Monitoring Performance of a Water Treatment System – Fish Tank.

This document is one part of several documents describing how a disturbance in one device can negativly influence other devices on a RAS-farm.

What you will learn in this document:

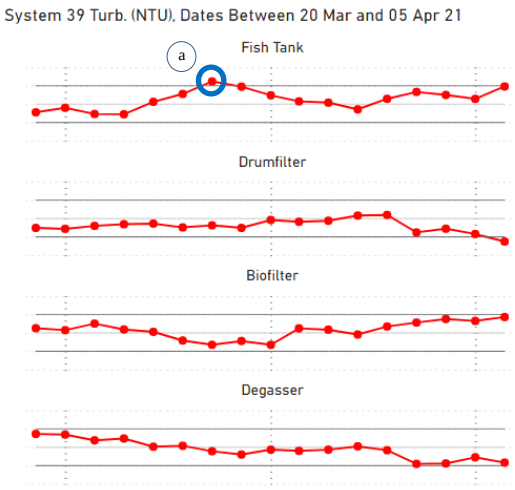
- See fish tank performance get damaged and see how this negatively impacts the performance of the water treatment system.

Fish Tank Monitoring

A diagram called a Perform-o-Gram, can simply show how turbidity is shifting around a RAS farm.

The Perform-o-Gram redline for the fish tank crosses the upper outer limit at point (a) below, giving a performance alert. The software tooltip explains that the amount of turbidity that has passed through the fish tank on this day is significantly different from the previous days. An auto-generated description explains how the fish tank had been performing earlier (b) and suggests potential causes for the process change (c).

Following the alert, the operator can access more detailed software tools to understand the cause for the change. In this case "candle charts" clearly indicated that a change in feed type and feeding regime were responsible for poorer tank self-cleaning up to and after the alert date (see "Turbidity Whitepaper" for more explanation).



System 39 Gradients, Dates Between 26 Mar and 26 Mar 21

Date	Description	Cause for Process Change
26-Mar-21		
Fish Tank		
Turb.	Turbidity had been increasing across Fish Tank but now spiking upwards	Sudden turb. release- flow change, over feeding
	b	c

But how did poorer self-cleaning by the fish tanks impact the rest of the RAS farm? A mass balance that determines how much turbidity was shifted by each device per day, clearly indicates the effect.

The top graph of the below figure A shows the turbidity timeseries for the RAS farm. In period (1) a stable turbidity level persisted, until the grey bar (fish tank performance alert). Thereafter turbidity rapidly increased - period (2).

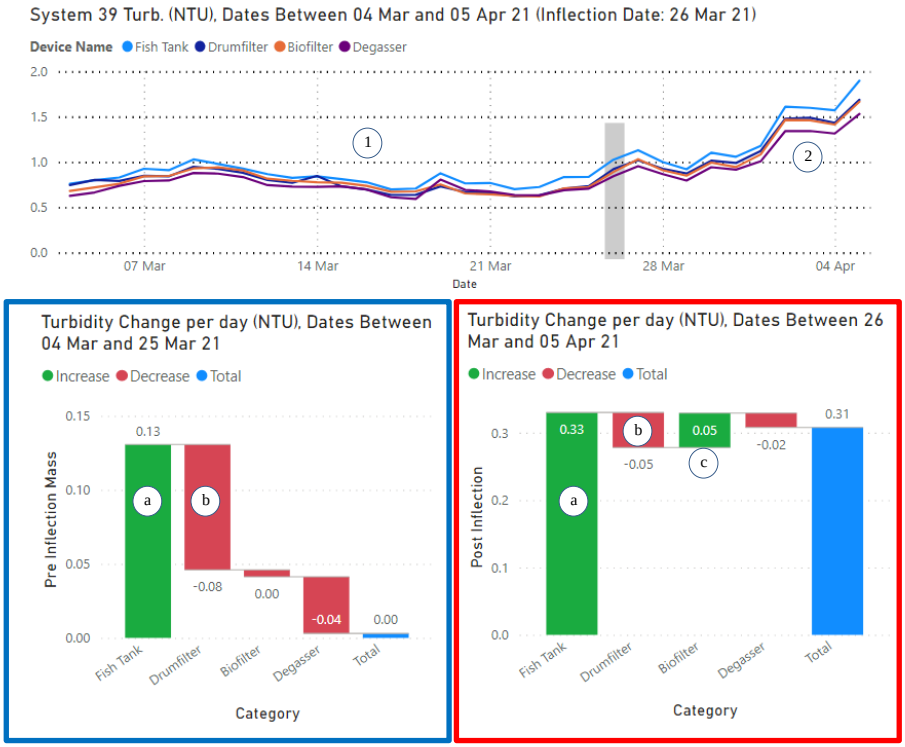


Figure A.

