Evaluation of the Performance of ACTIFLO® Clarifier in the Treatment of Mining Wastewaters: Case Study of Costerfield Mining Operations, Victoria, Australia

Seyed Mohsen Samaei, Shirley Gato-Trinidad

Abstract**—**A pre-treatment stage prior to reverse osmosis (RO) is very important to ensure the long-term performance of the RO membranes in any wastewater treatment using RO. This study aims to evaluate the application of the Actiflo® clarifier as part of a pre-treatment unit in mining operations. It involves performing analytical testing on RO feed water before and after installation of Actiflo® unit. Water samples prior to RO plant stage were obtained on different dates from Costerfield mining operations in Victoria, Australia. Tests were conducted in an independent laboratory to determine the concentration of various compounds in RO feed water before and after installation of Actiflo® unit during the entire evaluated period from December 2015 to June 2018. Water quality analysis shows that the quality of RO feed water has remarkably improved since installation of Actiflo® clarifier. Suspended solids (SS) and turbidity removal efficiencies has been improved by 91 and 85 percent respectively in pre-treatment system since the installation of Actiflo®. The Actiflo® clarifier proved to be a valuable part of pre-treatment system prior to RO. It has the potential to conveniently condition the mining wastewater prior to RO unit, and reduce the risk of RO physical failure and irreversible fouling. Consequently, reliable and durable operation of RO unit with minimum requirement for RO membrane replacement is expected with Actiflo® in use.

Keywords**—**Actiflo® clarifier, membrane, mining wastewater, reverse osmosis, wastewater treatment.

I. Introduction

ONE of the most significant primary industries and contributors to the Australian economy is mining. However, large volume of wastewater which is contaminated with various metals and minerals is produced during the mining processes every day. Untreated mining effluents can be harmful to the surrounding environment including natural water sources and aquatic life [1]. Many mines recycle and re-use as much water as it is possible considering the site-specific conditions. Therefore, before discharging the wastewater back into environment, mining companies have to treat wastewaters to minimize their environmental impacts, and to comply with local discharge regulations.

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There are a large number of commercially available mines in Australia including Costerfield operations in Victoria which are currently using RO plant as a post-treatment stage to efficiently remove heavy metals and other contaminants from mining effluent [2]-[7]. However, the most important aspect toward any RO operation is the attention to pre-treatment equipment. Inadequate feed pre-treatment can increase the risk of physical damage of RO membranes and fouling potential [8]. Mandalay Resources Costerfield operations treatment plant which consists of pre-treatment system and RO unit, has started operation in 2014. Initial pre-treatment processes on site consisted of inline coagulation, pH adjustment, polymer dosing and multimedia filtration to condition the feed water before the RO plant [9]. However, the initial pre-treatment system was not capable of proper conditioning of raw mining wastewater to feed into RO unit. Unsuitable quality of RO feed water caused RO membranes to be fully replaced twice within two years of operation due to irreversible fouling and physical damage of RO membrane. To address this problem, in October 2017, Actiflo® clarifier which is developed by Veolia Water Technologies has been added to the pre-treatment system to improve the quality of RO feed water.

This paper presents a detailed assessment of an existing Actiflo® clarifier in treating wastewater from a large -scale mining operations located in Victoria, Australia. The paper begins with the case description followed by the detailed discussion about the Actiflo® clarifier rejection efficiency. Finally, the key findings regarding the performance of Actiflo® for the treatment of RO feed water will be presented.

II. Case Description

A. Study Area

This case study is performed at the Costerfield operations owned by Mandalay Resources Ltd located approximately 100 km northwest of Melbourne, Victoria, Australia [10], [11]. The Costerfield Operations include the underground gold-antimony Augusta mine and the Cuffley deposit which have been operational since 2006 and 2013 respectively and were the ore source for the Brunswick processing plant. Fig. 1 illustrates the Brunswick site which encompasses processing plant, administration offices and workshops, tailing storages, RO plant, core farm and core processing facility [11].

B. Wastewater Treatment Plant

In 2014, the Costerfield Mining treatment plant consists of pre-treatment system with the RO plant constructed at the Brunswick processing plant in order to treat wastewaters from underground operations.

The waste product from the RO plant which is known as RO brine is stored in the plastic-lined evaporation dams at Augusta and reused in the processing plant or have it evaporated on tailing storage facilities [11].

1. Pre-Treatment System

Initial pre-treatment system on site which was constructed in 2014, consists of inline coagulation, pH correction, polymer dosing and multimedia filtration. In current pre-treatment system, which has been upgraded since October 2017, Actiflo® is installed before the feed tank, and wastewater from the underground mining operations goes directly to the Actiflo®. Clarified water from the Actiflo® then passes through the multimedia filters (MMFs) consisting of three layers of media; anthracite, sand and garnet with a total bed depth of 120 cm. MMFs help to further remove the flocs produced during Actiflo® process. MMFs permeate then enters the filtered water tanks. Backwashing with filtered water are used periodically for MMFs cleaning. Backwash from the MMFs goes to Tailing Storage Facilities [9].

2. RO Plant

The RO unit consists of two stages embedded with 96 polyamide membranes. Stages 1 and 2 contain eight and four pressure vessels, respectively. The installed RO unit has the capacity of permeate flow of 2 ML/d. There are 5 µm and 1 µm cartridge filters prior to the RO stage. Water from filtered water tanks pushes through these cartridge filters via the RO low pressure pump (4-6 bar). Then, the RO system high pressure pump transfers the filtered water from cartridges to RO membranes. This high-pressure pump has a variable speed driven that operates in response to feed flow to provide a constant pressure during operation (112 m^3/h at 34.5 bar). RO concentrate and permeate will be collected in brine tank and permeate tank, respectively. The content of permeate and brine tanks is discharged to Wappentake Creek and Evaporation pond respectively via two permeate and brine transfer pumps. The permeate flush pump is used periodically to push the permeate from permeate tank through the RO membranes to displace the concentrated feed water. CIP system (cleaning in place) consists of a pump, a tank, and a cartridge filter for removing any possible coarse particles in chemical solution before injecting to RO membranes [9]. Fig. 2 presents a technical drawing that illustrates the Costerfield water treatment plant including the pre-treatment system and RO.

