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Energy, nutrient and sludge reduction using BOC

Kinnegar, N. Ireland, September 2019

Highlights

- Total nitrogen removal increased by 6% and total phosphorus by 26% compared to benchmark
- 34% reduction in power required to remove BOD, from 55.2 kWh/tBOD to 36.6 kWh/tBOD
- Rapid recovery in biomass observed in SBR (sequencing bioreactor) by MLSS (mixed liquor suspended solids)
- Greater SBR settleability

Introduction

Wastewater treatment is becoming more and more critical to reducing effluent loads into natural water systems and securing clean, potable freshwater for the future. Population growth places demands on our natural resources, and as water is a vital resource it is essential to find innovative solutions to treat wastewater. The aim of innovations within the wastewater processing industry are to speed up the process, find cost-effective solutions and reduce the loadings in the shortest period.

This trial was to show the effect of adding a Bio-Organic Catalyst (BOC), a composition of concentrated small molecular proteins and a non-ionic surfactant, to the wastewater treatment process. BOC is an organic solution that can optimise the dissolved oxygen levels, reducing the energy required by the process, and can also biodegrade and solubilise organic contaminants. This would both reduce the petrochemical load of the process and reduce its economic cost and environmental impact.

Background

The test site is a municipal sewage treatment plant with an authorised 110,000 PE (population equivalent) capacity, treating up to 1250 m^3/hr of wastewater. The plant is run privately and monitored by the Water Authority. It runs at an efficient 0.15 kWh/m^3. Similar wastewater treatment plants in the same area run at over 1 kWh/m^3. Settled sludge is collected from the process and disposed of by incineration, and clean water discharge is into the local coastal sea.

The trial seeks to demonstrate the BOC effect on energy consumption measured as kWh/removal of BOD and reductions in sludge volume. Bio-organic catalysts (BOCs) are a group of chemicals made through biochemical processes, that provide numerous benefits to the aerobic and anaerobic biological processes used to convert organic waste loadings into high-quality discharges. BOCs can be applied system-wide to bring critical solutions to the fundamental challenges of wastewater treatment. For example, reducing odours, improving dissolved oxygen levels, reduction of organic loadings and biosolids, and improvements in discharges (figure 1).