The bottom graphs showing mass balance for the days before, blue box, and the says after, red box. In the period before the alert, blue box, the turbidity was 0.13 NTU passing across the fish tank. In the period after the alert, red box, the turbidity was 0.33 NTU. This is more than twice the previous level.

Mass balance shows that drumfilter performance also reduced from removing -0.08 NTUs before, to removing -0.05 NTUs after (b). The biofilter also began to lose particles following the change in fish tank performance (c).

From the overall pattern, the change in fish tank performance meant particles stayed longer within the fish tank, creating additional fine colloids that pass more readily through the water treatment devices, contributing to a general increase in system turbidity.

Monitoring Performance of a Water Treatment System – Drumfilter.

This document is one part of several documents describing how a disturbance in one device, can negatively influence the other devices on a RAS-farm.

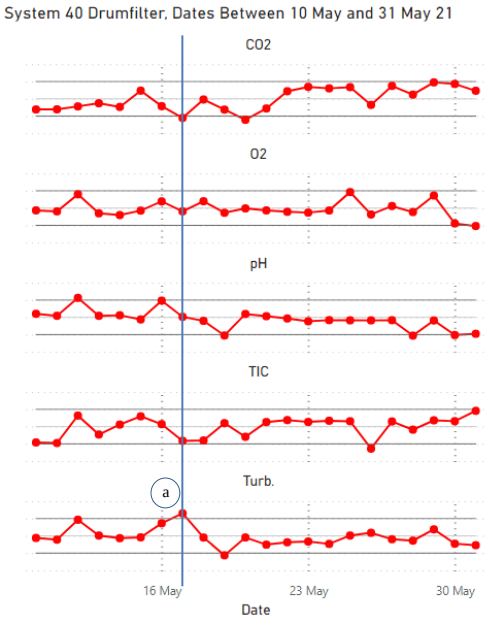
What you will learn in this document:

- See how excessive turbulence damaged drumfilter performance.

Drumfilter Monitoring

The Perform-o-Gram can also be focused upon a single device, monitoring multiple parameters. For example, a drumfilter Perform-o-Gram below.

The redline crosses the top outer limit for turbidity at point (a), giving a performance alert. The software tooltip explains that although the drumfilter has removed turbidity on the past days, but on this day the turbidity is increasing across the drumfilter. The software tooltip explains that the amount of turbidity that has passed through the drumfilter on this day is significantly different from the previous days. An auto-generated description explains how the drumfilter had been performing earlier (b) and suggests potential causes for the process change (c).



System 40 Gradients, Dates Between 17 May and 17 May 21

Date	Description	Cause for Process Change
17-May-21		
Drumfilter		
Turb.	Turbidity had been decreasing across Drumfilter but now spiking upwards	Drum not working, overflow/bypass, particles broken
CO2	Carbon Dioxide had been decreasing across Drumfilter but now spiking downwards	Flow increased, greater turbulence, pH increase

b c

At in depth analysis at a customer, it was discovered there was a lift pump breakdown starting on the date of the drumfilter performance alert. This meant a 25% drop in system flow for some days, with interesting results for drumfilter performance.

Normalizing gradient data means that parameters of very different scales (eg: NTU vs. %) can be directly compared to each other on a 0-1 scale (Figure B).

