A WATER TREATMENT OPERATOR IN ANTARCTICA

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79th Annual WIOA Victorian Water Industry Operations Conference and Exhibition
Bendigo Exhibition Centre
31 August to 1 September, 2016

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ABSTRACT

Veolia is collaborating on research into water and waste treatment technologies, under a five-year Memorandum of Understanding with the University of Melbourne (MoU, 2015-2020). The first project focused on sites at Australia's Casey Station, operated by the Australian Antarctic Division (AAD), in East Antarctica. This project aims to utilise low-energy biological processes, such as biofiltration, to treat summer melt water contaminated with diesel-based hydrocarbons.

Veolia's technical experts and operational staff have had the opportunity to participate in a water treatment plant development project at Casey Station, Antarctica. Under the direction of University of Melbourne Project Team Leader, Kathryn Mumford, and Australian Antarctic Division (AAD) Project Manager, Tim Spedding, the team were commissioning and operating a plant to treat water as part of the clean-up of contaminated sites impacted by diesel spills in Antarctica.

This paper will describe the process of retrofitting and re-commissioning a package water treatment plant designed to operate in the extreme Antarctic environment.

1.0 INTRODUCTION

A mobile water treatment plant (WTP) was constructed in 2002 for use at remote Antarctic contaminated sites during clean-up activities. The WTP features coagulation/flocculation, lamellar settling, bag and media filtration and finally ion exchange. The plant was designed originally to treat suspended solids and heavy metals from landfill leachate at Casey station in Antarctica. This WTP has been the subject of an intensive research program in remote cold regions site remediation since 2002 (See Figure 1).

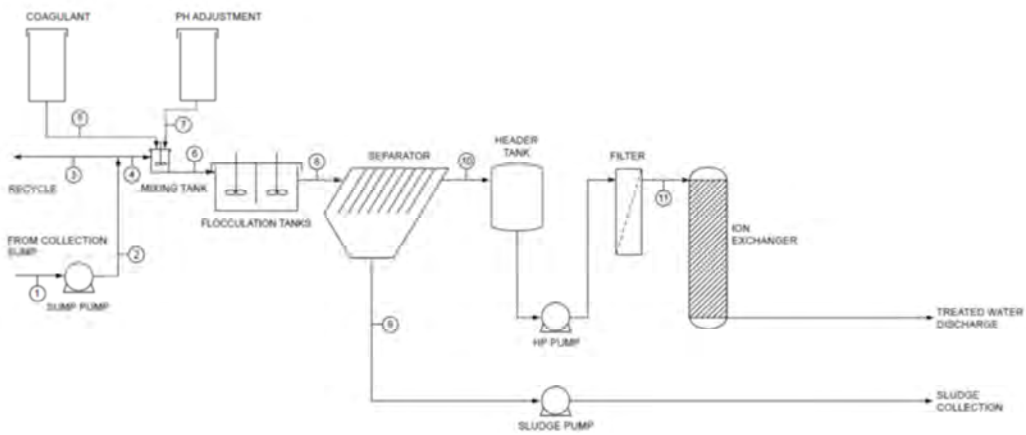

Figure 1: ***Process flow diagram of original process configuration of the Casey WTP***

More recently a new project has launched, this time associated with treatment of water contaminated as a result of diesel spills. Once again the WTP will be an important component of contaminated site remediation activities in Antarctica, as well as a valuable source of scientific information into the use of water treatment in cold regions.

On the 6th of October 2015, Veolia and the University of Melbourne signed a 5 year Memorandum of Understanding (MoU) to collaborate on research into better water and waste treatment technologies for both municipal and industrial sectors. The first collaborative project to be launched under the umbrella of the 5 year MoU focuses on the remediation of contaminated sites impacted by hydrocarbon (diesel) spills in Antarctica. Veolia supported the University of Melbourne on Antarctic Science Project 4029, through provision of remote technical and onsite operational support of the WTP at Casey Station.

