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Evaluation of a PeCOD Monitoring Device for Use in Pulp and Paper Operations. Phase 1: Comparison of PeCOD to the conventional Dichromate COD Method for Conventional Pulp Mills

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Prepared by:
Brian O'Connor and Serge Genest, FPInnovations
570 St. Johns Blvd, Pointe-Claire, Quebec, Canada

Prepared for:
Stephen Moore and Robert V. Menegotto, Mantech
5473 Highway 6 North, Guelph, Ontario, Canada

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CONTACT

Brian O'Connor
Research Manager
Environment & Sustainability
514-630-4121
brian.oconnor@fpinnovations.ca

Serge Genest
Associate Research Leader
Environment & Sustainability
514-782-4482
serge.genest@fpinnovations.ca

Table of contents

List of figures

List of tables

1. BACKGROUND

In the pulp and paper industry the impact of dissolved organics, as measured by COD, can have a large influence on cost and performance in the area of brownstock washing for kraft mills as well as for the optimum control of the wastewater treatment plant for all types of pulping operations (such as bleached chemi-thermomechanical pulp (BCTMP) and thermomechanical pulp (TMP)). Since robust on-line samplers for COD are not currently available, most kraft mills will resort to the use of soda loss or conductivity as an indicator of brownstock washing efficiency. With respect to the mills treatment system, due to the lack of on-line COD measurement methods, most mills will use residual nutrients or a daily COD analysis as an indication of performance for COD and BOD reduction and control. The implementation of a simple and robust on-line COD analysis, such as the PeCOD system, would be of benefit and help mills address both cost and performance factors.

However, before opportunities are developed for the use of PeCOD in the pulp and paper industry, it is essential that the PeCOD system can correlate well with traditional measurement techniques employing dichromate. For future use scenarios, in kraft mills key areas of interest would be brownstock washer filtrates, and primary and secondary treated effluents. For mechanical pulp mill operations, primary and secondary treated effluents as well as points in the white water system could also be of interest.

2. OBJECTIVES

There were two objectives for this work divided into Phase 1 and Phase 2. The objective of Phase 1 was to compare the PeCOD analysis results, obtained using both Mantech's benchtop L100 analyzer and its P100 on-line system, to the conventional method for COD analyses in use at all mills which employs dichromate, for a variety of representative pulp mill effluents. The second objective (Phase 2) was to test the on-line system to examine its operation using select samples associated with either Kraft of mechanical pulp mill operations.

3. PHASE 1: COMPARISON OF PECOD TO THE CONVENTIONAL DICHROMATE COD METHOD

For this phase of the work FPInnovations procured representative samples of effluents from kraft and mechanical pulp mills, which represent the main industry in Canada. In order to examine an appropriate range of concentrations and to develop statistical comparisons, the samples were analyzed in triplicate for PeCOD (using both L100 and P100 setups), COD and filtered COD (using the standard HACH dichromate method). The effluent samples were all filtered before analysis using 35 µm PE filters. Comparisons of kraft and TMP primary and secondary treated effluents, across a range of representative concentrations, were conducted in order to obtain a robust comparison for the mill process effluents. Also, for each sample, the turbidity, chloride and sulfate content and the pH was determined. The original primary effluent sample and select samples were also sent for BOD analysis to a contract laboratory.

3.1. KRAFT MILL EFFLUENTS

Primary treated and secondary treated effluent samples were obtained from five separate Canadian Kraft mills. The samples were kept in cold storage until analysis. Historical data obtained by FPInnovations indicated that Kraft primary effluents can have COD values ranging from 300-2500 with an average of 980 mg/L. Kraft secondary treated effluents were found to have COD values ranging from 180-900 with an average of 450 mg/L. Based on the expected COD levels, the Yellow sensor (for COD values up to1500 mg/L) was employed in the L100 and P100 units..

3.1.1. PRIMARY TREATED KRAFT MILL EFFLUENTS

Primary treated effluents from three Kraft mills were utilized for the comparison. In addition, the effluent from Mill A was spiked with a concentrated effluent sample in order to generate a range of concentrations and was also spiked with varying levels of condensate or weak black liquor to simulate sewer losses. The samples were all filtered before analysis using 35 µm PE filters. For the dichromate method, the samples were analyzed both filtered and unfiltered. For each sample, the turbidity, chloride, sulfate content and the pH was also determined. Select primary effluent samples were sent for BOD analysis to a contract laboratory. The results of all the COD analysis are provided in Table 1. The other chemical analysis parameters are provided in the Appendix.