3. Operational Problems in RO Plant

The polyamide RO membranes unit was first commissioned in August 2014, and RO membranes were fully replaced in November 2014 after three months of installation due to significant increase in RO operating pressure. Typically, commercial RO membranes are expected to last about 2-5 years depending on the nature of feed water and efficiency of the pre-treatment system [14]. In November 2016, failure of RO membranes was identified after elevated results over repeated water samples analysis. Consequently, in December 2016, the membranes were replaced again just after two years of first replacement due to poor quality of RO permeate and non-compliance with license condition [15]. In order to find out the problem details, two RO elements (lead and tail modules) from RO plant were sent to Wastewater Futures Pty Ltd to assess the membrane's health after two years of operation. Based on the autopsy results, both modules were severely fouled, and cleaning using citric acid was not efficient to remove fouling. Wastewater Futures Pty Ltd then recommended a full replacement of RO modules [16]. Figs. 3 (a) and (b) are photos of the external of RO elements after two years of operation as part of visual and stereomicroscopic inspection undertaken by Wastewater Futures Pty Ltd. Investigation undertaken revealed that improper feed pre-treatment caused the failure of RO. Initial pre-treatment system without Actiflo® was not capable of efficient removal of SS and turbidity from RO feed water which resulted in RO membrane's irreversible fouling. To address this issue, Actiflo® clarifier has been added to the pre-treatment system in October 2017 for proper conditioning of RO feed water.

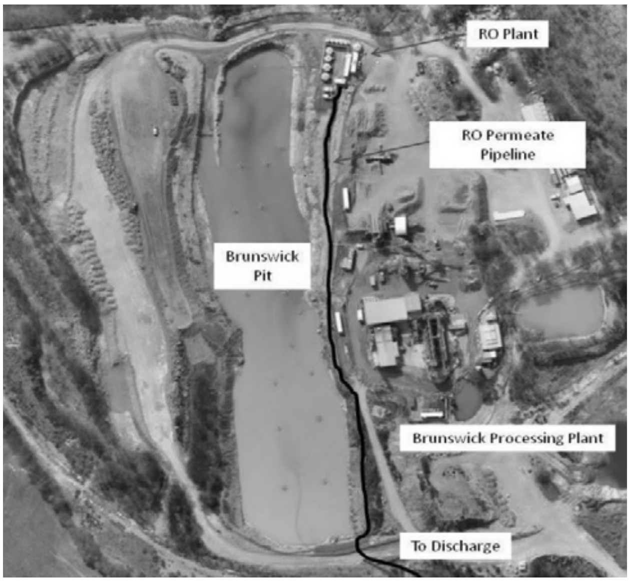


Fig. 1 Brunswick site (reprinted form [12])

C. Environmental Protection Authority (EPA) Victoria Compliance

According to EPA Vitoria 2014 [12], discharge of RO permeate to surface waters must be in accordance with the EPA Compliance for Discharge. RO permeate quality against EPA license limits is presented in Table I. As stated in EPA annual performance statements for the period of July 2015 to 16 and July 2016 to 2017, there are some dates when the non-compliance occurred. The summary of particulars of non-compliance is as follows: in 23/09/2015, elevated antimony concentration is identified in RO permeate. Increased turbidity in RO plant feed water and poor efficiency of pre-treatment system resulted in additional fouling of RO membranes. This contributed to low efficiency in RO plant which led up to non-compliance with license condition in terms of Antimony level. RO permeate continued to be discharged ensuring adequate dilution of non-compliant water [20]. In November 2016, failures of RO membrane identified after elevated readings of different compounds were recorded, and RO permeate discharge was immediately stopped. Discharge was suspended from 23 November 2016 until 22 December 2016. After fully replacement of RO membranes in December 2016, RO permeate quality returned to permitted limits [15].

In summary, according to Table I average concentration of Antimony in RO permeate during July 2015 to July 2017 was higher than discharge limits. In order to prevent reoccurrence of the non-compliance and to avoid RO plant failure, EPA Victoria recommended pre-treatment process upgrade. Actiflo® clarifier is commissioned in October 2017 to treat feed water to a stable quality to enable steady feed to RO plant.