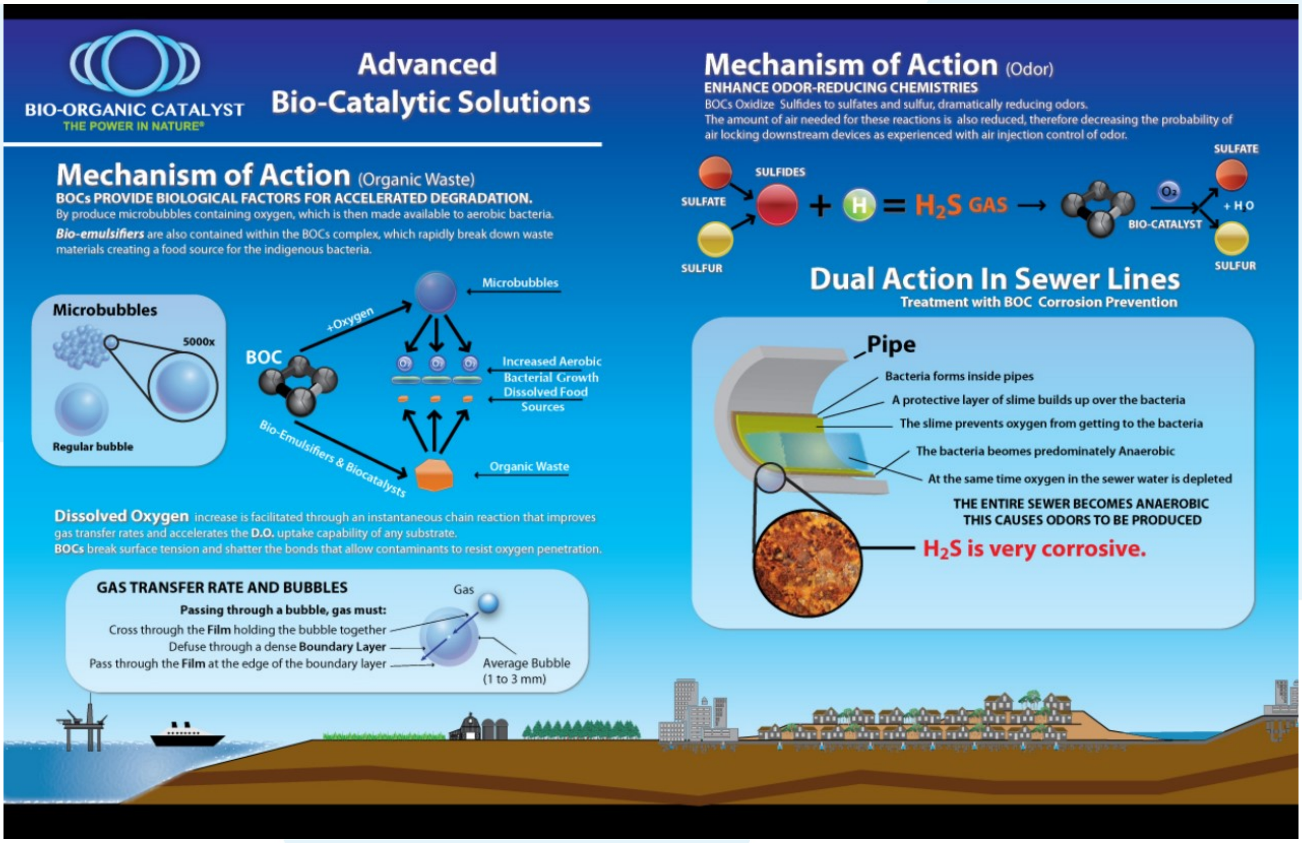

Figure 1: The mechanism of action of BOC additives in the wastewater treatment system.

BOC allows a higher conversion of organic wastes, reduce energy usage, and lower sludge volumes. BOC will therefore substantially expand a wastewater facility's total loading and capacity requirements. By significantly lowering the biosolids, reduced processing and dewatering requirements, as well as transportation costs for hauling away these biosolids to landfills. BOC is unique in the ability to provide substantial improvements in dissolved oxygen levels, while simultaneously reducing the energy requirements of the aeration systems; this is both economically compelling, as well as critically important when the wastewater system is attempting to treat heavy organic loadings than the designed system.

Method

A dosing system was connected from a one cubic metre (IBC) of BOC to the inter-stage pumps prior to the pump outlet. Dosing was set initially at 2 mg/L/100BOD then reduced to 1mg/L/100BOD. Dosing started on the 28th February and continued for four weeks. In the second and third weeks, there was an increased flow to the plant, which reduced the desired dose and normalised in the later part of the trial. A second IBC was installed on the 22nd March (figure 2).