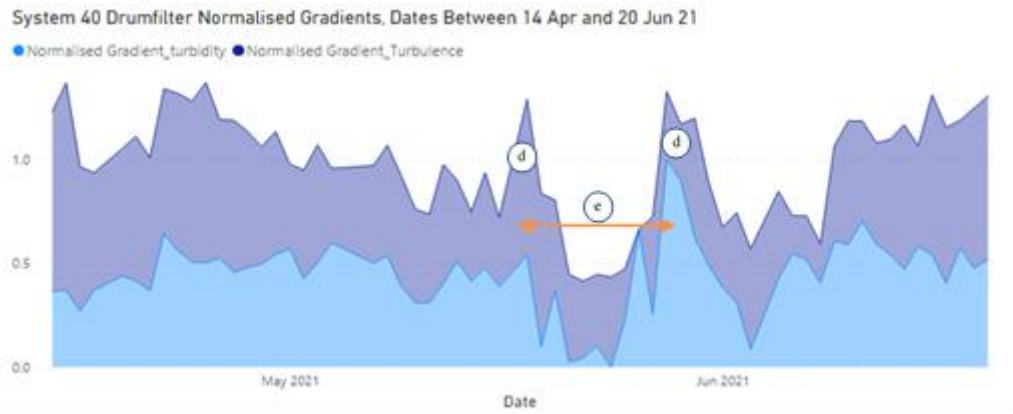


Figure B shows a graph of normalized turbidity removal vs. normalized Turbulence across a drumfilter. The larger the number, the worse is the removal of turbidity and increased water turbulence. The smaller the number the better the removal of turbidity and less turbulence. Curves are stacked to better see the relationship.

The pump breakdown resulted in large spikes for both the normalized turbidity and turbulence curves (d). The change in flow resulted in sudden turbulence shifts across the drumfilter. It increased air entrainment and reduced the amount of turbidity being removed.

By contrast, the period where the drumfilter had reduced flow saw both the normalized curves for turbidity and turbulence drop to their lowest for the period (e). These dips indicate a period of reduced turbulence and maximized drumfilter particle removal. The Customer was then able to infer that at maximum system flow, there was too much turbulence and particle breakdown causing poorer drumfilter performance.

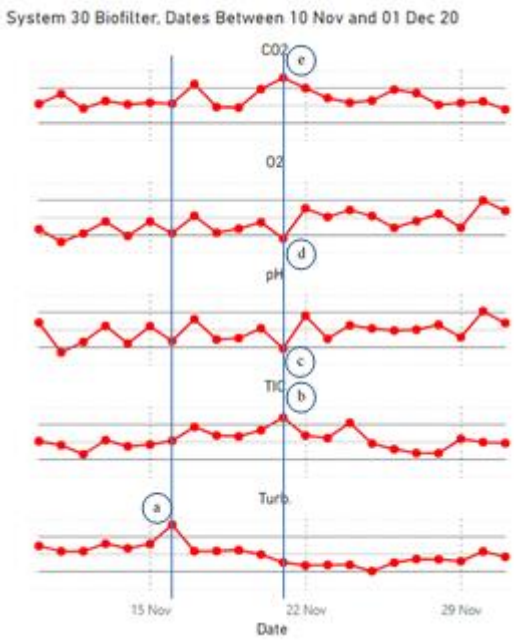
Monitoring Performance of a Water Treatment System – Biofilter.

This document is one part of several documents describing how a disturbance in one device, can negatively influence the other devices on a RAS-farm.

What you will learn in this document:
- See a biofilter go from healthy to unhealthy.

Biofilter Monitoring

The biofilter is complex with heterotrophic, nitrifying, denitrifying, sulphate reducing and other bacteria, all influencing the water. Monitoring the water quality gradient across a biofilter is essential to get an indication of the dominating bacterial processes occurring within. By measuring many biofilters, Blue Unit has developed KPIs that help recognize whether a biofilter is healthy or unhealthy.