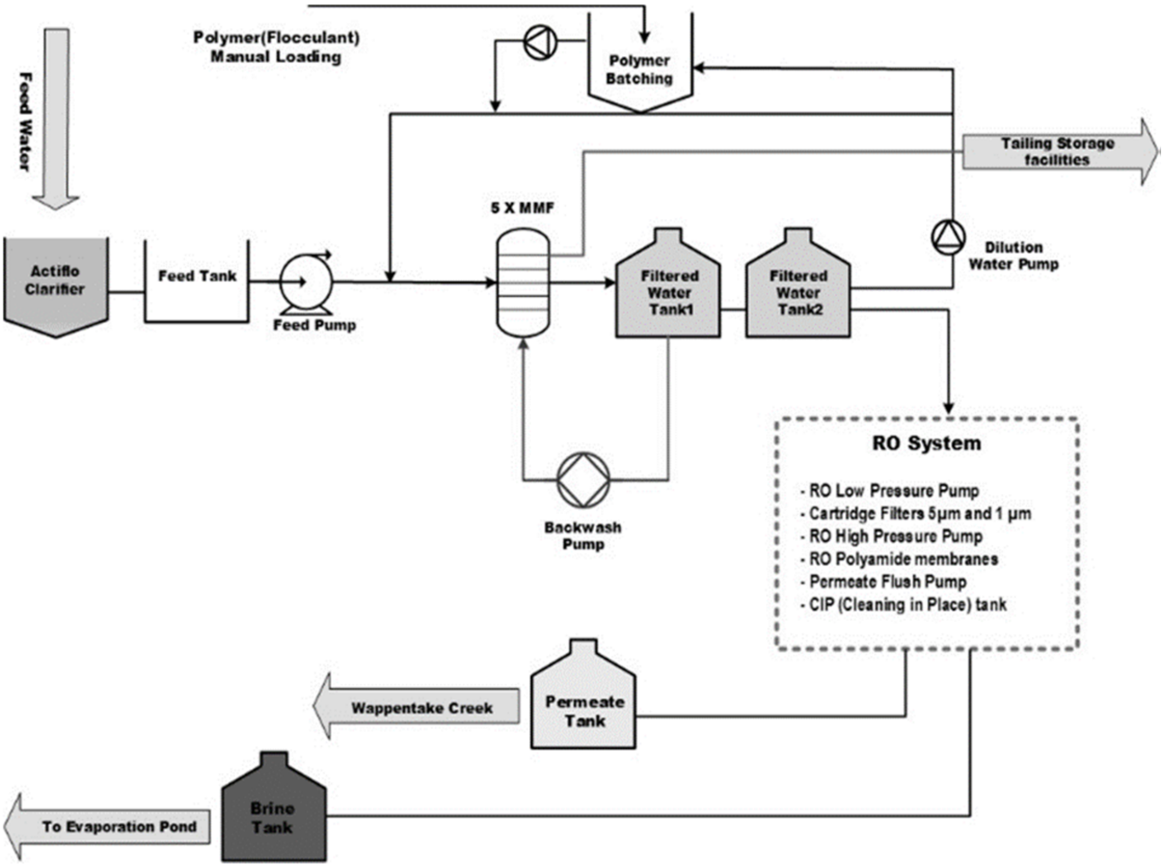


Fig. 2 Mandalay water treatment plant (adapted from [13])

TABLE I
RO PERMEATE (ROP) QUALITY VERSUS EPA COMPLIANCE FOR DISCHARGE [15], [20]

Indicator	Limit Type	Unit	ROP July 15 to16	ROP July 16 to 17	Discharge Limit
pH	Min/Max	pH	6.07-8.2	6.9-8.84	6-9
Antimony	Max	Mg/L	0.286	0.537	0.114
Arsenic	Max	Mg/L	0.001	0.001	0.001
Cadmium	Max	Mg/L	0.0001	0.001	0.002
Chromium	Max	Mg/L	0.001	0.001	0.002
Copper	Max	Mg/L	0.001	0.002	0.007
Iron	Max	Mg/L	0.006	0.05	0.13
Lead	Max	Mg/L	0.001	0.001	0.008
Nickel	Max	Mg/L	0.001	0.001	0.002
Zinc	Max	Mg/L	0.018	0.043	0.062
DO as Mg/L	Max	10th Percentile	7.14	7.05	8.5
TDS	Max	Mg/L	154	220	450
Turbidity	NTU	75th Percentile	1.10	0.4	10

III. ACTIFLO ® CLARIFIER

A. Working Mechanism and Specifications

Actiflo® clarifier is developed by Veolia Water Technologies and operates based on a combination of chemical precipitation, microsand enhanced flocculation and lamella sedimentation processes [17]. This unit has some unique benefits over other clarification processes of similar capacity including quick start-up times for attaining peak efficiency, reduced chemical consumption, short retention times and smaller footprints [18].

As mentioned in the previous section, this unit has been in operation since October 2017 in Mandalay Resources Costerfield operations to address poor RO feed water quality issue. It is installed before the feed tank. The unit consists of three flocculation basins followed by a lamella sedimentation tank. It has three low speed agitators with an axial mixing pattern operating in the flocculation basins. After inline addition of coagulant, raw wastewater enters Actiflo® in the coagulation tank to produce flocs. The coagulated water then enters the injection tank in which ballasted floc formation begins. In this basin, polymer and microsand are mixed to bind the chemically produced flocs to the microsand through polymer bridges. In the maturation tank, an additional amount of flocculants is added to further boost the formation of microsand ballasted flocs. The fully flocculated water then enters the lamella settling tank where the microsand ballasted flocs quickly settle to the bottom while the clarified water rises through the zone. Clarified water leaves Actiflo® through a series of collection channels. The sand sludge slurry is collected at the bottom of the clarifier with applying scrapers. The collected sand sludge slurry is then pumped by centrifugal pumps to hydrocyclone which allows the microsand to be recycled for reuse purpose, while sludge is removed for further processing including thickening and final disposal [18]. Fig. 4 shows the schematic diagram of Actiflo® clarifier unit

Table II presents the capacities of different basins of Actiflo® operating on site. The current unit has been tested to 80 m^3/h flow rate. As per advice from the manufacturer the unit is capable to run effectively up to 180 m^3/h to reduce turbidity and SS, although the unit has not been tested for this flow rate so far.