The data for the HACH dichromate method indicate that the removal of the filterable material did not have a large impact on the COD levels measured. For the samples analyzed, it was observed that the difference between unfiltered and filtered dichromate data was minimal with the unfiltered values being 0-4.9% higher than the filtered values. This is important as it indicates that the solids are not important contributors to total COD and that the filtering required for the PeCOD units will not represent significant losses in comparison to the unfiltered dichromate method.

In terms of reproducibility, based on the triplicate analyses that were conducted, the L100 and the P100 data were very consistent with low variability comparable to what was observed for the dichromate method. The average % standard deviations were as follows: L100 (1%); P100 (1.9%); filtered dichromate (1%) and unfiltered dichromate (1.7%)

Table 1. Comparison of PeCOD L100, P100 and Hach Dichromate COD results for Kraft Primary Treated Effluents

Mill Sample ID	L100, mg/L (% SD)	P100, mg/L (% SD)	L100:P100 Diff., %	Hach, mg/L		
				Filtered (% SD)	Unfiltered (% SD)	% Diff.
A1	353 (1.3)	334 (5.9)	5.6	286 (0.9)	288 (0.7)	0.7
A2	670 (2.1)	647 (1.5)	3.5	553 (0.6)	571 (4.4)	3.2
A3	922 (1.6)	924 (0.2)	-0.2	810 (0.3)	814 (1.0)	0.5
A4	1224 (1.4)	1148 (3.7)	6.2	1082 (1.5)	1086 (0.9)	0.4
A5	1567 (1.4)	1531 (2.8)	2.3	1405 (1.0)	1434 (1.0)	2.0
B1	739 (0.6)	602 (1.4)	18.5	634 (1.8)	800 (7.5)	2.1
B2	672 (1.3)	595 (0.3)	11.6	674 (0.3)	701 (1.4)	3.9
C1	1405 (0.9)	1379 (2.4)	1.8	1088 (1.4)	1130 (0.5)	3.7
A7 (+Cond)	1045 (1.0)	1120 (1.1)	-7.2	1193 (1.8)	1237 (1.7)	3.6
A8 (+Cond)	1348 (0.4)	1416 (0.8)	-5.1	1453 (1.2)	1487 (0.5)	2.3
A9 (+ cond)	608 (1.1)	701 (0.3)	-15.3	635 (0.5)	668 (21)	4.9
A10 (+ cond)	903 (0.8)	975 (1.1)	-8.0	938 (1.1)	937 (0.3)	0
A11 (+ cond)	1476 (0.6)	1632 (2.2)	-10.6	1548 (1.3)	1536 (0.7)	-0.5
A12 (+WBL)	1216 (1.8)	1033 (0.7)	15.1	1177 (1.8)	1203 (1.6)	2.2
A13 (+WBL)	1568 (0.6)	1368 (2.5)	12.8	1637 (0.5)	1623 (2.2)	-0.8
A14 (+WBL)	680 (1.0)	769 (1.8)	-13.1	657 (0.5)	657 (1.7)	0
A15 (+ WBL)	1051 (0.3)	1177 (0.4)	-12.0	1065 (1.0)	1066 (0.6)	0.1
A16 (+WBL)	1489 (1.2)	1578 (1.1)	-6.0	1495 (0.7)	1498 (0.5)	0.2

Cond: Condensate; WBL: Weak black liquor.

For the primary treated effluents from the 3 mills, the L100 and P100 PeCOD values were observed to be on average slightly higher than those obtained with the filtered dichromate method. For the regular effluents the L100 values were on average 116% (90-129) of the dichromate values while the P100 values were on average 109 % (90-130) of the dichromate values. For the effluents spiked with condensate or weak black liquor the relationship was slightly lower with L100 values 97% (88-104) of the dichromate and the P100 values 102 % (90-110) of the dichromate results. The difference in response to these spiked effluents could potentially be due to various organic or inorganic components in the condensate or weak black liquor that affect or interfere with the reactivity of the PeCOD sensors.

A comparison of the L100 data versus the filtered dichromate and the P100 versus the filtered dichromate is provided in Figures 1 and 2, respectively.

