Landfill Leachate Treatment using Reactive Filter Units

1. Project overview

Penrith City Council and CORE agreed to utilise Advanced Biofiltration Technology (ABT) using Organic Filter Media (OFM) containing recycled organic products for the treatment of leachate at the decommissioned Gipps Street Landfill. The site is currently being used as a sports field and is scheduled for urban development. Leachate is currently treated by large scale terraced and vegetated treatment beds diverted to an evaporation pond.

CORE's project team installed Reactive Filter Units (RFUs) to demonstrate water quality improvement capability. The demonstration shows that leachate water quality can be significantly improved by OFM in a non-vegetated system occupying a much smaller and lower cost footprint.

The project received funding support from the NSW Environment Protection Authority through its Waste Less, Recycle More Organics Market Development grants.

2. Project site details and project design

Leachate waters flow along a series of terraced treatment beds into an evaporation pond adjacent to South Creek that is designed to prevent contamination of the creek from pond overflow during high precipitation. Creek water quality is used to identify regulatory compliance. Benchmarking data was obtained from "Penrith City Council Macroinvertebrate Study, Spring 2014" from located near the landfill sites:

1. SCC – South Creek at St Clair
2. SCM - South Creek at The Kingsway, St Marys.

Water quality is listed in the following table:

Table 1. *South Creek Water quality at two sites*

Parameter	South Creek SCC	South Creek SCM
pH	7.00	7.29
EC (uS/cm)	874.2	723.2
DO (% Saturation)	37	48.86
Turbidity (NTU)	59.84	18.26
TN (mg/L)	1	0.9
TP (mg/L)	0.08	0.05
TKN (mg/L)	0.8	0.8

Parameter	South Creek SCC	South Creek SCM
NO_x-N (mg/L)	0.23	0.07
NH_3-N (mg/L)	0.04	0.03
Ca^{2+} (mg/L)	24	20
K^+ (mg/L)	12	11
SO_4^{2-}(mg/L)	46	39

Following an initial site visit, CORE conceptualised how RFUs can be integrated into the current leachate treatment system for the purpose of the demonstration. CORE proposed to use RFUs as water quality improvement devices. The layout of the treatment trains is shown below in Figure 1.

Figure 1. *Existing vegetated swales for leachate treatment (left) and proposed RFUs (non-vegetated treatment to existing system (right)*

The RFUs are designed to take influent into the top manifold and treat the pollutants in the leachate by passing through multi layered biofiltration cartridges inside the unit. Effluent from the RFU is emitted from the bottom outlet valve. RFU1 & 2 are placed near the leachate inlets which are designed to treat the leachate before entering the second stage treatment bed.

1. **Device manufacture and installation**

The RFU's main components include inlet pipes, outlet valve, an internal manifold to spread the supply of water, cartridges filled with OFM and a supporting rigid $1m^3$ plastic container. Most of the device and media components used in the RFU were supplied locally.

The installation stage of the Gipps Street project was completed in December 2019 by the CORE connection team. Two RFUs were separately installed at the right, and left-hand side of the existing vegetated swale as shown in the site photos below. Both RFUs were installed at approximately 1/3 of the slope of the overall vegetated terraces, which allows the leachate to be gravitationally fed to the manifold spreader into the RFU treatment system.

Figure 2. *2 RFUs installed on site*

Following OFM filtration processes, treated outflow is emitted to the vegetated swale of the existing treatment process. It should be noted that the current influent pumping system works intermediately to pump the leachate from the storage tanks to the vegetated swales from which the RFU receives its inflow. RFU is also equipped with overflow should continuous high flow be introduced into the unit.

2. Standard Operation Procedures for sampling

Following the installation of the RFUs at Gipps Street Landfill, a sampling procedure was designed to guide site technicians on sampling locations, frequency, methods and sample storage. Figure 3 below indicates the sampling locations for RFU 1 and RFU 2.