TABLE II
CAPACITIES OF BASINS OF ACTIFLO® CLARIFIER UNIT ON SITE

Basin	Capacity (m^3)
Coagulation	6.8
Injection	6.8
Maturation	23.4
Lamella	13

B. Discussion on Efficiency of Actiflo® for the Removal of Various Compounds

1. RO Feed Water Analysis before and after Installation of Actiflo®

To evaluate the treatment performance of new pre-treatment configuration consisting of Actiflo® with previous pre-treatment system, water samples were taken on different dates from the nominated sample collection valves located prior to RO unit before and after Actiflo® installation and were sent to an independent laboratory for testing. Table III presents all the evaluated parameters of RO feed water including total SS, total dissolved solids (TDS), dissolved oxygen (DO), sulfate, chloride, dissolved major cations and dissolved metals before and after installation of Actiflo® unit. It is worth mentioning that Mandalay requested some elements including sulfate, chloride, calcium, magnesium, sodium and potassium for testing despite not being required by EPA Victoria. The reason is to have access to the full parameters of RO feed water quality. In order to discuss the performance of Actiflo® unit in pre-treatment system, mathematical average concentration of various compounds during the available evaluated period has been summarized in Table IV. Considering mean or average concentration of various compounds is the best available option to convey the central tendency of the available data, because its value always reflects the contributions of each of the data values for the whole evaluated period. However, in order to justify average concentration values, the monthly trend of the levels of various compounds is also presented by comparing same month data between two different years. These monthly and average values will be used in the following sections to produce bar graphs to give a clear picture of the quality of RO feed water before and after installation of Actiflo®. Table V compares RO feed water and permeate quality after adding Actiflo® to pre-treatment system with EPA discharge limits. According to Table V, RO feed water complies with most of the EPA compliance for discharge after adding Actiflo® to pre-treatment system with the exception of TDS, DO, nickel and antimony content. In addition, by comparing Tables I and V, it can be concluded the antimony level is significantly reduced in ro permeate after adding Actiflo® and meets EPA compliance for discharge. It is believed that reduced turbidity in RO feed water by Actiflo® leading up to minimum fouling of RO filters within RO plant. This contributes to better efficiency in the RO plant including Antimony removal.

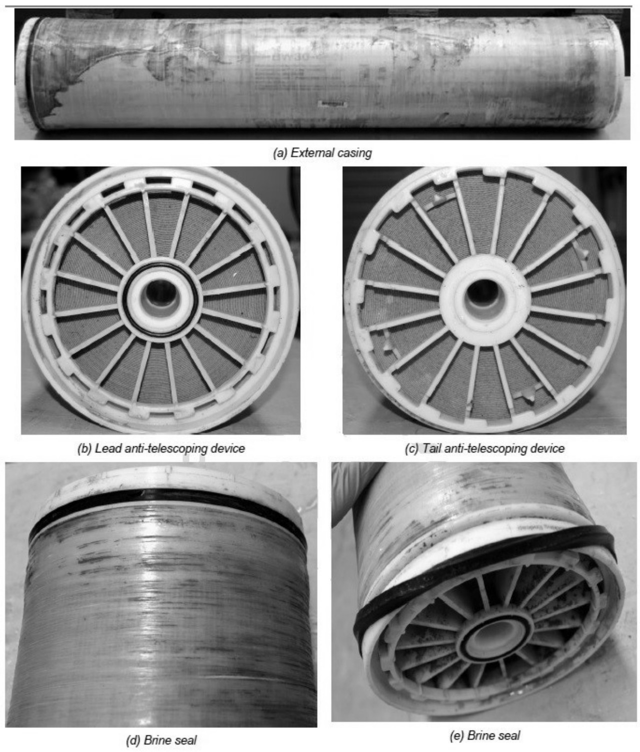
TABLE III
RO FEED WATER QUALITY ON DIFFERENT DATES BEFORE AND AFTER INSTALLATION OF ACTIFLO® [19]

	Date	pH	TDS	SS	Turbidity	DO	SO_4^{-2}	Cl^-	Ca	Mg	Na	K	Sb	As	Cd	Cr	Cu	Ni	Pb	Zn	Fe
	Dec-15	8.1	5360	34	49.6	7.6	510	2850	171	231	1360	14	16.9	0.037	<0.0001	<0.001	<0.001	0.015	<0.001	0.047	<0.05
	Jun-16	7.88	4900	31	36.5	9.5	455	2620	136	225	1260	12	20.7	0.032	<0.0001	<0.001	<0.001	0.017	<0.001	0.048	0.21
Before Actiflo®	Sep-16	8.13	4300	37	31.4	7.6	507	2520	148	198	1180	11	17.1	0.025	<0.0001	<0.001	<0.001	0.013	<0.001	0.006	<0.05
	Dec-16	8.01	4560	5	15.6	-	484	2360	120	166	1190	9	28.3	0.026	<0.0001	<0.001	<0.001	0.017	<0.001	0.029	<0.05
	Feb-17	7.88	4990	79	53.3	9.6	552	2570	162	202	1220	12	23.4	0.027	<0.0001	<0.001	<0.001	0.021	<0.001	0.006	<0.05
	Jul-17	7.97	3930	10	5.1	10.4	471	2040	155	193	1070	10	22.7	0.001	<0.0001	<0.001	<0.001	0.018	<0.001	0.072	<0.05
	Feb-18	7.69	5520	5	3.3	7.9	596	2830	197	237	1180	20	21.9	0.001	<0.0001	<0.001	<0.002	0.052	0.001	0.036	<0.05
After Actiflo®	Mar-18	7.38	5840	5	1	8.6	700	2810	189	245	1330	19	31.8	0.002	<0.0001	<0.001	<0.001	0.014	<0.001	<0.005	<0.05
	Jun-18	7.77	5750	5	4.7	9.5	627	2700	195	283	1200	26	10.2	<0.001	<0.0001	<0.001	<0.001	0.014	0.001	0.018	<0.05