For the PeCOD L100 versus filtered dichromate (Figure 1), the following linear correlations were observed.

For effluents samples only:

$$L100 = 1.15 \times \text{Filtered dichromate};\ r^2 = 0.97$$

For effluents spiked with condensates:

$$L100 = 0.93 \times \text{Filtered dichromate};\ r^2 = 0.99$$

For effluents spiked with weak black liquor:

$$L100 = 0.99 \times \text{Filtered dichromate};\ r^2 = 0.99$$

For the PeCOD P100 versus filtered dichromate (Figure 2), the following linear correlations were observed.

For effluents samples only:

$$P100 = 1.1 \times \text{Filtered dichromate};\ r^2 = 0.94$$

For effluents spiked with condensates:

$$P100 = 1.0 \times \text{Filtered dichromate};\ r^2 = 0.96$$

For effluents spiked with weak black liquor:

$$P100 = 0.96 \times \text{Filtered dichromate};\ r^2 = 0.70$$

The results suggested that both L100 and P100 systems gave very good correlations with the filtered dichromate method and would be able to provide fairly accurate predictions of mill effluent COD values. The addition of the condensate or weak black liquor reduced the L100 and P100 values slightly as compared to the filtered dichromate method. It was noted that for individual samples there could be differences in the benchtop L100 unit as compared to the on-line P100 unit. These differences were variable and the values for the L100 could be either somewhat greater (up to 18% higher) or up to 15% lower than the comparable P100 values.

3.1.2. SECONDARY TREATED KRAFT MILL EFFLUENTS

Secondary treated effluents from four Kraft mills were analyzed during this phase of the project. The effluent from Mill A was spiked with concentrated effluent to generate a range of COD concentrations. Four effluent samples from three different mills were also tested to examine whether mill variability would have an impact on the correlations. For the secondary treated effluents no spiking experiments were conducted since in mill operations the final effluent COD variability would be dependent on the overall efficiency of treatment and not necessarily on mill losses. The results of all the COD analysis are provided in Table 2. The other chemical analysis parameters are provided in the Appendix.

Again, the data for the HACH dichromate method indicate that the removal of the filterable material did not have a large impact on the COD levels measured. In terms of reproducibility, based on the triplicate analyses that were conducted, the L100 and the P100 data were again very consistent with low variability comparable to what was observed for the dichromate method. The average % standard deviations were as follows: L100 (1.6%); P100 (2.3%); filtered dichromate (2.5%) and unfiltered dichromate (1.0%).

Table 2. Comparison of PeCOD L100, P100 and Hach Dichromate COD results for Kraft Secondary Effluents

Mill Sample ID	**L100** (% SD)	**P100** (% SD)	**L100/P100 Diff., %**	**Hach Filtered** (% SD)	**Hach Unfiltered** (% SD)
A1	276 (0.6)	238 (2.6)	13.8	198 (3.9)	191 (1.5)
A2	535 (0.3)	509 (0.5)	4.9	405 (1.5)	389 (1.1)
A3	678 (1.7)	653 (2.3)	3.7	473 (1.0)	507 (0.6)
A4	806 (1.8)	763 (2.7)	5.3	571 (1.2)	626 (0.3)
A5	951 (1.6)	890 (2.3)	6.4	692 (2.5)	724 (0.8)
A6	1202 (0.9)	1151 (0.6)	4.2	898 (1.9)	933 (0.6)
B1	159 (3.8)	102 (5.1)	35.8	89 (7.4)	110 (2.4)
D1	552 (1.3)	492 (1.2)	10.9	363 (1.4)	415 (0.2)
D2	677 (2.8)	626 (1.1)	7.5	485 (2.1)	515 (1.6)
E1	345 (1.7)	272 (4.9)	21.2	251 (1.8)	264 (1.0)

A comparison of the L100 data versus the filtered dichromate and the P100 versus the filtered dichromate is provided in Figures 3 and 4, respectively.

For the PeCOD L100 versus filtered dichromate (Figure 3), the following linear correlation was observed.

$$L100 = 1.38 \times \text{Filtered dichromate};\ r^2 = 0.99$$

For the PeCOD P100 versus filtered dichromate (Figure 4), the following linear correlation was observed.

$$P100 = 1.30 \times \text{Filtered dichromate};\ r^2 = 0.99$$

In both cases there were very good correlations between the PeCOD values and the filtered dichromate results. For identical samples, in all cases the L100 was found to respond slightly higher than the P100 by an average of 11% (ranging from 4 - 35%).