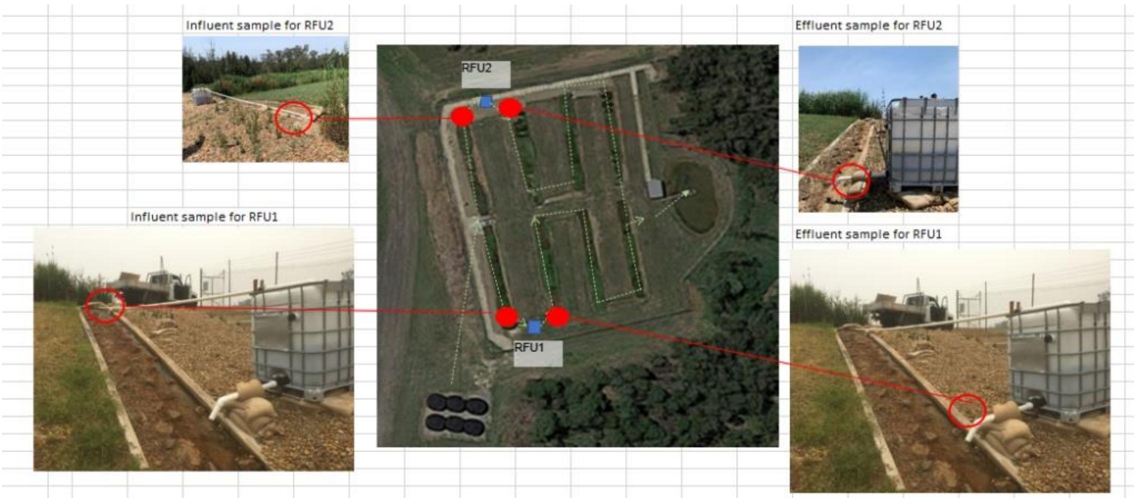

Figure 3. *Sampling locations on site*

The inlet and outlet samples were taken from each RFU during compliant rainfall events. All samples were stored in the laboratory supplied plastic sampling bottles and placed in an ice box for immediate transportation. All samples are analysed by the (NATA) ALS Environmental laboratory at Smithfield.

The pollutants monitored in this project include Copper, Iron, NH3, Nitrite, Nitrate, Total Kjeldahl Nitrogen, Total nitrogen, Total phosphorus, pH, Suspended Solids and Turbidity.

3. Baseline sampling and water quality

In order to understand the pollutants concentration levels prior to the RFUs operation, baseline samples were taken in September 2020 from the sump receiving the leachate from the collection tanks which then overflows into the existing terraced treatment beds.

Figure 4. *Sampling from the sump for baseline sample*

The baseline sample is reported with the following pollutant concentrations:

Table 2*. Pollutant concentrations in sump sample*

	Units	**Concentration**
pH	pH Unit	7.88
Suspended Solids (SS)	mg/L	16
Copper	mg/L	<0.001
Zinc	mg/L	0.009
Iron	mg/L	7.64
NH3	mg/L	27.7
NOx	mg/L	0.07

	Units	Concentration
Total Kjeldahl Nitrogen as N	mg/L	29.5
Total Nitrogen as N	mg/L	29.6
Total Phosphorus as P	mg/L	0.04
Turbidity	NTU	97.3

The results of the sump sample analysis show that untreated leachate has a high concentration of iron. Although copper and zinc showed relatively low concentrations in this sample OFM design targeted all metals.

Nitrogen and turbidity are also showing relatively high levels so OFM components that can target these were used. It should be noted that this baseline testing is only a preliminary analysis for the project team to understand the pollutant concentration levels on site and design an appropriate filter media, noting that the pollutant concentration levels often vary from time to time.

4. RFUs performance monitoring sampling

Four sampling events were conducted on 26th October 2020, 30th October 2020, 18th February 2021 and 18th March 2021. Leachate collection tanks are primed and generally only discharge the leachate during and after rain events. Sampling was carried out within 24 hours from an eligible rain event. Samples were collected from rainfall events with a precipitation intensity equivalent to 12mm per hour.

Figure 5. *Taking samples on site and Samples placed in cooler box*

Water samples were tested by NATA accredited ALS Environmental Laboratory on the concentrations of the pollutants. The 4 sampling events measured influent and effluent of the RFU. The event mean concentrations (EMCs) of each pollutant in the influent and effluent draw the pollutants spectrum of the untreated and treated leachate, respectively (Refer to Table 3).