Veolia provided technical design support, and an operator/maintainer was sent to provide operational support at Casey station, for Antarctic Science Project 4029. The aim was to repurpose and recommission the plant to treat diesel contaminated snow and leachate from sediments. Veolia staff worked with a team comprising staff from the Australian Antarctic Division and the University of Melbourne to commission, operate and monitor the water treatment process. Under the direction of University of Melbourne Project Team Leader, Kathryn Mumford, and AAD Project Officer Tim Spedding, Veolia staff worked with the project team members, who were able to successfully start up and operate the treatment plant, treating around 60,000L of contaminated water between the 22nd November to mid-December 2015.

Figure 2: ***Onsite at Casey Station, Antarctica***

The following sections describe the key activities undertaken with regard to pre-commissioning, commissioning and operation of the Casey WTP. In addition to this, options for possible future improvements to the process are discussed.

2.0 PRE-COMMISSIONING ACTIVITIES

The pre-commissioning phase of the Casey WTP project was conducted between the 19th and the 22nd of November 2015. Key activities included:

- Initial inspection and condition assessment of the plant. Condition was rated as good.
- Parts list for modifications compiled and parts sourced.
- Location for treatment identified and cleared ready for plant to be deployed.
- Plant brought onto site, further plant inspections to confirm planned modifications.

Modifications were determined to be raising the original ion exchange columns by 200mm. These columns were to be retrofitted to become activated carbon filters, including changes to plumbing, pipework and installation to allow for easier disconnect/reconnect.

Further pre-commissioning activities included:

- Electrical testing of mixers, pumps, lights, heaters and GPOs
- Repair of seized centrifugal pump and reconnection.
- Bund construction for storage of contaminated meltwater for treatment in WTP.
- Filter columns raised and re-plumbed.
- Check operations of chemical dosing system.

<u>Figure 3:</u> ***Raising the columns in the Casey WTP***

3.0 COMMISSIONING ACTIVITIES

The commissioning activities occurred from the 22nd of November 2015 and included:

- Hydrostatic testing of plant and repair of leaks
- Set up of feed and discharge lines.
- Open up, fill filter columns with granular activated carbon (GAC) and close up.
- Connect sump pump in bund and run WTP discharge line to permeable reactive barrier.
- Start-up plant, monitor and adjust flows across process.
- Monitor WTP ambient air quality for volatile hydrocarbon.

<u>Figure 4:</u> ***Connecting up the pump pipework prior to commissioning***

4.0 OPERATION

4.1 Plant Operation

The optimum plant flowrate was found to be 6 litres/min. Based on the experience of the Veolia and University of Melbourne operators onsite, this flow was found to produce sufficient contact time in the filter columns to remove hydrocarbon without it breaking through too quickly. Overall it was found that around 15,000L of hydrocarbon-contaminated snow-melt could be treated before the filter column media reached exhaustion.

The upstream processes (flocculation tanks, settler, bag filters) were all commissioned and operational from commencement of plant start-up. However in the first phase of the project, other than hydrostatic and electric testing, the chemical dosing system was not commissioned and operational. It was later in the season that the chemical dosing system was commissioned.

Operational activities were conducted between the 23rd November and the 10th December, at which point the Veolia operator formally handed over to the project team who were continuing for the remainder of the summer. Operational activities included:

- Plant condition and monitoring checks.
- Repair equipment if needed and rectify any plant issues (ie frozen pipework, split valves etc.)
- Start-up plant and monitor flows on an hourly basis.
- Sample collection.
- Air quality monitoring
- Discharge water quality monitoring
- Bag filter and filter column pressures and flows.
- Change out of GAC as required.

Further activities included procedure writing and training of new operators.

4.2 Filter Column Media

The initial composition of the filter columns was a mixture of zeolite and GAC. This was found to reach adsorption capacity too quickly and hydrocarbon started breaking through. Hence it was decided that the columns would be filled with 100% GAC. The volume of carbon used in each column was determined to be around 60L.