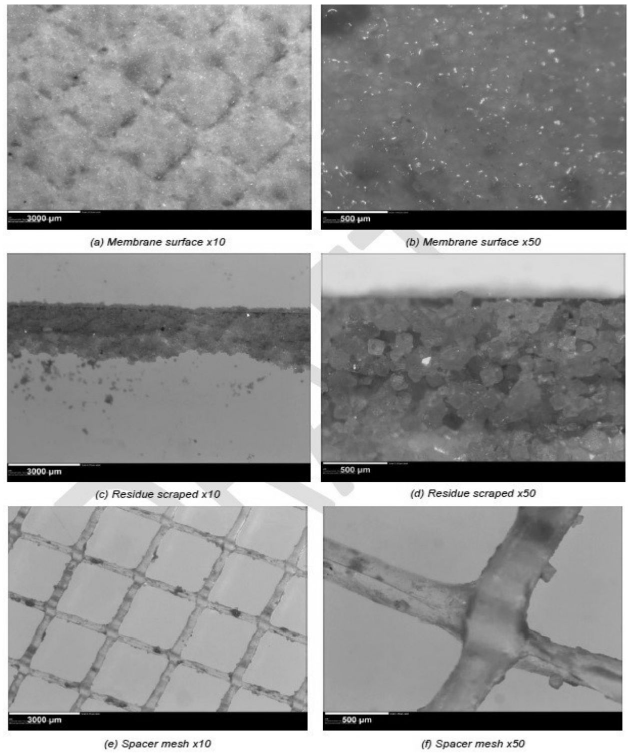
All units are in mg/L excluding Turbidity
Turbidity Unit: NTU (Nephelometric Turbidity Units)

a) SS, Turbidity and DO

The performance of upgraded pre-treatment unit consists of Actiflo® unit in terms of SS, DO and turbidity removal is shown in Figs. 5-7. Significant improvement is observed in removal of suspended solids and turbidity concentrations with Actiflo® in use. As shown in Table III, Actiflo® permeate SS and turbidity concentration as low as 5 mg/L and 1 mg/L are observed, respectively. On average, Actiflo® improved SS and turbidity removal efficiency by 85 and 91, respectively. However, there is no significant change in average DO level of RO feed water since Actiflo® has been commissioned.



(a)



(b)

Fig. 3 (a) External inspection of RO elements (reprinted from [16]), (b) Stereomicroscope inspection of RO elements (reprinted from [16])

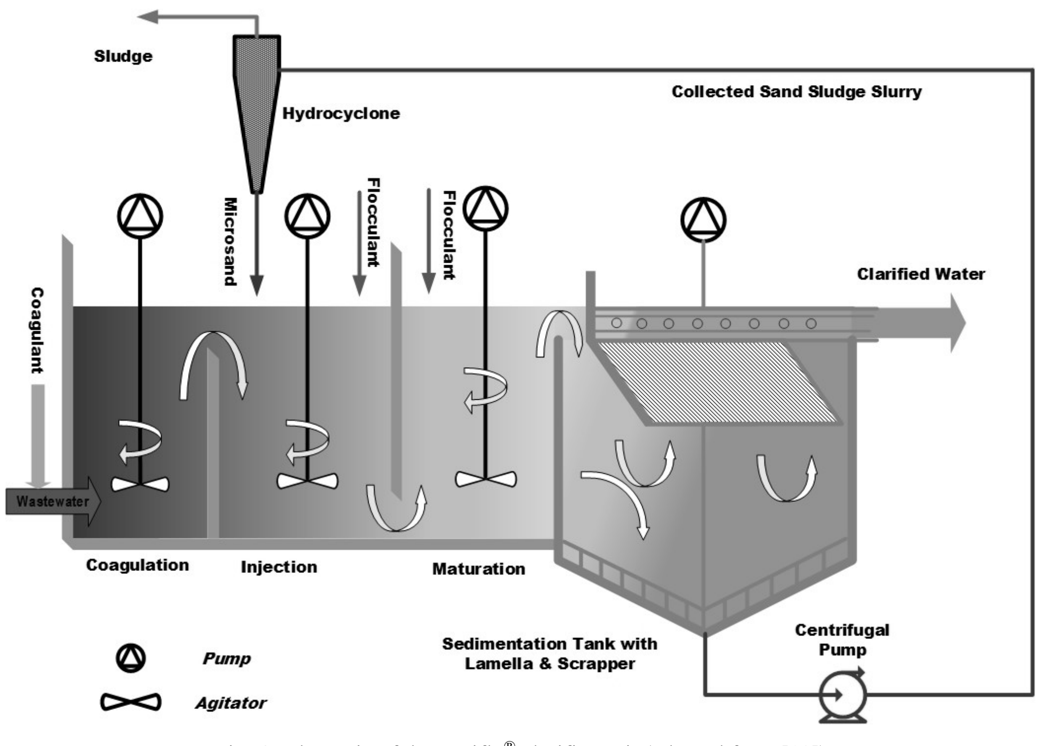


Fig. 4 Schematic of the Actiflo® clarifier unit (adapted from [18])

TABLE IV
AVERAGE CONCENTRATION OF VARIOUS COMPOUNDS IN RO FEED WATER BEFORE AND AFTER INSTALLATION OF ACTIFLO®

Configuration	pH	TDS	SS	Turbidity	DO	SO_4^{-2}	Cl-	Ca	Mg	Na	K	Sb	As	Cd	Cr	Cu	Ni	Pb	Zn	Fe
Before Actiflo®	8	4673	32.7	31.9	8.94	479	2493	149	203	1213	11	21.5	0.025	<0.0001	<0.001	<0.001	0.017	<0.001	0.035	<0.08
After Actiflo®	7.61	5703	5	3	8.67	641	2780	194	255	1237	22	21.3	<0.0013	<0.0001	<0.001	<0.001	0.027	<0.001	<0.02	<0.05

All units are in mg/L excluding Turbidity
Turbidity Unit: NTU (Nephelometric Turbidity Units)