In comparing all of the Kraft effluent data, it was observed that the slopes for the secondary treated vs primary treated effluents were slightly higher indicating a greater response of the PeCOD to secondary effluents as compared to primary treated effluents. It is possible that this may be related to the higher levels of recalcitrant COD that is present in the secondary treated effluents.

A comparison of the L100 versus the P100 PeCOD data, for all of the effluents (not including condensate or weak black liquor spikes), is provided in Figure 5. As mentioned previously, on average the response from the two instruments was very comparable, however there were both positive and negative differences observed for individual samples.

The correlation for the primary treated Kraft mill effluents was:

$$L100 = 0.99 \times P100;\ r^2 = 0.92$$

The correlation for the secondary treated effluents was:

$$L100 = 1.1 \times P100;\ r^2 = 0.99$$

3.2. MECHANICAL PULP MILL (TMP AND BCTMP) EFFLUENTS

Given the lower water usage associated with TMP and BCTMP mills the COD is typically higher than that found in Kraft mill effluents. Historical data obtained by FPInnovations indicates that TMP primary effluents have a COD ranging from 350-4550 mg/L, whereas BCTMP effluents can exhibit higher COD ranges of 2300-8700 mg/L. TMP secondary treated effluents were observed to have COD ranges of 47-217 mg/L, whereas BCTMP effluents were found to have COD ranges of 260-1200 mg/L.

3.2.1. PRIMARY AND SECONDARY TREATED EFFLUENTS

For this component of the study only a single primary treated effluent sample was obtained from a TMP mill (Mill F). The effluent as received had a very high dichromate COD level and hence required various dilutions with water to bring it into a range suitable for analysis using the Yellow range PeCOD detectors. Secondary treated effluents were obtained from Mill F as well as two samples from TMP Mill J and three samples from BCTMP Mill I. The samples were kept in cold storage until analysis.

A comparison of the L100 and P100 PeCOD data with the dichromate filtered and unfiltered data, for both primary and secondary treated effluents, is provided in Table 3. Additional chemical analysis parameters are provided in the Appendix.

In terms of the impact of solids on total effluent COD, the results indicate that for primary treated TMP effluents the solids are not significant and contribute only 2-4% to the overall COD. In terms of reproducibility, based on the triplicate analyses that were conducted, the L100 and the P100 data were again very consistent with low variability comparable to what was observed for the dichromate method. The average % standard deviations were as follows: L100 (0.9%); P100 (2.8%); filtered dichromate (1.1%) and unfiltered dichromate (1.8%).

Table 3. Comparison of PeCOD L100, P100 and Hach Dichromate COD results for Mechanical Pulp Mill Primary and Secondary Treated Effluents

Mill Sample ID	L100 (% SD)	P100 (% SD)	L100:P100 Diff., %	Hach Filtered (% SD)	Hach Unfiltered (% SD)
Primary Treated Effluents					
F1 - TMP	1253 (0,5)	1411 (3.6)	-13	1373 (0.3)	1400 (0.7)
F2 - TMP	1093 (1.4)	1059 (1.6)	3	1030 (0.6)	1052 (1.9)
F3 - TMP	591 (0.9)	561 (4.6)	5	571 (0.2)	585 (0.3)
F4 - TMP	442 (0.2)	407 (1.7)	8	430 (0.8)	438 (0.6)
Secondary Treated Effluents					
F1 - TMP	664 (2)	661 (3.4)	1	498 (1.3)	521 (2.4)
F2 - TMP	348 (0.7)	315 (1.6)	10	248 (1)	257 (1.0)
F3 - TMP	176 (0.4)	151 (4)	14	124 (1.4)	136 (3.1)
F4 - TMP	62 (1.1)	94 (9)	-51	46 (0)	54 (5.4)
J1 - TMP	281 (1.3)	334 (0.9)	-19	243 (0.2)	244 (1.7)
J2 - TMP	278 (0.9)	334 (2.4)	-20	245 (5.5)	247 (2.6)
I1 - BCTMP	1346 (0.9)	1465 (2.1)	-9	1175 (0.6)	1196 (0.8)
I2 - BCTMP	1275 (0.1)	1383 (0.9)	-8	1069 (1)	1086 (1.9)
I3 - BCTMP	1264 (1.7)	1384 (0.4)	-10	1078 (0.7)	1113 (1.0)

A comparison of the L100 data versus the filtered dichromate and the P100 versus the filtered dichromate, for the primary and secondary treated effluent samples is provided in Figures 6 and 7, respectively.