4.3 Bag Filters

The plant uses 2 x bag filters upstream of the filter columns. These are used to strain out coarse particles that potentially carry over from the settler due to the extremely low water temperatures. This is to prevent blockage of the GAC filter columns. The 5 micron filter bags tended to foul up quickly and cause a drop in flow across the process. This is likely due to no upstream chemical dosing in the early part of the season to encourage coagulation/flocculation and settling of particles. It may also be that the 5 micron bags are too fine and a coarser filter material (i.e. 10 micron) may be needed.

5.0 DISCUSSION

5.1 Operational Performance

The GAC filter columns in the Casey water treatment plant have the following design characteristics:

Table 1: ***GAC filter column design characteristics***

Column height	1.5	m
Column dia.	0.25	m
Columns in train	2	
trains in parallel	2	
Volume GAC	0.06	m3
Height GAC	1.2	m
Volume/train	0.12	m3
Total vol.	0.24	m3
Plant flowrate	6	L/min
Train flowrate	3	L/min
EBCT	40	min

A short review of literature of activated carbon adsorption of hydrocarbons, indicated recommended empty bed contact times (EBCT) of up to 120 minutes and a range of typical adsorption capacities.

Table 2: ***EBCT and adsorption capacities for GAC from literature***

Parameter	Contact	Concentration-range	Max Adsorption Capacity
	time (min)	mg/L	mg/g GAC
*Toluene	?	1.6-4.4	8.75
**Naphthalene	120	0-5	10
**Naphthalene	40	0-5	6

*Chemistry of Water Treatment, Second Edition Samuel D. Faust, Osman M. Aly July 1, 1998 by CRC Press

**C. Valderrama a, J.L. Cortina b,*, A. Farran b, X. Gamisans a, C. Laoa, Kinetics of sorption of polyaromatic hydrocarbons onto granular activated carbon and Macronet hyper-cross-linked polymers (MN200), Journal of Colloid and Interface Science 310 (2007) 35–46

5.2 Recommendations

Based upon operational observations between November 22nd and December 10th 2015, as well as an analysis of operational and design data from the Casey WTP, the following options are put forward for consideration for further investigation:

Option 1:

Optimise the removal of hydrocarbons through the GAC filter columns using existing equipment with no modifications. This would involve adjusting flows to achieve a better EBCT, commission chemical dosing to achieve to an optimum pH range and sourcing the most suitable GAC for hydrocarbon adsorption capacity. This approach would have limitations. The flows would need to be reduced down to 2 L/min to achieve a more suitable EBCT, posing issues with freezing of lines. However, this would be the cheapest and simplest option.

Option 2:

Replace the existing GAC filter columns with larger columns. This would be to achieve an EBCT of at least 120 minutes and provide greater overall adsorption capacity to reduce change out frequency. This would be the most expensive option in terms of capital cost.

6.0 CONCLUSION

A mobile water treatment plant (WTP) was constructed in 2002 for deployment to remote Antarctic contaminated sites for use during clean-up activities. In 2015 a project was launched to repurpose and recommission the above-mentioned mobile water treatment plant to treat diesel contaminated snow and leachate from sediments. Veolia technical and operational staff were involved in this project under the project management and direction of the Australian Antarctic Division and the University of Melbourne.

Modifications were made and the plant was recommissioned in November 2015. The optimum plant flowrate was found to be 6 litres/min. Based on the experience of the operators onsite, this flow was found to produce sufficient contact time in the retrofitted activated carbon filter columns to remove hydrocarbon without it breaking through too quickly. Overall it was found that around 15,000L of hydrocarbon-contaminated snow-melt could be treated before the filter column media reached exhaustion.

Possible future improvements to the plant and treatment performance is to either increase GAC filter size, or slow down plant flow. Either of these could be used to improve the empty bed contact time and hydrocarbon removal from the contaminated water.

7.0 ACKNOWLEDGEMENTS

The author would like to acknowledge project partner, the University of Melbourne, as well as the Australian Antarctic Division and funding via the Antarctic Science Program (Project 4029).

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