Technical Note 20

Coagulation Control Using Streaming Current Monitoring in a 'Flashy River'

Introduction

Streaming current based coagulation control systems are often used to control coagulation where the raw water source is a 'flashy river' and where a rainfall event can result in large changes in coagulant dose in order to accommodate the rapidly changing nature of the raw water. Traditionally jar tests have struggled to keep up with the rapidly changing raw water leaving the operator and the plant never quite 'right' during the event particularly on smaller unmanned sites. Using a feedback control such as streaming current can greatly enhance the coagulation on site. This technical note aims to explain some common observations and their causes.

What is happening to the raw water during rainfall events?

The obvious answer is that it is getting more turbid and the coagulant dose has to go up to deal with the higher turbidity. But that's not all, depending on the nature of the river the pH will change, temperature can change, the level of dissolved organics and alkalinity can change, and all of these have an effect on coagulation, some seen (like turbidity) and some not (like pH and dissolved organics).

How do these factors affect coagulation?

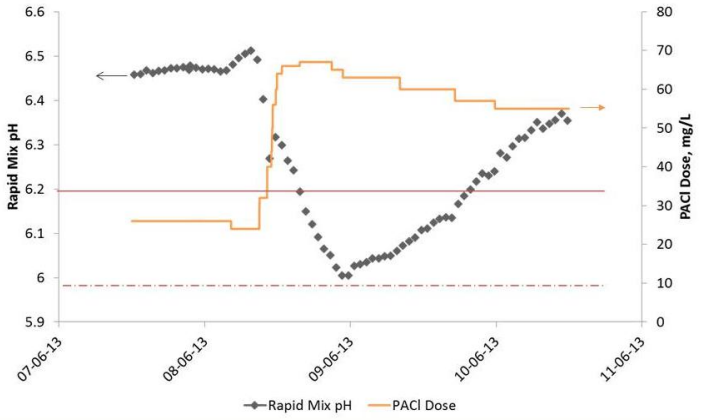
- ***Changing pH and temperature*** - the pH and temperature can increase or decrease during a rainfall event depending on the raw water source and this can either increase the efficiency or decrease the efficiency of the coagulation, by affecting the coagulant hydrolysis reaction and therefore the amount of charge available. Changes to pH can last much longer than changes to turbidity or organics.

- ***Changing alkalinity*** - during rainfall events the alkalinity can change up or down which doesn't have too much of an effect on coagulation unless the post-coagulation alkalinity drops too low and then it is possible for a rainfall event to mean that there isn't enough alkalinity for the hydrolysis reactions of the coagulant to take place and that can leave a serious problem for coagulation control which can only be rectified by adding alkalinity - typically soda ash or lime - to the raw water.

- ***Changing dissolved organics*** - organics can also go up or down during a rainfall event but typically they go up. This is the 'unseen' demand on coagulant and many interesting effects have been seen with regards to dissolved organics, for example, it is not uncommon for a peak of organics or a 'front' to come down the river before the turbidity and even more common is for the organics to remain elevated after the turbidity has gone back to normal.

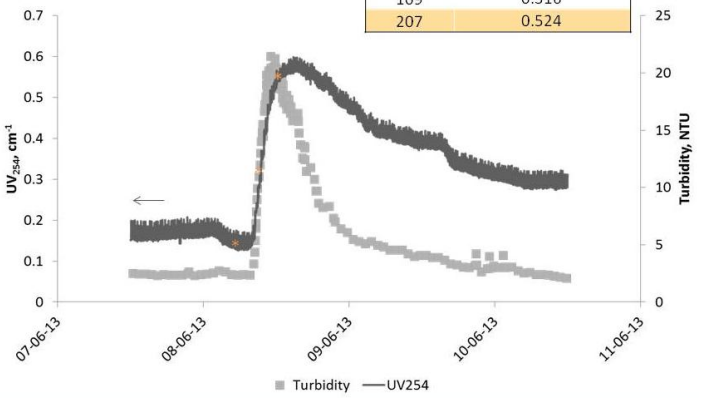
- ***Increasing turbidity*** - this will require an increase in coagulant. Turbidity is the visible raw water change during a rainfall event.

