MF PRESERVATIONS, ISSUES AND LESSONS LEARNT AT LUGGAGE POINT ADVANCED WATER TREATMENT PLANT

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ABSTRACT

During extended shutdown periods it is necessary to preserve microfiltration (MF) racks to inhibit biological growth on the fibres within the membrane. Biological growth on the fibres will lead to reduced performance when the units are put back into service, with extensive chemical cleaning necessary to improve performance to acceptable levels.

The Luggage Point Advanced Water Treatment Plant (AWTP) has gone through two extended shutdown periods where it has been necessary to preserve all of the MF racks. After the initial shutdown, the success of the preservation process was measured by the extent of decay of the preservation solution. At Luggage Point AWTP, the decay of the preservation solution demonstrated greater than expected results. Thus, in the subsequent shutdown period, daily monitoring was conducted to monitor the performance of the preservation process. This paper will discuss some of the issues observed at the Luggage Point AWTP during the preservation processes. The results of the daily testing conducted will be presented, with the observed rate of the preservation solution degradation discussed.

1.0 INTRODUCTION

During periods of extended shutdown (typically greater than 4 days) preservation of the Micro Filtration (MF) racks is necessary. Preservation of the MF racks is required to prevent biological growth and fouling of the membrane fibres. Biological growth and fouling of the membrane fibres will in turn lead to reduced performance when the units are put back into service, with extensive chemical cleaning necessary to improve performance of the membranes back to acceptable levels.

Before the MF units are put into preservation it is necessary to conduct chemical cleaning of the membranes to remove both biological growth, organics and metals from the fibres. The units are put through what is referred to a "clean in place" (CIP) which involves an initial clean with citric acid and sulphuric acid solution to remove metals followed by a sodium hypochlorite and sodium hydroxide solution to remove organics. After this process is completed the rack can be put into preservation. The preservation process involves the makeup of preservation solution; with the use of reverse osmosis (RO) permeate water and sodium hypochlorite. The rack is first flushed to ensure it is free of contaminates and then the preservation solution is batched and circulated through the rack, completing the preservation process. The preservation solution was batched to a concentration 100mg/L.

The Luggage Point Advanced Water Treatment plant (AWTP) has undergone two extended shutdown periods where it has been necessary to preserve all of the MF racks. Luggage Point AWTP has eleven Pall manufactured (Pall Corporation, Port Washington, NY) MF racks with each rack containing 122 modules. After the initial shutdown the extent of decay of the preservation solution was questioned, and as a result daily monitoring of the preservation solution was conducted during the secondary shutdown. The results of the daily monitoring will be discussed.

2.0 DISCUSSION

2.1 Initial Shutdown

During the initial shutdown at Luggage Point AWTP the preservation was completed following the aforementioned process. Sampling of preservation solution was very limited with the bulk of the analysis conducted during the development of the preservation procedure in order to ensure that the preservation solution strength was at 100mg/L. Sampling of the preservation solution midway through the shutdown period was attempted. However, due to lack of suitable sampling locations and health and safety risks involved, extensive sampling wasn't conducted. The samples that were taken did show a marked decay in the preservation solution; however the extent to which these samples are representative of the entire sampling period is questionable.

System limitations were identified during the first shut down period. The required operator intervention and monitoring at all stages of the process and was a timely and labour intensive process. The preservation process used RO permeate water for batching and flushing however the RO units were in preservation and therefore unable to produce permeate for the service water required to complete any re-preservations of the MF modules.

After the shutdown it became evident that further monitoring of the MF modules would be beneficial to gain a better understanding of the decay of the preservation solution. An automated preservation sequence would be favourable for future preservations.

2.2 Secondary Shutdown

Luggage Point AWTP had a secondary shutdown period from August 2010 to February 2011. Prior to this shutdown, works were undertaken to install a sample point on the inlet manifold to each of the MF racks to enable daily sampling. The same shutdown and preservation procedure undertaken during the initial shutdown period was repeated to preserve the racks. An automated preservation recipe was also developed making the preservation process much less complicated.