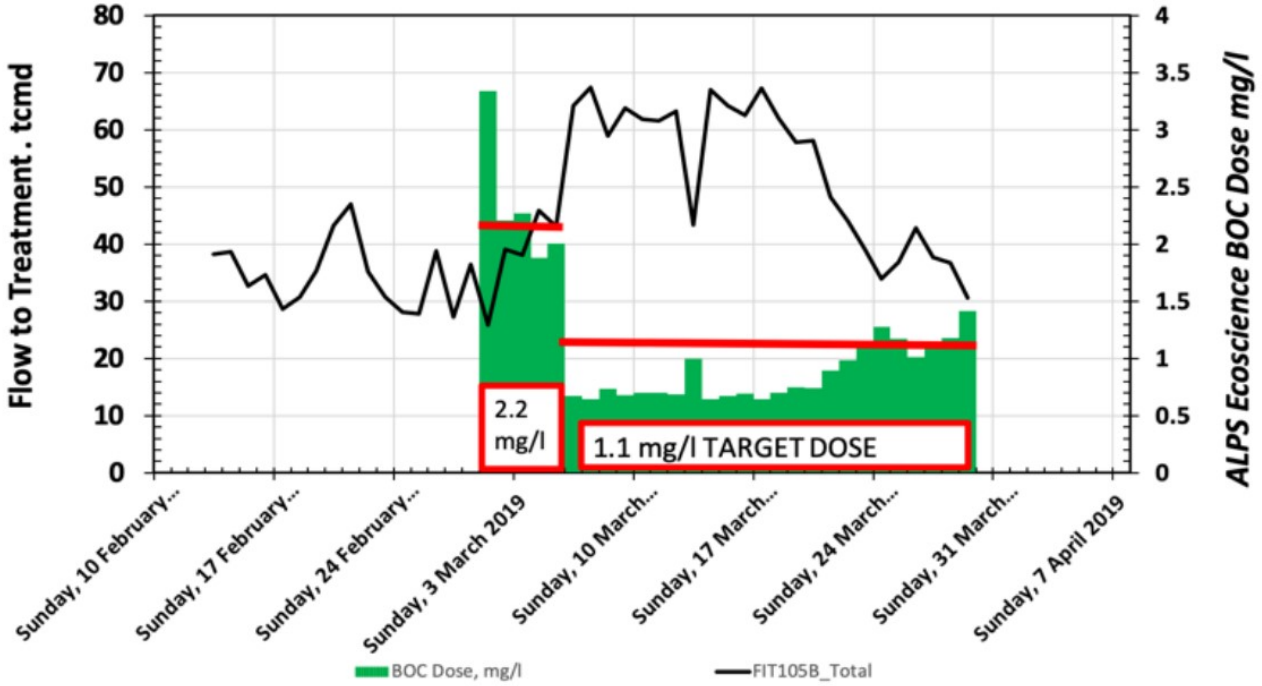

Figure 2: Input flow (in t cubic metres per day) and quantity of BOC dosing (mg/L) into the wastewater treatment plant through the period of study.

On the graph, the actual and desired BOC dosing rates are shown by a red line. The dosing rate was determined through previous analysis of the feedstock.

Results

The loadings to the plant immediately dropped on the commencement of BOC dosing. The average pre-trial BOD averaged 130mg/l (from January until March) and this reduced to an average of 83.7mg/l in the trial period with a low of 28.5mg/l. This constitutes an average of 35% lower BOD (figure 3).

