment for many years and has been investigated in the past but never utilised due to the overall additional costs.

Poly aluminium chloride is an inorganic coagulant (as is aluminium sulphate) that enables removal of turbidity, colour and taste in various water treatment plants, without significantly lowering pH.

While aluminium sulphate does the same job, unfortunately it reduces the pH of the water at a much faster rate, which can eventually lead to post flocculation problems. As a consequence, Poly aluminium chloride can deal with high turbidity/low alkalinity conditions with little likelihood of post flocculation.

The results of the November 2002 trial are indicated the Table 2 below.

Table 2: ***Glenmore Water Treatment Plant Coagulant Trial Results***

Glenmore Water Treatment Plant Coagulant Trial – 12 to 15 November 2002-11-26 (Optimum dosage rates) #									
Chemical	GWTP Consumption ML/day	Coagulant Dose mg/l	Lime Dose mg/l	Polymer Dose mg/l	Coag kgs 'as delivered product'	Coag Cost	Lime Cost	Poly Cost	**Total Cost/ML**
Alum Sulphate	111	52	26	0.12	12280	$1,541	$511	$81.25	**$19.22**
Poly aluminium chloride - PAC	111	20	6	0.24	2220	$2,442	$118	$162.50	**$24.53**

*Costs are GST exclusive
#Turbidity ~170 NTU

Poly aluminium chloride enabled complete replacement of aluminium sulphate and the removal of 77% of post dosed hydrated lime. It was found that the polymer dose needed to be doubled to achieve optimum operating conditions for flocculation. The cost increase for the substitution of aluminium sulphate with poly aluminium chloride was in the order

of $5.31 per ML.
In the shorter term it was proposed to purchase Polyaluminium Chlorhydrate when needed in 1,000 litre returnable bulky boxes and associated metering pumps to treat low alkaline high turbidity water, which occurred for up to approximately 1 month each year. At the time the product was not intended to replace the existing coagulant due to the additional cost. It was anticipated that the additional annual budget impost would be in the order of $10,000.

The trial indicated that the use of Polyaluminium Chlorhydrate would be an appropriate chemical for the replacement of Aluminium Sulphate for the treatment of low alkaline waters needing a high coagulant dose.

Further test work involving Polyaluminium Chlorhydrate as a primary potable water coagulant was performed in February 2003 and the results are given in Table 3.

Table 3: ***Glenmore WTP Polyaluminium Chlorhydrate Trial Results***

Glenmore Water Treatment Plant PAC Usage – 1400 Wed 12/02/03 to 1300 Thu 21/02/03					
Chemical	**Total ML Treated**	**Coagulant Dose Mg/L**	**Lime Dose Mg/L**	**Polymer Dose Mg/L**	**Total Cost**
PAC	480	40	12	0.31	
		$21,120	$1021	$908	$23,048
Alum	480	200	73	0.12	
		$12,048	$6,209	$351	$18,609
	PAC	**Alum**	**Lime**	**Polymer**	
Cost per tonne	$1,100	$126	$177	$6,100	
Cost difference	$4,439.61	(PAC treatment additional cost)			
Pre-Dosing Facility Annualised Costs					
Capital cost	$6,587.68		Capital	Interest	Years
Maintenance	$1,000.00		-$60,000	7%	15
TOTAL	$7,587.68				
Net Cost Difference	**$3,148.07**	**(PAC treatment saving)**			

Turbidity Range: 284-727 NTU

While the installation of a pre-dosing facility was previously budgeted to cover the worst-case scenario, this project was in the investigative stage. Any permanent pre-dosing facility would have required extensive lab work with different types of raw water to prove its success as the installation of a facility would have required significant work to be carried out on the raw water delivery pipe upstream of the Treatment Plant and would have likely added to raw water pumping costs.

It was clearly known how much pre-dosed alkalinity could be needed but the concern was that previous experience indicated that such dosing would not work with the Glenmore Plant configuration (lime dose to close to flash mixer).

The cost of the usual types of pre-dose facility was approximately known so such an amount was allocated while investigations continued into Polyaluminum Chlorhydrate as an alternate primary coagulant.

The cost of pre-dosing calcium hydroxide during the February 2003 event would have been in the order of $2,800. The net cost of using Polyaluminum Chlorhydrate was in the order of $4,440. However the Capital and Operating costs of a pre-dosing facility needed to be considered.

The annual costs of such a facility whether used or not was in the order of $7,600. Providing there was only one such event for the year, which would generally be correct, the cost of Polyaluminium Chlorhydrate usage was lower and in this instance by $3,150.

As a consequence of this a Tender for the Supply and Delivery of Poly Aluminium Chlorhydrate for two years were invited in November 2003. Polyaluminum Chlorhydrate was only to be used as a substitute for Aluminium Sulphate at times when Aluminium Sulphate cannot perform appropriately due to the prevailing raw water conditions including high turbidity and low alkalinity.

Towards the end of this two year tender period it was identified that the existing primary coagulant dosing pumps were at times working outside their efficiency curves which was leading to less than optimal dosing.

In December 2005 the existing primary coagulant dosing pumps were replaced with new pumps, which provided finer and more accurate pumping control particularly in the lower dose ranges of less than 30mg/l.