After the preservations had been completed sampling was conducted on the MF racks to assess the free chlorine and total iron concentrations present. Iron was tested as it was anticipated that there would be some residual carryover as a result of the flocculation/clarification process undertaken upstream on the MF racks. While regular backwashing and chemical cleans are undertaken to remove iron, the effectiveness of these cleans at removing all residual iron is difficult to determine. The iron, when combined with the chlorine, results in precipitation of the iron and could lead to the decay of the preservation solution. Sampling showed elevated levels of iron and chlorine levels that varied significantly between the racks. The results obtained during the first fortnight of sampling indicated that the preservation solution was decaying significantly to the point where all chlorine was being exhausted and elevated iron levels were present. These factors indicated that subsequent re-preservation of the MF racks was required. Figure 2.1 and 2.3 present the free chlorine concentrations in MF racks 1-5 and 6-11 respectively. These figures clearly demonstrate that the free chlorine concentration degraded significantly and increased sharply when re-preservation was performed. Figure 2.2 and 2.4 present the total iron concentrations in MF racks 1-5 and 6-11 respectively. These figures demonstrate an increase in the total iron concentration as free chlorine concentration decreases.

A decrease in the total iron concentration can be seen subsequent to the re-preservation. It was concluded that the chlorine was precipitating out the remaining iron in the MF rack and the iron was slowly being flushed through the racks with time and subsequent flushes/re-preservations. This indicates that re-preservations are necessary on all of the MF racks, in order to retain effective chlorine residual and inhibit biological growth.

As it became evident that secondary re-preservations would be required, a temporary service water line was installed that utilised potable water in order to provide an alternate source of water for the re-preservation process. After the installation of the temporary service water line re-preservations of the MF racks were undertaken. The effect of re-preservation on the total iron concentration can be seen in Figure 2.1 and 2.2, after the 18/08/2010. Post 18/08/2010 a similar pattern was observed with chlorine residuals degrading significantly, however the peak total iron concentrations were not as high as the concentrations observed after the first preservation sequence, which indicates that the total iron was being flushed out by the preservation solution.