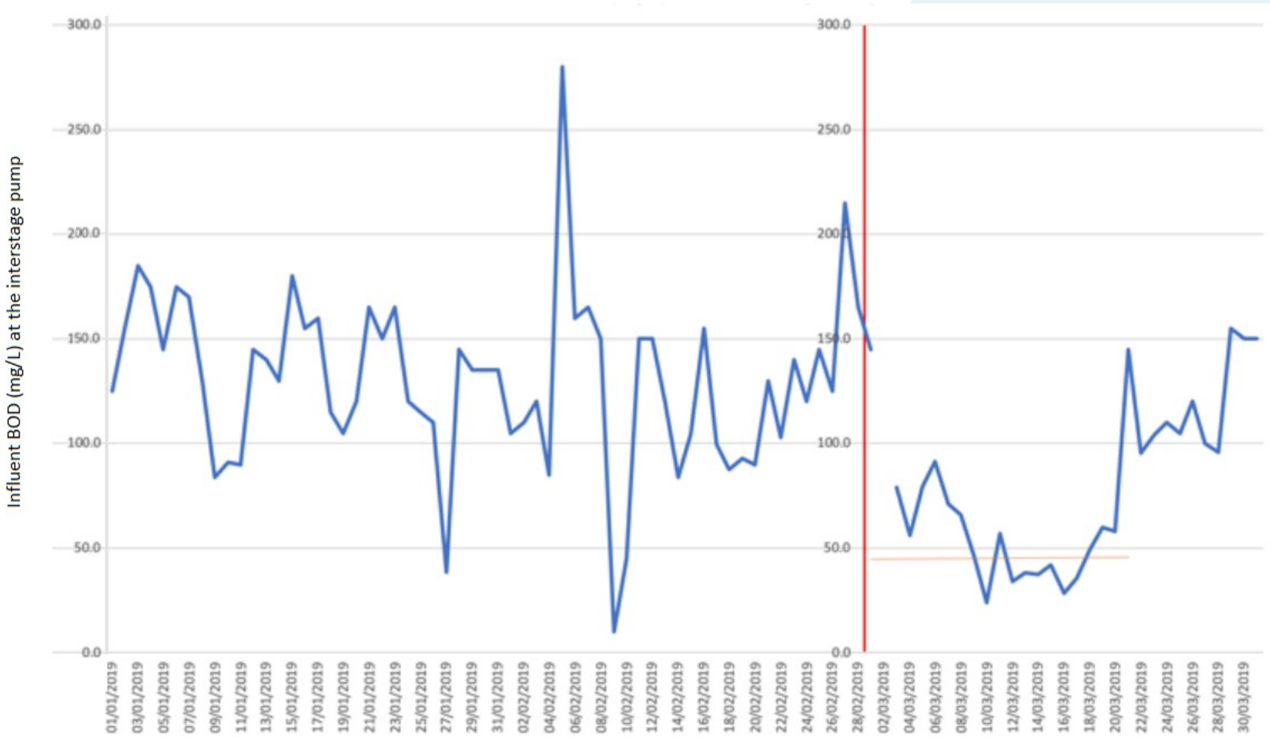

Figure 3: Biological oxygen deman (in mg/L) of the influent wastewater to the plant after the dosing point, before and during the study period. The commencement of BOC dosing is indicated by a vertical red line.

The drop in wastewater BOD was mirrored by other measured system parameters (figure 4).

	STATS - COMPARISON OF MASS REMOVAL MAIN PARAMETERS						
29/03/2019	**Ammonia mg/l as N**	**Biochemical Oxygen Demand (ATU) mg/l O2**	**Chemical Oxygen Demand mg/l O2**	**Phosphorous (SRP) mg/l as P**	**Phosphorous (TOT) mg/l as P**	**Suspended Solids mg/l**	**Total Nitrogen mg/l as N**
PRE TRIAL STATS		**15**	**Days**		**13/02/2019**		**28/02/2019**
MAX	1457	8099	17321	80	180	8546	1533
AVG	**1082**	**4634**	**11498**	**42**	**121**	**5349**	**1158**
MIN	585	3040	7667	0	76	2428	730
TRIAL STATS (BENCHMARK)		**29**	**Days**		**28/02/2019**		**29/03/2019**
MAX	1239	8011	16614	54	161	8297	1491
AVG	1074	4628	11520	71	152	5338	1228
MIN	609	3190	8504	64	141	2474	895
AVERAGE	-1%	0%	0%	70%	26%	0%	6%
TRIAL STATS		**29**	**Days**		**28/02/2019**		**29/03/2019**
MAX	1461	5862	17115	73	174	9196	1552
AVG	**693**	**3000**	**8334**	**26**	**90**	**4591**	**747**
MIN	245	896	3636	-10	33	1969	231
AVERAGE	-36%	-35%	-28%	-38%	-26%	-14%	-36%

Figure 4: Characterisation of the influent wastewater before and after adding the BOC additive.

Compliance (figure 5, figure 6) was visually reduced however the total load removal was reduced due to this large reduction in influent loadings.