For the PeCOD L100 versus filtered dichromate (Figure 6), the following linear correlation was observed for the mechanical pulp mill effluents.

Primary Treated: L100 = 0.98 x Filtered dichromate; r^2 = 0.96

Secondary Treated: L100 = 1.18 x Filtered dichromate; r^2 = 0.99

For the PeCOD P100 versus filtered dichromate (Figure 7), the following linear correlation was observed for the mechanical pulp mill effluents.

Primary Treated: P100 = 1.0 x Filtered dichromate; r^2 = 0.99

Secondary Treated: P100 = 1.28 x Filtered dichromate; r^2 = 0.99

In both cases there were excellent correlations between the PeCOD values and the filtered dichromate results.

As was observed in the Kraft mill testing there was variability in the response of the L100 as compared to the P100 data, for identical samples. For the primary treated effluents the L100 data was higher 3 out of 4 times (3-8% greater) and lower one time (13% lower). For the secondary treated effluents which contained more diverse samples (2 TMP and 1 BCTMP mill) the L100 data was higher 3 out of 9 times (1-10% higher) and lower 6 out of 9 times (2-20% lower if we disregard one obvious outlier).

Again, a comparison of all of the mechanical effluent data indicated that the slope for the secondary treated vs primary treated effluents were always slightly higher indicating a greater response of the PeCOD to secondary effluents as compared to primary treated effluents. We would again postulate that this may be related to the higher levels of recalcitrant COD expected to be present in the secondary treated effluents.

A comparison of the L100 versus the P100 PeCOD data, for all of the mechanical pulping effluents is provided in Figure 8. As mentioned previously, on average the response from the two instruments was very comparable, however there were both positive and negative differences observed for individual samples.

The correlation for the primary treated mechanical pulp mill effluents was:

L100 = 0.96 x P100; r^2 = 0.95

The correlation for the secondary treated mechanical pulp mill effluents was:

L100 = 0.92 x P100; r^2 = 0.99

4. SUMMARY

In this study a comparison of effluent COD results using two separate PeCOD analyzers (Bench top L100 and on-line P100) and the standard dichromate method (filtered and unfiltered) were conducted for a number of different primary and secondary treated effluents from both Kraft and mechanical pulp mill operations. The standard dichromate testing with the unfiltered and filtered samples indicated that the effluent solids were not significant contributors to the total effluent COD, typically representing less than 2% of the total. Since the PeCOD analysis can only be done on filtered samples, this indicates that the removal of solids will not have an impact on the overall results. In terms of reproducibility, the comparative results indicated that the PeCOD analyzers showed excellent reproducibility between triplicate analyses.

In terms of correlation with the standard dichromate method, for all of the effluent samples (i.e., primary or secondary treated, Kraft, TMP or BCTMP operations), both the L100 and P100 PeCOD units demonstrated very good correlations with r^2 values of between 0.92-0.99. In terms of differences it was noted that on average both of the PeCOD units gave slightly higher values than the traditional dichromate method. For the primary treated Kraft mill effluents the PeCOD was typically 10-15% higher and for the secondary treated Kraft mill effluents the PeCOD values were typically 30-38% higher. For the primary Kraft mill effluent spiked with either condensate or weak black liquor, the slope of the correlation was somewhat lower, possibly due to interactions with the detector. For the primary treated mechanical pulp mill effluents the PeCOD was similar to the dichromate values and for the secondary treated mechanical pulp mill effluents the PeCOD was on average 18% higher. In all instances the PeCOD slopes for the secondary treated effluents were greater than the slopes for the corresponding primary treated effluents. This could be due to the fact that the treated effluents contain higher levels of recalcitrant COD which the PeCOD measures more effectively than the dichromate method.

In comparing the results from the two PeCOD units it was observed that the L100 benchtop unit typically recorded higher COD values as compared to the results from the on-line P100 unit.