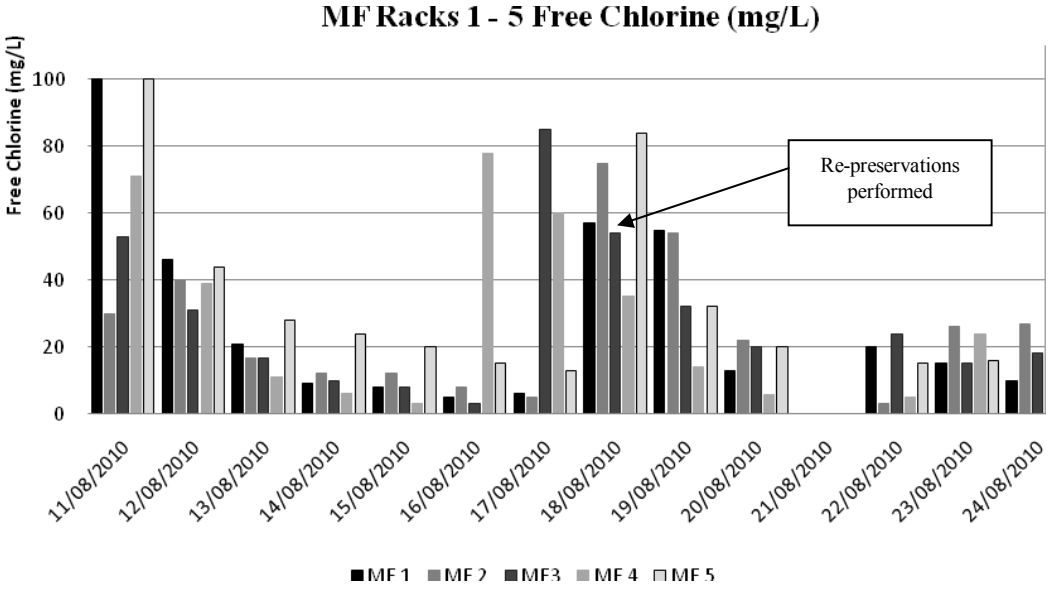

Figure 1: ***Free Chlorine Residual (mg/L) MF racks 1 –5***

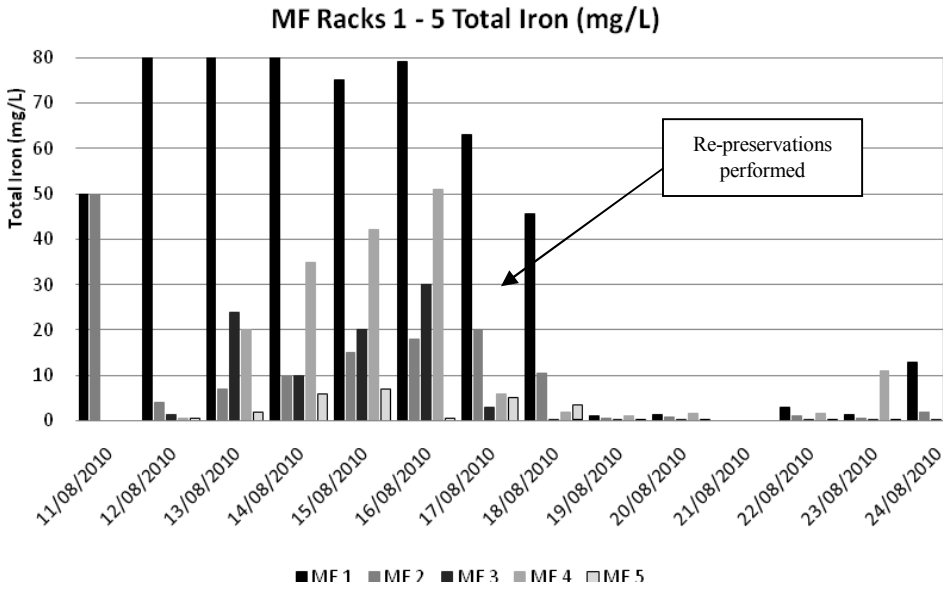

Figure 2: ***Total Iron (mg/L) MF racks 1 – 5***

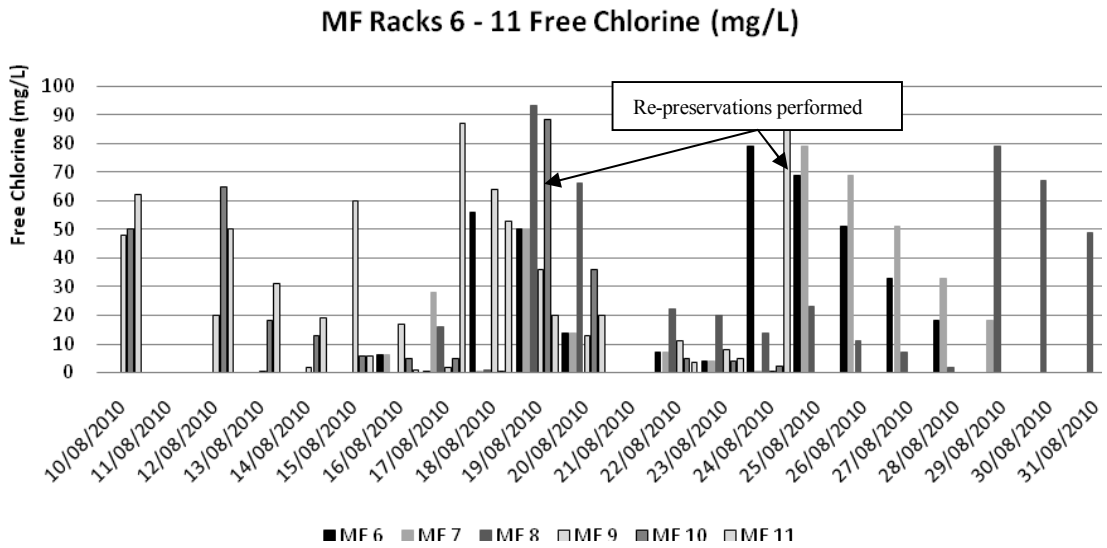

Figure 3: ***Free Chlorine Residual (mg/L) MF racks 6 –11***

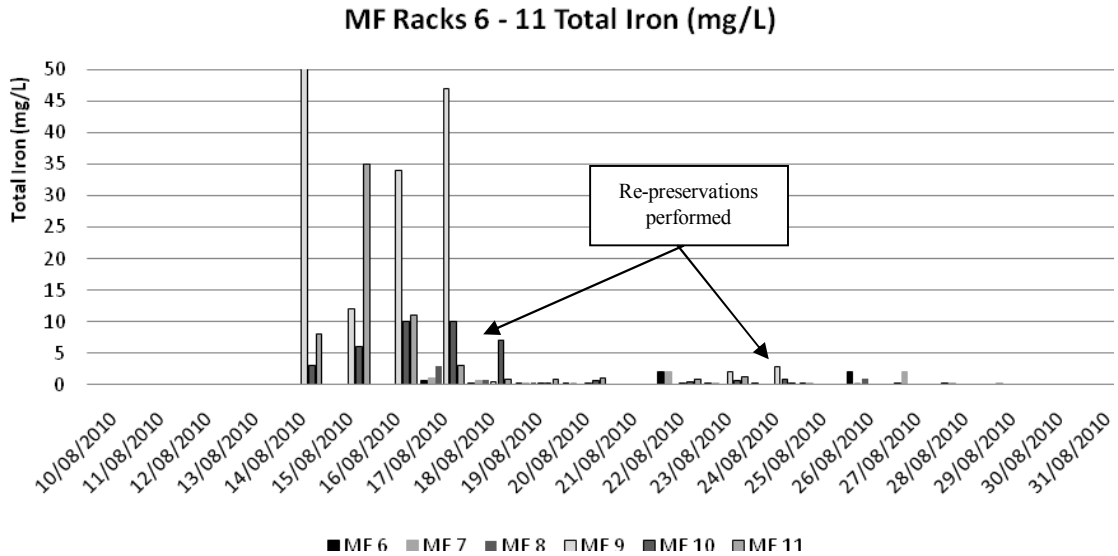

Figure 4: ***Total Iron (mg/L) MF racks 6 – 11***

The results of the sampling period also indicated that three of the racks (MF racks one, four and nine) continued to display higher than expected chlorine degradation and total iron concentrations. To remove this excess iron, secondary CIP's were performed with citric acid. Post the CIP's, the racks were re-preserved. Figure 2.5 depicts the response of MF rack 9 to the citric acid CIP. In this example a citric acid CIP was performed twice on the same day. Immediately after the first citric acid CIP the racks was put back into preservation and sampled to ensure the concentration of the preservation solution were acceptable. As demonstrated in the figure the free chlorine concentration is approximately 80 mg/L following a re-preservation, with slightly elevated total iron levels. Subsequent sampling two hours later showed a dramatic increase in total iron (to approximately 250mg/L) and significant degradation of free chlorine concentration to 5 to 10mg/L. An additional citric acid CIP was performed and sampling of the preservation solution performed which showed similar results to those obtained after the first citric acid CIP and re-preservation. Generally total iron values after a preservation are quite low and slowly increase over days.

The introduction of a citric acid CIP had a significant effect in removing the iron into solution, where it was subsequently precipitated once the rack was preserved again. Similar responses were also observed in MF racks one and four after citric acid CIP's were performed. Once the excess iron was removed the racks returned to a normal re-preservation sequence requiring re-preservation every three to five days. Similar to that observed in the other MF racks.