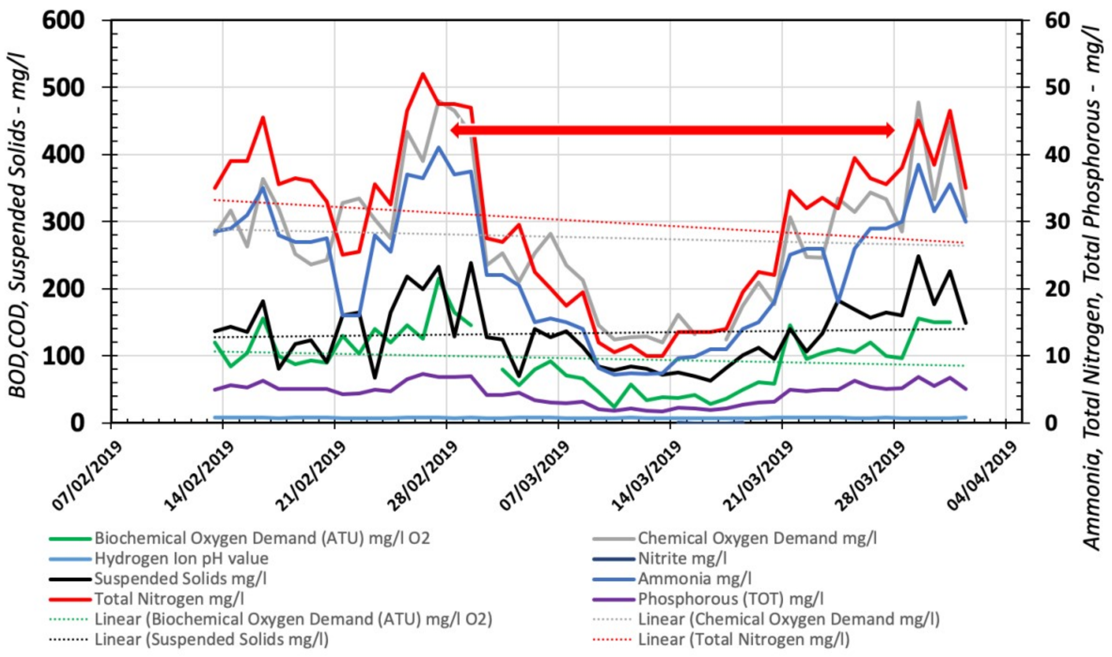

Figure 5: The WWTP influent to treatment load, showing the biochemical and nutrient composition of the influent to the treatment process before and during the trial dosing of BOC. The dosing period is indicated by a horizontal red line. Analysis is based on 24-hr composites at the Interstage pumps.

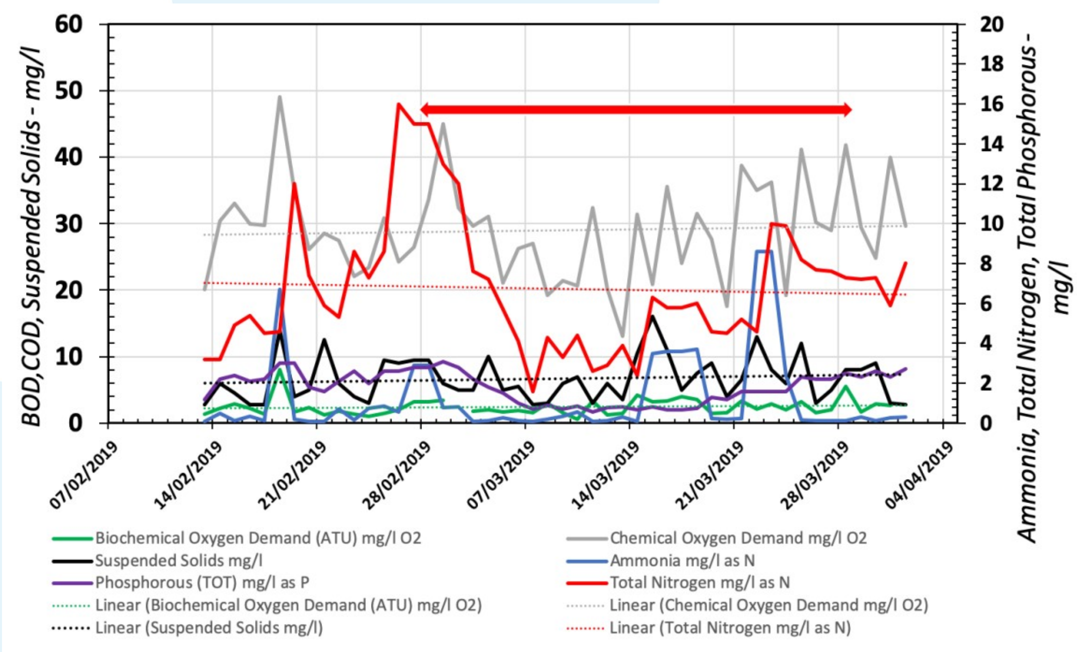

Figure 6: The WWTP Effluent discharge quality, showing the biochemical and nutrient composition of the tidal discharge effluent before and during the trial dosing of BOC. The dosing period is indicated by a horizontal red line. Analysis is based on 24-hr composites at the tidal discharge point.