TABLE V
RO FEED WATER AND PERMEATE QUALITY AFTER ADDING ACTIFLO® AGAINST EPA DISCHARGE LIMITS [12], [19]

Indicator	Limit Type	Unit	RO Feed Water Quality	ROP Quality	Discharge Limit
pH	Min/Max	pH	7.6	7.48	6-9
Antimony	Max	Mg/L	21.3	0.03	0.114
Arsenic	Max	Mg/L	0.001	0.001	0.001
Cadmium	Max	Mg/L	0.0001	0.0001	0.002
Chromium	Max	Mg/L	0.001	0.001	0.002
Copper	Max	Mg/L	0.001	0.001	0.007
Iron	Max	Mg/L	0.05	0.05	0.13
Lead	Max	Mg/L	0.001	0.001	0.008
Nickel	Max	Mg/L	0.027	0.001	0.002
Zinc	Max	Mg/L	0.015	0.04	0.062
DO as Mg/L	Max	10th Percentile	8.67	9.2	8.5
TDS	Max	Mg/L	5703	147	450
Turbidity	NTU	75th Percentile	3	0.5	10

b) Total Dissolved Solids

As shown in Figs. 8-10, Actiflo® had limited capability of removing inorganic and dissolved organic matters in mining wastewaters. Based on Table II, on average, TDS concentration has been increased by 15 percent during the period between Februarys to June 2018. This is due to releasing ions that comprise TDS from drilling rocks when underground water flows over them. Generally speaking, not all the TDS increases are related to performance of pre-treatment equipment, this occurs as a result of formation changes while drilling. The chemical properties of mining wastewaters vary, depending on the formation from which the wastewater was produced. The increase of TDS infers a contribution of naturally occurring brine during drilling from February to June 2018. According to the results, Actiflo® does not have any significant contribution on further reducing TDS level of RO feed water. Advanced treatment by membrane filtration is required to efficiently reduce TDS levels in mining effluents.

c) Sulfate, Chloride and Dissolved Major Cations

As can be seen in Figs. 11-16, changes in average concentration of sulfate and chloride and dissolved major cations in RO feed water for the entire evaluated period are negligible. In addition, the same month data of the levels of sulfate, chloride and dissolved major cations between two different years confirms this. Actiflo® does not further improve the removal of sulfate, chloride and dissolved major cations, and advanced post treatment methods including RO, electrodialysis and distillation can be applied to reduce the chloride, sulfate and major dissolved component content of mining wastewater.

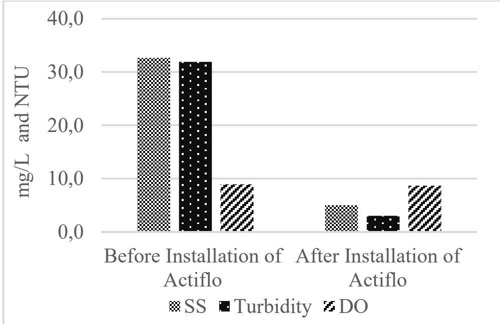


Fig. 5 Average concentration of SS, DO, and Turbidity in RO feed water for the entire evaluated period

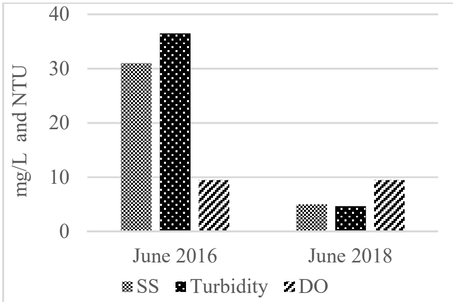


Fig. 6 Concentration of SS DO and Turbidity in RO feed water in June 2016 and June 2018

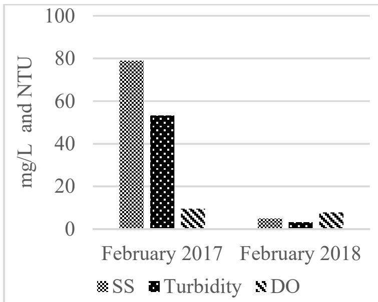


Fig. 7 Concentration of SS, DO, and turbidity in RO feed water in February 2017 and February 2018

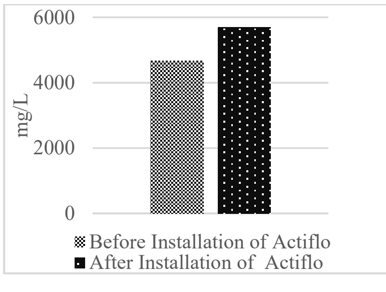


Fig. 8 Average concentration of TDS in RO feed water for the entire evaluated period

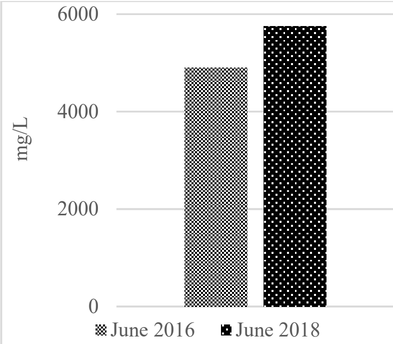


Fig. 9 Concentration of TDS in RO feed Water in June 2016 and June 2017

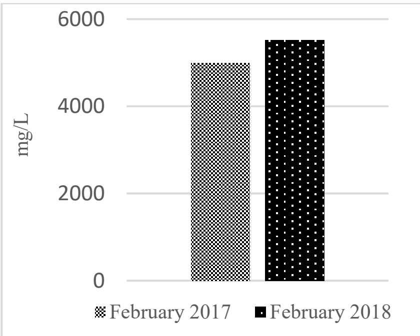


Fig. 10 Concentration of TDS in RO feed Water in February 2017 and February 2018

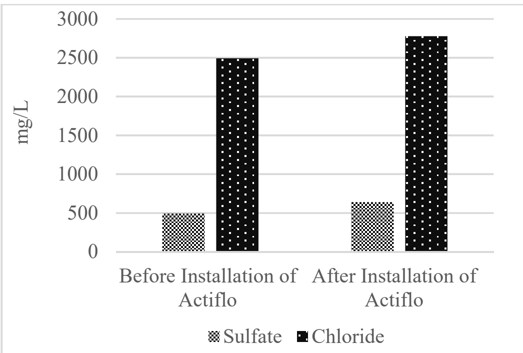


Fig. 11 Average concentration of sulfate and chloride in RO feed Water for the entire evaluated period