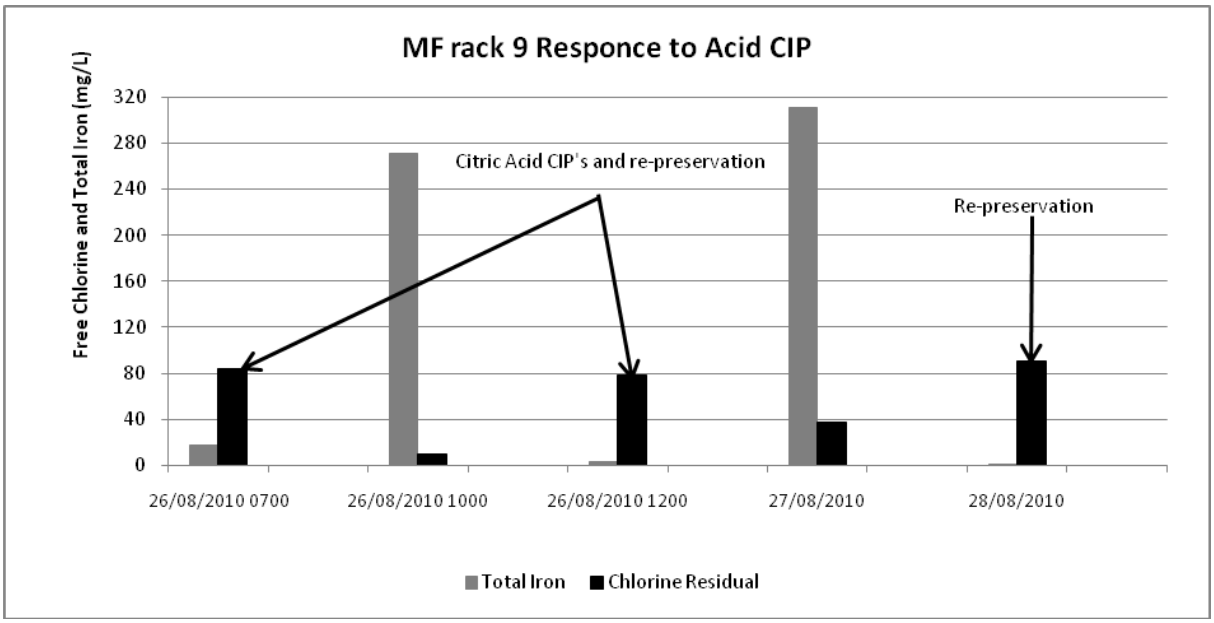

Figure 5: ***MF 9 Response to Citric Acid CIP***

After the initial week of sampling and subsequent re-preservations, it became apparent the re-preservation of the MF racks would be required every two to three days. After the first month this was able to be reduced to once a week, as the iron levels started to decrease significantly and chlorine residuals started to remain steady. It was observed that once the total iron concentration reached above 0.15 mg/L the free chlorine residual began to degrade rapidly. A protocol was adopted that if either total iron reached levels around 0.15 mg/L or the free chlorine residual dropped below 10 mg/L a re-preservation was performed in order to ensure biological fouling of the fibres in the membrane did not occur.

In late November 2010 five MF racks where taken out of preservation and put back into service for recommissioning of the plant. They were later put back into preservation in late December. Prior to being put into preservation a CIP was not performed. It was anticipated that due to low loading on the plant, there would be very little organic fouling or metals build up in the MF racks. However sampling showed the preservation solution was decaying overnight with very little free chlorine remaining combined with an increase in total iron levels. As a result of the increase in total iron, it was decided that citric acid CIP's are necessary. As a result of the citric acid CIP's the chlorine and iron levels started to return to normal conditions, with re-preservations required every three to five days on average. This indicates that CIP's are necessary before putting a rack into preservation to ensure the removal of excess contaminates.

When all the MF racks were returned back into normal service in February 2011, they all exhibited normal rates of performance, with no fouling observed and additional chemical cleans not necessary.

3.0 CONCLUSIONS

The Luggage Point AWTP has been through two extended shutdown periods. After the first shutdown a number of questions still remained regarding the effectiveness of the preservation solution. Subsequently during the second shutdown period monitoring of the MF racks was conducted to assess extent of decay of the preservation solution.

The extent of decay of the preservation solution was greater than what was expected. It became apparent the presence of iron in the MF racks was having a significant effect on the effectiveness of the preservation solution. This in turn required additional acid cleaning to be performed on the MF racks to remove the excess iron. It can be concluded that adequate chemical cleaning of the MF racks prior to them being put into preservation is a must. To assess the success of this cleaning at removing contaminants from the membranes daily sampling needs be conducted to gain an understanding of the processes occurring.

In the initial design of many systems the provision of an alternative supply of service water is often not considered necessary; however an alternative supply of water for use during non routine operations needs to be considered. As was experienced at Luggage Point AWTP an alternative supply of service water was essential. At the completion of the secondary shutdown a permanent alternative water supply line was installed, for the use on future shutdown periods.

In conclusion, the daily monitoring of the MF racks provided invaluable data that indicated the preservation solution was decaying significantly. This was largely due to the presence of excess iron within the racks. With additional acid cleaning this was removed and the rate of decay of the preservation solution was within acceptable levels. Daily monitoring ensured that no fouling occurred and that the racks returned back to normal performance levels.