The compliance data in figure 5 and figure 6shows a visual reduction in most of the loads. The power consumption was measured using kWh per TBOD removed, it was shown that when adjusting for the influent loading by replacing this with the benchmark average a 34% reduction in energy was observed (figure 7).

Figure 7: Power consumption per tonne of BOD using adjusted Influent loading, before and during the BOC trial.

The reductions in the influent against the average could have been a result of dilution of the influent due to a heavy rainfall or the dosing of BOC. However, the rainfall was normal at the start of the dosing period (there was heavy rainfall on the 6th February, seven days after the start of the dosing trial, figure 8), so the reductions of nitrogen, BOD, phosphorus etc (figure 5) can be attributed to the addition of BOC.

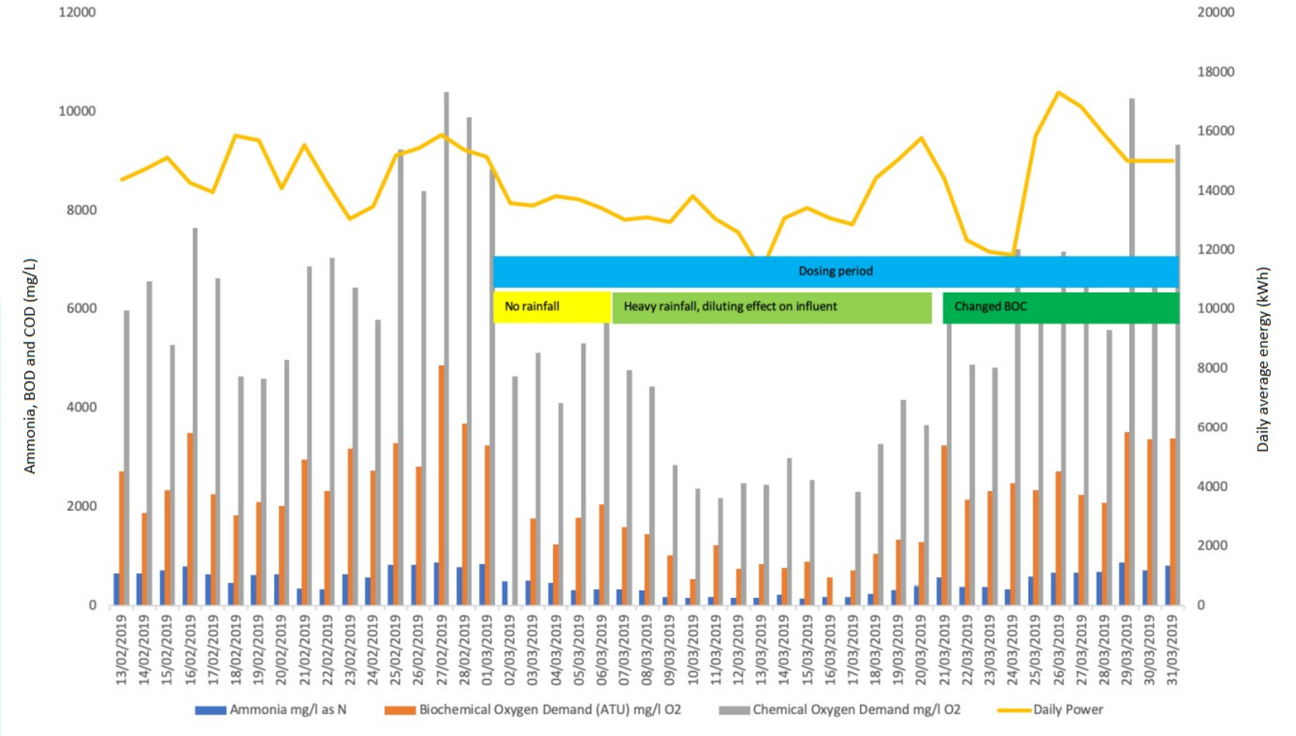

Figure 8: Ammonia, BOD and COD (mg/L) of the WWTP influent and daily electrical generation (kWh) before and during the trial, with rainfall and dosing period indicated.