- pH > 6.0 during upset



- Raw water quality of rainfall event
- Raw Water UV_{254}: ~0.6 cm^{-1}
- Raw Water Turbidity: ~21 NTU

Color, TCU	Raw Water UV_{254}, cm^{-1}
84	0.158
109	0.316
207	0.524



McVicar, M. Atlantic Canada Water and Wastewater Association - 2013 Conference Presentation. *Using Advanced Online Instrumentation for Coagulation Process Optimization and Control* (Dalhousie University) <http://acwwa.ca/conferences/2013confpresentations/category/94-dalhousie-university-using-advanced-online-instrumentation-for-coagulation-process-optimization-and-control.html>

Why does my Streaming Current Monitor track up with the turbidity but not come down with it?

Often the turbidity is what we see when we refer to a 'rainfall event'. The rain washes particulate into the river and the increased volume stirs up the sediment and we get an increase in turbidity. The Streaming Current sees the increasing negative charge in the raw water and increases the coagulant dose appropriately. What we don't see is that the dissolved organics is also elevated and the pH is often changed. As the rain stops and the turbidity settles out we are left with clear raw water with elevated organics (which take much longer to 'settle out'). The Streaming Current Monitor still detects the elevated organics and is dosing to remove those. This is often interpreted as overdosing by operators. Also if there is significant change in pH after the rainfall event compared with prior to the event, the change in pH on the charge available from the coagulant can affect the coagulation.

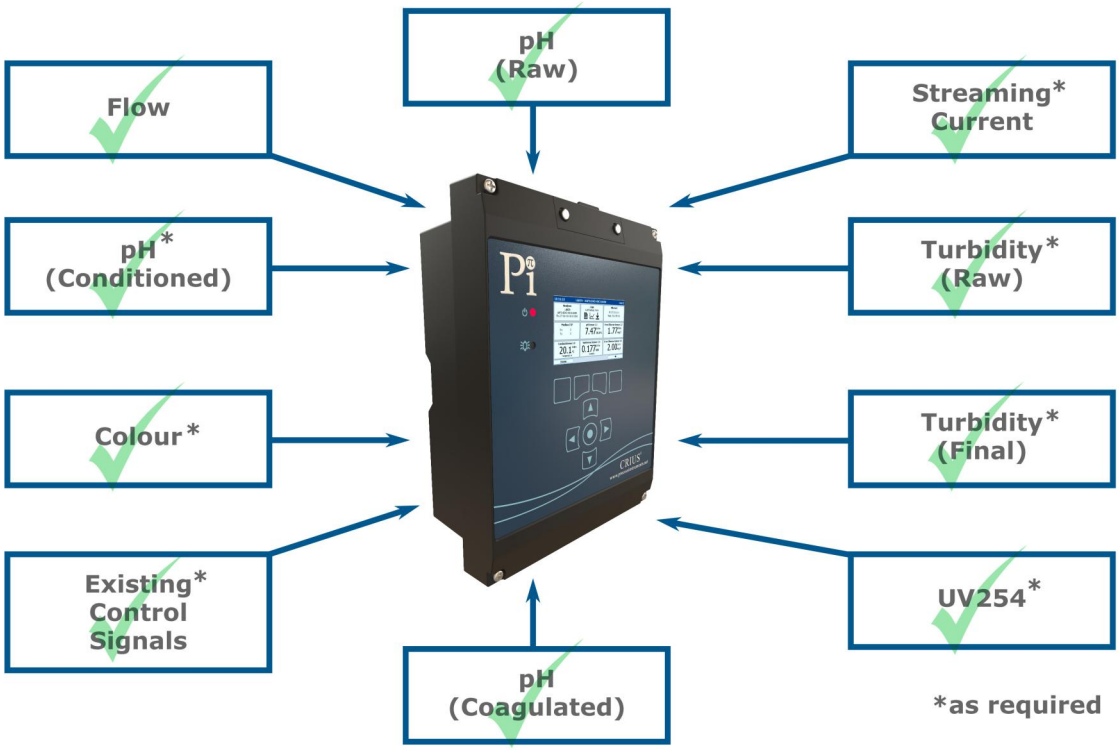
But the blanket is also indicating that we are overdosing.