In terms of potential applicability in pulp and paper mills, the excellent correlation between either PeCOD unit and the conventional dichromate method suggests that the PeCOD analyzer could be an excellent tool to help mills either control nutrient optimization or optimize in-mill operations.

Figure 1. PeCOD L100 versus filtered dichromate COD for primary Kraft mill effluents. Diamond (Mill A); Square (Mills B and C); Circle (Mill A + weak black liquor); Triangle (Mill A + condensate).

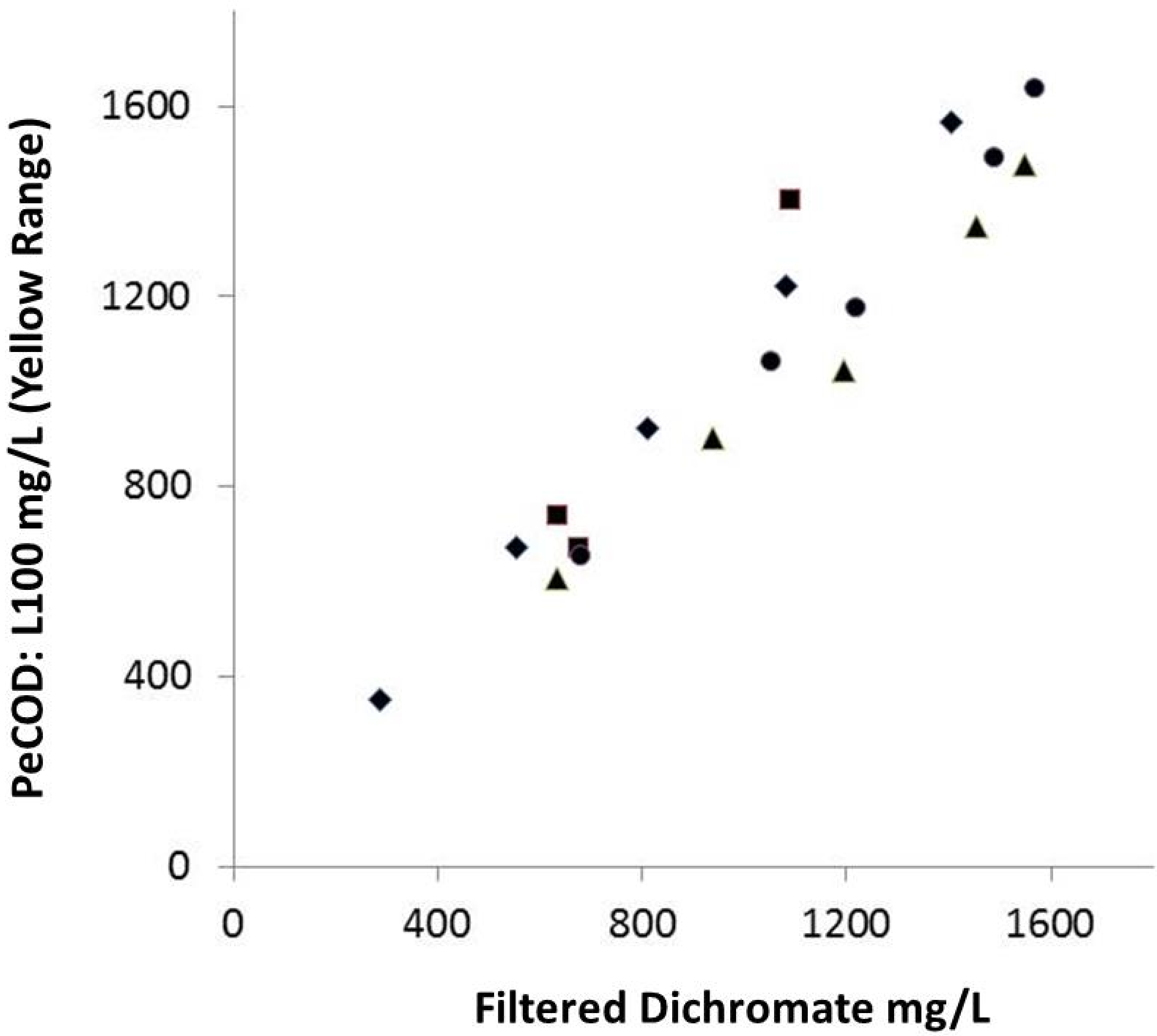


Figure 2. PeCOD P100 versus filtered dichromate COD for primary Kraft mill effluents. Diamond (Mill A); Square (Mills B and C); Circle (Mill A + weak black liquor); Triangle (Mill A + condensate).