Dose Rates and associated Costs are provided in Table 4 & Table 5 respectively.

Table 4: ***Dose Rates***

Chemical	Date	Total ML	Mega Pac Dose mg/L	Alum Sulphate Dose mg/L	Lime Pre Dose mg/L	Post Lime Dose Mg/L	Polymer Dose mg/L	Chlorine Dose Mg/L
Mega Pac 23	14/4/06 to 20/6/06	3378.17	37	Nil	Nil	10	0.2	0.9
Alum/Lime Pre Dose	14/4/06 to 20/6/06	3378.17	Nil	230	12	38	0.4	1.2

Table 5: ***Costs***

Cost Mega Pac 23	Alum Cost	Lime Pre Dose Cost	Post Lime Dose Cost	Polymer Cost	Chlorine Cost	Total Cost	Cost Diff Total	Cost/ ML
$137,434	Nil	Nil	$6,452	$4,580	$5,475	$153,943	$22,794	$45.57
Nil	$127,696	$7,742	$24,518	$9,161	$7,618	$176,738		$52.32

Turbidity Range: 280-1000 NTU

With these pump changes a further extended trial of Polyaluminium Chlorhydrate at Glenmore Water Treatment Plant was conducted from 14 April 2006 to 20 June 2006 and cost savings were:

- $ 6.75 ML versus calculated Aluminium Sulphate with Lime Pre Dose; or
- $22,764 for the period.

This cost saving has not only been largely attributed to the use of Polyaluminium Chlorhydrate (versus Alum Sulphate with Lime Pre Dose) but also to the new primary coagulant dosing pumps.

In the past when Polyaluminim Chlorhydrate was dosed with the existing Alum Sulphate delivery pumps, dose rates (particularly less than 30 mg/l) were not accurate from a pumping perspective as this was outside the range of the existing pumping efficiency curves. Hence Polyaluminim Chlorhydrate consumption was higher than required.

The trial was further extended until October 2006. Polyaluminium Chlorhydrate was purchased on a 'spot basis' until May 2007 when tenders were invited for the Supply and Delivery of Poly Aluminium Chlorhydrate on a three-year basis with a two-year option to replace Aluminium Sulphate as the primary coagulant.

During the trial there was only a 0.1 - 0.3 reduction in the Raw Water pH.

Since May 2007 Polyaluminium Chlorhydrate has performed well with cost savings in the order of approximately $5/ML being achieved compared to an Alum Sulphate Lime pre dose combination when dosing high turbidity low alkaline raw water.

3.0 CONCLUSION

The benefits of Poly Aluminium Chlorhydrate versus Alum Sulphate with Lime Pre Dose as a primary coagulant for potable water treatment at Glenmore Water Treatment Plant are listed below:-

- Significant Reduction in Lime Consumption: greater than 80%. Polyaluminium Chlorhydrate has very little effect on raw water pH and consequently less lime is required for pH correction. This has led to savings in maintenance costs (eg. cleaning) due to far less deposits in the water distribution system including clear wells & potable water reservoirs.
- Eliminated need for existing Alum Sulphate Pumps and associated maintenance costs.
- Eliminated requirement for a Lime Pre Dose Facility
- Eliminated need for flushing of Alum Sulphate Suction Lines and as a result eliminates the impact of acidic material on the pH of the Glenmore Water Treatment Plant Sludge Lagoons.
- Eliminated need for Raw Water Inlet Chemical Dispenser Box Cleaning.
- No requirement for storage tank agitation of Polyaluminium Chlorhydrate compared to Alum Sulphate.
- Polyaluminium Chlorhydrate has nil solids content and hence less solids loading on existing Glenmore Water Treatment Plant Sludge Lagoons compared to

Bauxitic Grade Alum Sulphate (which has a specification of less than two (2) % insolubles).

- Polyaluminium Chlorhydrate is Sulphate free, which consequently leads to reduction in Sulphate levels in Sewer.
  When alum sulphate is used as a primary coagulant the water entering the sewer system is higher in Sulphates, which contributes to odour problems in drains, pumping stations and sewerage plants. Usage of Polyaluminium Chlorhydrate reduces this contribution to odour generation.
- Higher Content of Active Ingredient
  Polyaluminium Chlorhydrate contains an aluminium content equivalent to 23.5% as Al_20_3. This is 3 times higher than Alum Sulphate thereby requiring as an absolute minimum 1/3 the storage capacity.
- Increase Glenmore Water Treatment Plant Chemical Storage Capacity: Increase of current Polyaluminium Chlorhydrate storage capacity (approx 24 kilolitres) by utilising existing three (3) @ 37 kilolitre Alum Sulphate Storage tanks to make a total storage of approx 135 kilolitres, hence can accept chemical deliveries in B Doubles and so reduce freight costs.

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5.0 REFERENCES

Rockhampton City Council Report - November 2002 - Water Treatment Plant Alternate Coagulant.

Alchlor Trial Report November 2002 - Mike Owens - Hardman Chemicals

Rockhampton City Council Report - February 2003 - Use of Polyaluminium Chloride

Rockhampton City Council Report April 2003 - Use of Polyaluminium Chloride

Using Polyaluminium Coagulants in Water Treatment - Peter Geebie