That is perfectly possible. In the past plants were interested in removing particulate and now there is more emphasis on removing organics. The way a blanket 'looks' can be a leftover from those times, i.e. a blanket can look 'wrong' based on how it used to look when we were mainly interested in removing particulate. The blanket might actually be right for removing high organics with low turbidity. The only way to be certain is to check the coagulant dose with an offline SCM or to do a jar test. In the case of a jar test you would also need to do a UV254 analysis to ensure that you are optimising for organics removal, as well as turbidity removal. It may be possible to get good turbidity removal and good flocs at a lower dosage (and the blanket looks good) but with your organics going straight through, with the consequent dangers of THM formation. In order to remove the organics it may be that a higher coagulant dose is required and the blanket and flocs may well look poor. Due to the effect of changing pH on the effectiveness of the coagulant there is also a consequent effect of pH on the blanket and floc formation. The less the pH varies, the less the blanket and floc will vary.

The Streaming Current Monitor seems to be very sensitive to changes in pH, is that right?

No. The Streaming Current Monitor is sensitive to the residual charge and that is what is sensitive to changing pH. The Streaming Current is doing it's job well when it sees changes in pH.

During coagulation there are a number of key variables that affect the process largely due to their effect on the hydrolysis reactions that produce the positive charge in the water that leads to the process of charge neutralisation and effective coagulation. These include; pH, temperature, alkalinity and coagulant. In an ideal world all of these variables would be controlled to give the plant optimum conditions for coagulation. Sometimes this isn't possible and a plant will 'manage' or 'live with' difficult variable water. Sometimes changing something (like the coagulant) can bring a plant into a controllable condition. One example might be changing from Alum to PAC if the plant suffers from variable pH in the coagulated water.



If a plant notices that the Streaming Current is going up and down with pH what they are seeing is that the charge produced by adding the coagulant is being affected by pH changes in the raw water and this would signal that further investigation might be needed to improve coagulation performance. Two things that might be considered are a change in coagulant and/or the introduction of pH control.

Can Streaming Current Monitor manage all eventualities?

No. Neither can any automatic coagulation control system. Some plants and some raw water conditions are so extreme that the only sensible option is to turn the plant off and wait for the raw water quality to return. Luckily these plants are few and far between. In other plants it may be necessary to change the coagulant or control the pH in order to improve control and coagulation.

Can UV254 feed forward coagulation control manage all eventualities?

No. For UV254 to provide effective control the majority of the coagulant demand has to be from Natural Organic Material which absorbs UV254 so that a linear relationship between UV254 and coagulant demand can be developed. Also if the turbidity is high, even with Pi's inbuilt turbidity compensation the absorption/attenuation by turbidity masks the absorption by organics in the analyser used for control, so at extremely high turbidity spikes, the UV254 correlation breaks down. UV254 is an extremely effective tool in feed forward control of coagulation but it relies on the quality of the correlation between 'ideal' coagulant dose and UV254 absorbance. Any factors that could affect the ideal dose but don't get picked up by UV254 such as changes in the make up of the dissolved organics or some industrial effluents will adversely affect how well UV254 on its own can control coagulation.

Is Streaming Current technology always the best to control coagulation?

No. There are many factors to take into consideration before choosing how to configure your coagulation control system. Raw water temperature, pH, alkalinity, turbidity, dissolved organics, coagulant type, inlet design and operation, post coagulant pH etc. The key to a successful implementation of coagulation control is to understand the process and to choose the control parameter(s) and the coagulant to suit the plant.

Generally though, in a 'Flashy River' source Streaming Current technology does give reliable coagulation control.

Water treatment site

Conclusion

What is the best way to control coagulation then?

The CoagSense from Pi allows the water engineer (and us) to choose to measure and control on all or any of the most critical parameters that affect a particular water treatment plant and therefore create an affordable and effective solution to your coagulation control requirements. For more information please go to www.processinstruments.co.uk/products/coagulation-controller or contact us on + (44) 1282 422835 to speak to one of our team of application specialists.