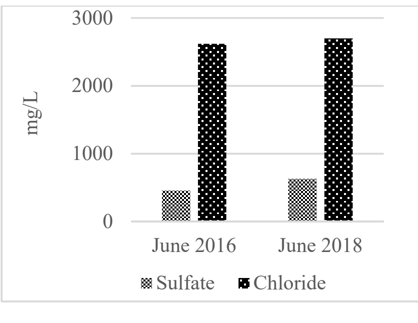


Fig. 12 Concentration of sulfate and chloride in RO feed Water in June 2016 and June 2018

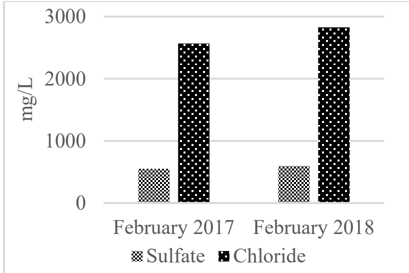


Fig. 13 Concentration of sulfate and chloride in RO feed Water in February 2017 and February 2018

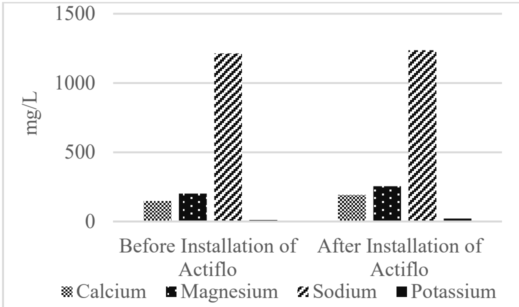


Fig. 14 Average concentration of dissolved major cations in RO feed water for the entire evaluated period

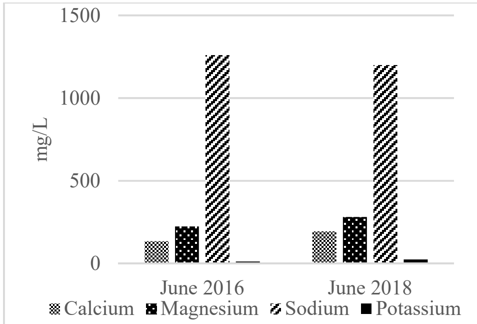


Fig. 15 Concentration of dissolved major cations in RO feed water in June 2016 and June 2018

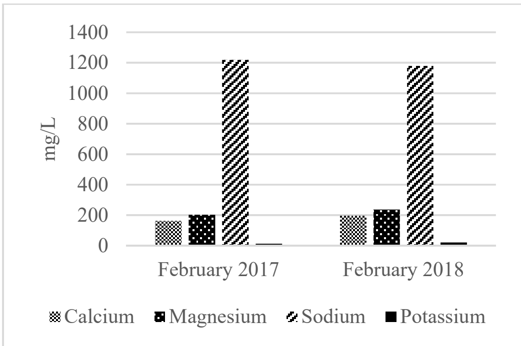


Fig. 16 Concentration of dissolved major cations in RO feed Water in February 2017 and February 2018

d) Dissolved Metals

Average concentration of dissolved metals in RO feed water for the entire evaluated period plus same month values of dissolved metals between two different years are presented in

Figs 17-25. According to Tables III and IV, the monthly trend and average values of dissolved metals showed that Actiflo® was capable of improving the removal of Arsenic in pre-treatment system; however, It has negligible effect on improving removal of some other dissolved metals including cadmium, chromium, copper, lead, iron and antimony. Increase in levels of nickel and zinc in RO feed water in February 2018 was certainly due to increase in initial values of nickel and zinc in raw wastewater on that time, and pre-treatment system containing Actilfo® did not efficiently reduced their level. Consequently, post- treatment by RO shall be incorporated on Actiflo® system to effectively reduce heavy metals concentration in final effluent for water reuse or disposal purposes.

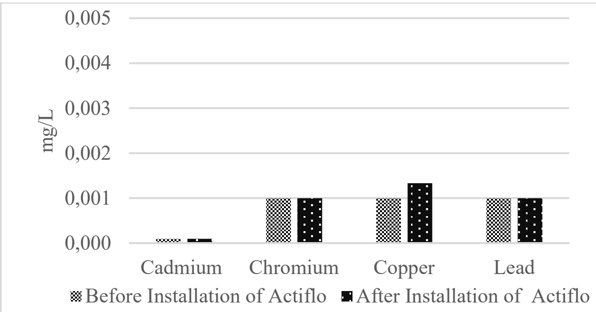


Fig. 17 Average concentration of Cadmium, Chromium, Copper and Lead in RO feed Water for the entire evaluated period

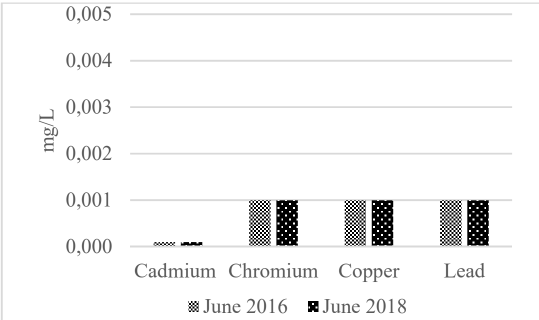


Fig. 18 Concentration of cadmium, chromium, copper and lead in RO feed Water in June 2016 and June 2018