System 30 Gradients, Dates Between 16 Nov and 21 Nov 20

Date	Description	Cause for Process Change
16-Nov-20		
Biofilter		
Turb. (a)	Turbidity had been decreasing across Biofilter but now spiking upwards	Biofilter trapping less, change in aeration/turbulence, increased salinity
21-Nov-20		
Biofilter		
TIC (b)	Total Inorganic Carbon had been decreasing across Biofilter but now spiking upwards	Damaged nitrification, reduced aeration
pH (c)	pH had been decreasing across Biofilter but now spiking downwards	Increased heterotrophic activity, sulfide release
O2 (d)	Oxygen had been decreasing across Biofilter but now spiking downwards	Increased heterotrophic activity, sulfide release
CO2 (e)	Carbon Dioxide had been decreasing across Biofilter but now spiking upwards	Sudden increase in solids capture

Figure C

A focused Perform-o-Gram, figure C, monitoring multiple parameters across the biofilter can help indicate a shift from health to unhealthy. The redline crosses the top outer limit for turbidity at point (a) below, giving a performance alert. The software tooltip explains that while fine turbidity had previously been trapped inside the biofilter, on this day a significant shift had occurred with large amounts of fine colloids spewing into the rest of the system.

The Perform-o-Grams for the other parameters also began to send alerts a few days after this date.

5 days after the initial biofilter performance alert, alerts came for total inorganic carbon-TIC (b), pH (c), oxygen - O_2 (d) and carbon dioxide - CO_2 (e). Clearly the biofilter was experiencing a severe transition.

By applying a mass balance, figure D, for total inorganic carbon (TIC) we can clearly see the shift inside the biofilter. The top graph of the below figure D shows the TIC timeseries for the RAS farm. In period (1) a stable TIC level persisted, until the grey bar. Thereafter TIC rapidly increased - period (2).

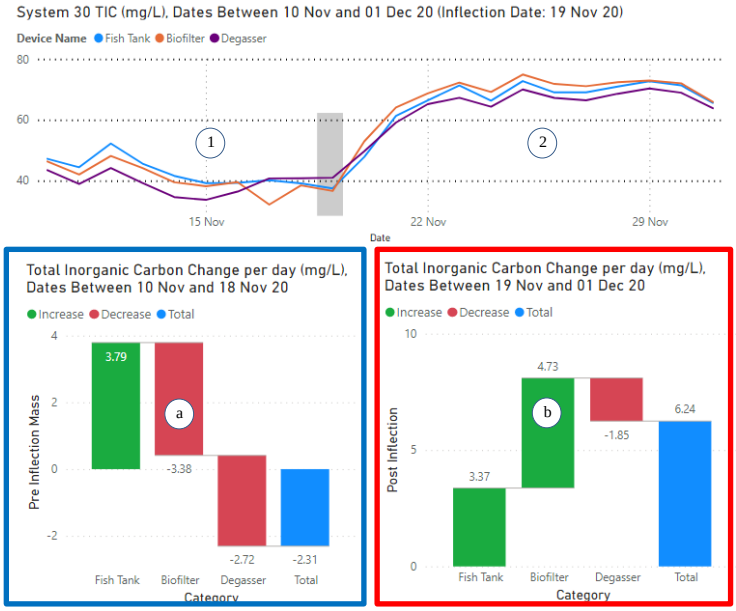


Figure D

The mass balance for the days before the performance alerts show a biofilter consuming -3.38 mg/L of TIC (blue box- a). This is normal for a healthy biofilter, where nitrifying bacteria consume CO_2 and bicarbonate. However, after the alerts, the biofilter suddenly began producing 4.73 mg/L of TIC (red box- b). This net increase in CO_2 production is indicative of a strong shift towards heterotrophic bacteria.

Analysis of other water quality parameters revealed that in period (2), fine turbidity again strongly accumulated inside the biofilter, and pH and oxygen dropped rapidly. All this indicates an unhealthy shift from nitrification to strongly heterotroph activity within the biofilter.

Monitoring Performance of a Water Treatment System – Degasser.

This document is one part of several documents describing how a disturbance in one device, can negatively influence the other devices on a RAS-farm.