The residency time and the physical kinetic nature in the interstage pump holding bins can be up to and in some cases higher than an hour, sufficient time for the BOC to take effect, as has been seen in other treated plants. It can then be surmised that the removals were compromised by the reduced inflows as discussed above. Figure 4 shows a comparison between the actual removals and a theoretical removal using average influent rates for the pre-trial data as used as a benchmark. Actual results show a reduced removal of 35% which is the average reduction in BOD loadings shown and discussed above. Using the theoretical data, it is even with the exception of N and P, this is consistent with other trials and treatment plants utilising the BOC and consistent with those claims. It is likely the Organic N and NH_4 was removed through the reduction of BOD and likewise the Total P was removed by an increased activity of PAO.

Biological robustness was seen in the recovery of one of the four SBR with a rapid increase in MLSS (figure 9). Also observed by the operator, the settleability in the SBR was improved after the first day of dosing.

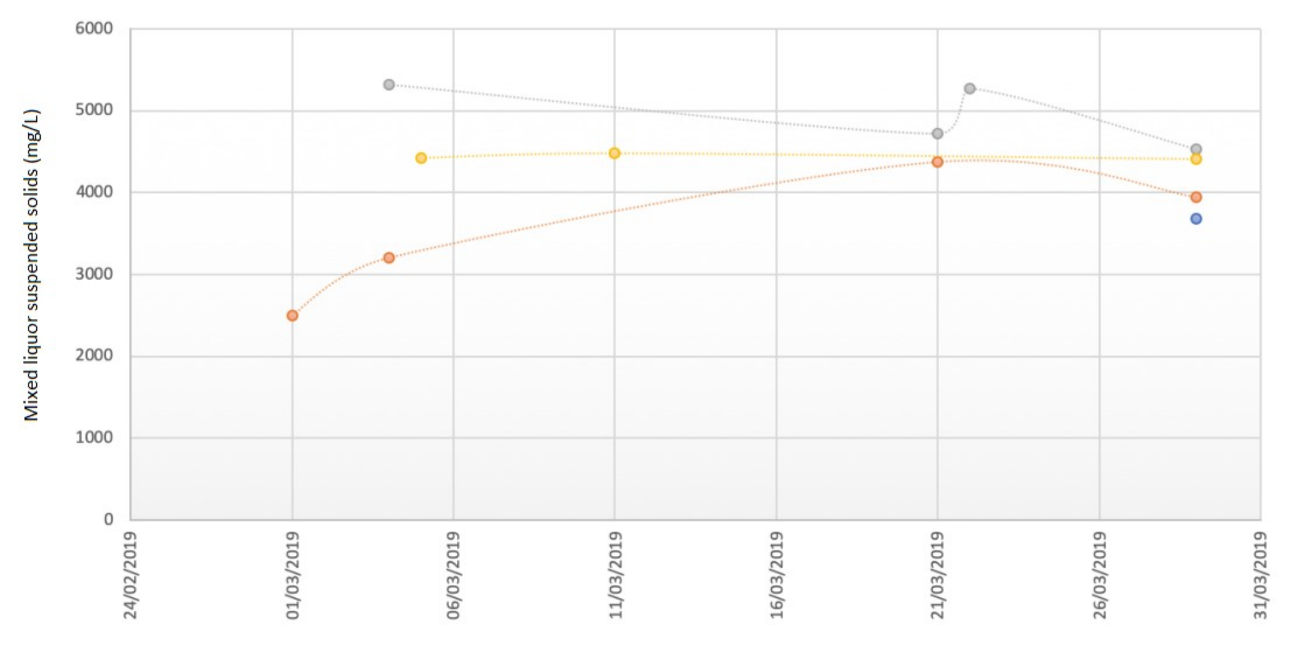

Figure 9: Mixed liquor suspended solids (MLSS) in mg/L in the sequencing batch reactors (SBRs) during the trial period.

Recommendations

Following this short trial, a longer trial is recommended, in which the dosing of BOC is proportional to the flow and the dosing point is downstream of the influent sampling point in the process flow. A system of measuring sludge and biological robustness will validate any reduction in sludge removals. The second stage treatment is planned to commence on the 1st of October 2019.