Table 3. *EMCs of pollutants in influent and effluent*

Pollutants	Unit	Influent			Effluent		
		Max	Min	Mean	Max	Min	Mean
SS	mg/L	162	12	30	31	2	10
Copper	mg/L	0.02	0.005	0.013	0.022	0.003	0.008
Zinc	mg/L	0.072	0.005	0.008	0.027	0.007	0.012
Iron	mg/L	28.4	0.51	0.97	0.85	0.11	0.53
NH3	mg/L	3.24	0.01	1.325	2.94	0.06	0.51
NOX	mg/L	5.6	1.9	3.08	6.08	1.25	2.79
TKN	mg/L	7.3	1.8	2.6	3.9	1.4	2.5
TN	mg/L	9.7	3.7	6.9	8.5	3	5.75
TP	mg/L	0.63	0.02	0.03	0.06	0.01	0.02
pH	-	8.03	2.45	7.75	8.17	7.51	7.92
Turbidity	NTU	121	3	15.5	16.6	0.8	5

Suspended solids and turbidity show high influent concentration, 162 mg/L and 121 NTU, respectively during some sampling events. Iron is the most concerning metal that showed remarkable high concentration of 28.4 mg/L in the influent sampled in March, while copper and zinc are in range of 5 µg/L to 72 µg/L. Influent total nitrogen (TN) and total phosphorus (TP) are in the range of 3.7 – 9.7 mg/L and 0.03 – 0.63 mg/L, respectively, which are not too hazardous. It should be noted that, there are two samples showing very acidic pH in the influent (Feb and Mar samples) which are below pH3.

Compared to the influent, RFU effluents showed lower ranges of the pollutant concentration in the sampling events, which means the pollutants have been removed by the RFUs. Pollutants like SS, turbidity, iron, zinc, NH3 are effectively reduced in concentration by the RFU treatment system operation. Furthermore, RFU was able to neutralise the influent as it was presented with a low pH.

It should be noted that EMCs give the pollutant concentration spectra by indicating maximum, minimum and mean concentrations of the pollutants during several sampling events. However, it does not show the removal rate of pollutants. The following Table 4 indicates the pollutants removal in a two indicative sampling events.

***Table 4**. Pollutant concentrations in influent and effluent and their removal by RFU*

Sampling event	**26/10/2020**			**18/02/2021**		
Pollutants	**In**	**Out**	**Removal**	**In**	**Out**	**Removal**
	mg/L		**%**	**mg/L**		**%**
SS	30	3	90	162	5	97
Copper	0.014	0.007	50	0.015	0.003	80
Zinc	1.26	0.11	91	0.072	0.008	89
Iron	1.26	0.11	91	28.4	0.53	98
NH3	0.99	0.06	94	3.24	0.64	80
NOx	5.6	1.46	74	2.44	3.02	-
TKN	2.6	2.4	8	7.3	1.8	75
TN	7.6	4.1	46	9.7	4.8	51
TP	0.05	0.02	60	0.63	0.01	98
pH	7.98	7.97	stable	2.87	7.81	neutralised
Turb.	**NTU**		**Removal**	**NTU**		**Removal**
	24	1.8	93	121	5.1	96

The test results showed that, RFU achieved considerable removal of conservative pollutants such as suspended solids, turbidity and metals, removal ranging from 80% - 98%. Particularly in March, a very high concentration of iron (28.4 mg/L) was shown in the influent and RFU was able to remove 98%. Nutrients like NH3, TN and TP were also removed with removal rate ranging from 50% - 98%. In addition, RFU was able to neutralise the acidic influent in the March sample.

Conclusions

These test results established that RFU with Organic Filter Media (OFM) can efficiently remove the pollutants of concern to acceptable concentrations. Interestingly these results demonstrate that high pollutant removal can be achieved by OFM in the absence of vegetation including some species of N such as NH3. Improved results for non-conservative pollutants such as TN & TKN are better demonstrated in vegetated systems. The results also show typical variable concentration behaviour of non-conservative pollutants.