What you will learn in this document:

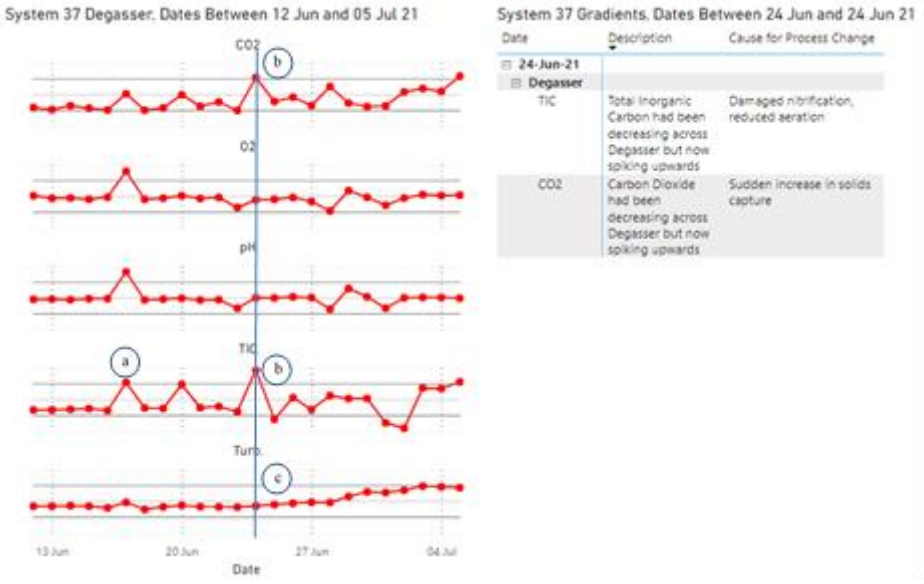
- See the connection between colloids and effectivity of a degasser to remove carbon dioxide.

Degasser Monitoring

The degasser is designed to strip out carbon dioxide (CO_2) from the water. However, a degasser with a large surface area can be affected by the same bacterial populations found inside the biofilter and the biofilter bacterial community can "grow out" across the degasser. By measuring many degassers, Blue Unit has developed KPIs that help recognize whether a degasser is healthy or unhealthy.

A focused Perform-o-Gram, figure E, monitoring multiple parameters across the degasser can help indicate a shift from health to poor health. The redline crosses the top outer limit for total inorganic carbon (TIC), firstly at (a) and then at (b) below, giving performance alerts. The software tooltip explains that while the degasser had previously been removing CO_2, on these days a significant shift had occurred meaning that CO_2 stopped being removed.

Figure E



At point (c), one can also see the turbidity Perform-o-Gram change trajectory. The software tooltip explains that before the performance alerts the degasser was mostly trapping fine particles. However, after the alerts and trajectory change, the degasser began to release fine particles.

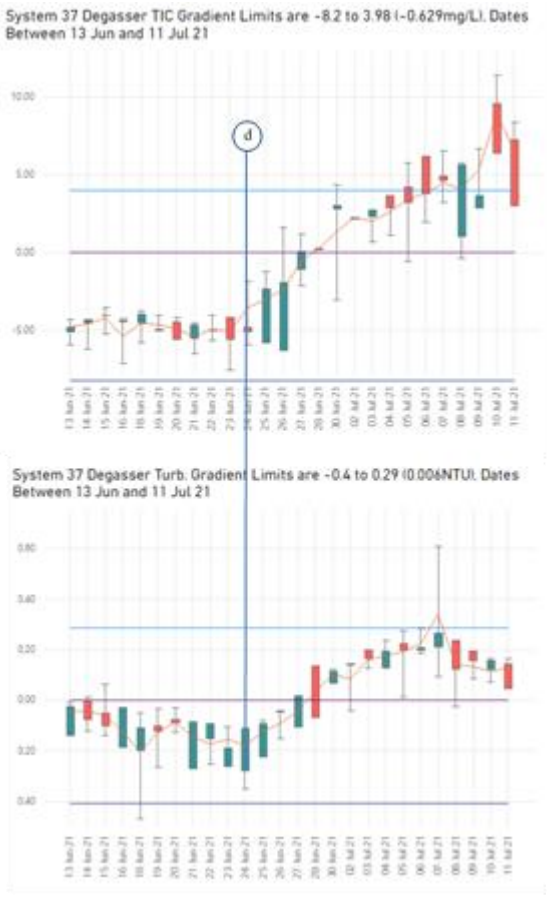


Figure F

The candle charts, figure F, illustrate the loss of degasser function with the shift in particles passing through the degasser. Line (d) is the day the Perform-o-Gram alerts began being generated. After these alerts, both degasser CO_2 stripping and turbidity trapping of fine particles both changed trajectory.