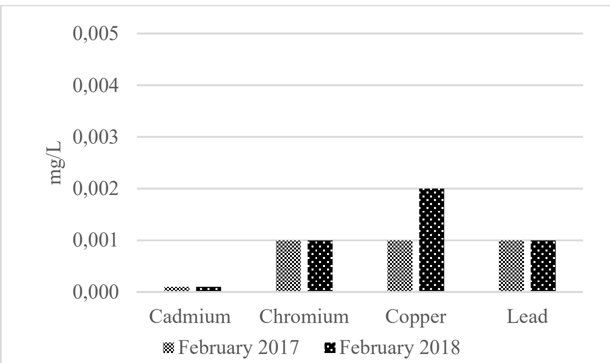


Fig. 19 Concentration of cadmium, chromium, copper and lead in RO feed Water in February 2017 and February 2018

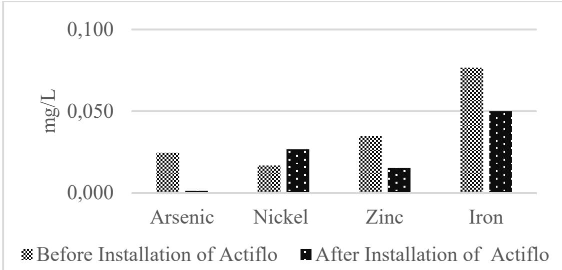


Fig. 20 Average concentration of arsenic, nickel, zinc and iron in ro feed water for the entire evaluated period

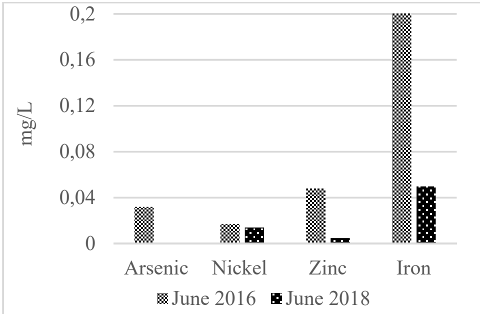


Fig. 21 Concentration of arsenic, nickel, zinc and iron in RO feed Water in June 2016 and June 2018

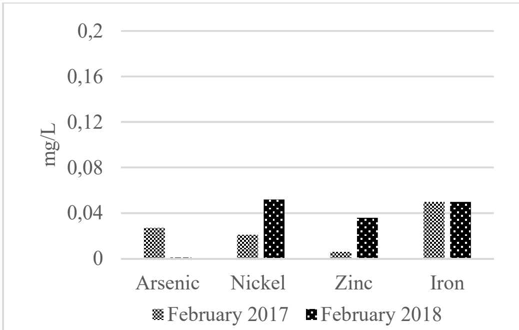


Fig. 22 Concentration of arsenic, nickel, zinc and iron in RO feed Water in February 2017 and February 2018

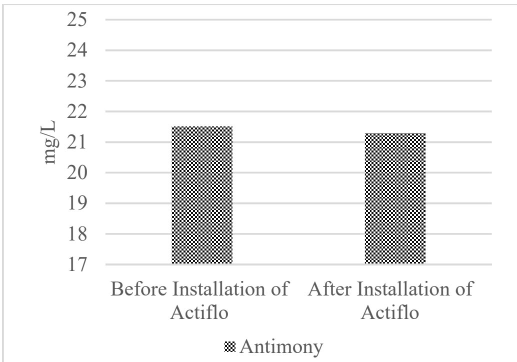


Fig. 23 Average Antimony level in RO feed water for the entire evaluated period

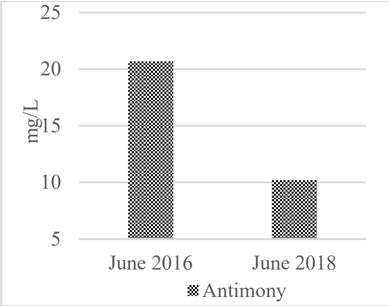


Fig. 24 Antimony level in RO Feed water in June 2016 and June 2018

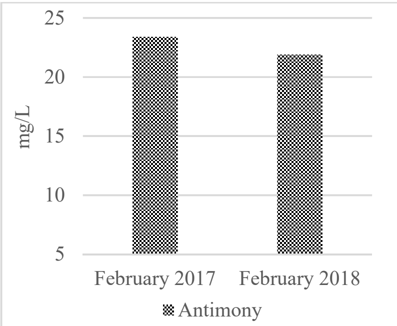


Fig. 25 Antimony level in RO Feed water in February 2017 and February 2018

IV. Conclusion

The data analysis carried out show that adding Actiflo® to pre-treatment system significantly improves the quality of RO feed water. It is capable of improving turbidity and suspended solids removal efficiencies of 85% and 91% respectively, hence in the long term, the risk of RO membrane physical damage and irreversible fouling will be minimized. In addition, average concentration of Arsenic has been reduced by 99.6% in RO feed water since Actiflo® has been installed. Based on the EPA guideline for water discharge, the pre-treatment system consisting of Actiflo® clarifier meets most of water quality discharge standards with the exception of TDS, DO, nickel and antimony content. By comparing RO permeate quality before and after adding Actiflo®, it is observed that antimony level is significantly reduced in RO permeate, and meets EPA compliance for discharge. Also, high concentration of TDS in RO feed water confirms that Actiflo® has limited capability in removing inorganic salt and organic matters that are dissolved in mining wastewaters. Advanced post treatment by RO is required to meet all discharge limits established by EPA Victoria.

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