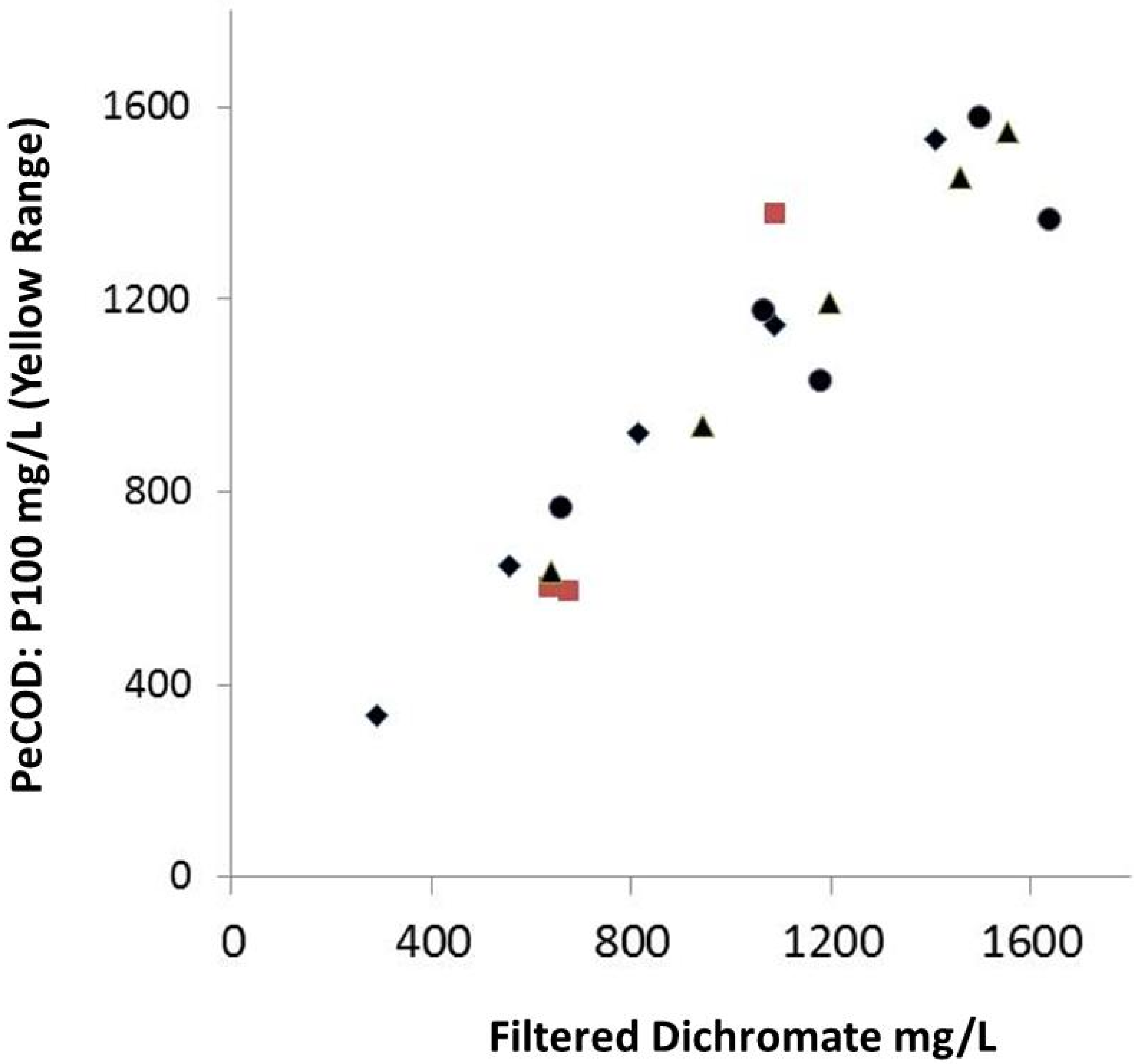


Figure 3. PeCOD L100 versus filtered dichromate COD for secondary Kraft mill effluents. Diamond (Mill A); Square (Mills B, D, E).

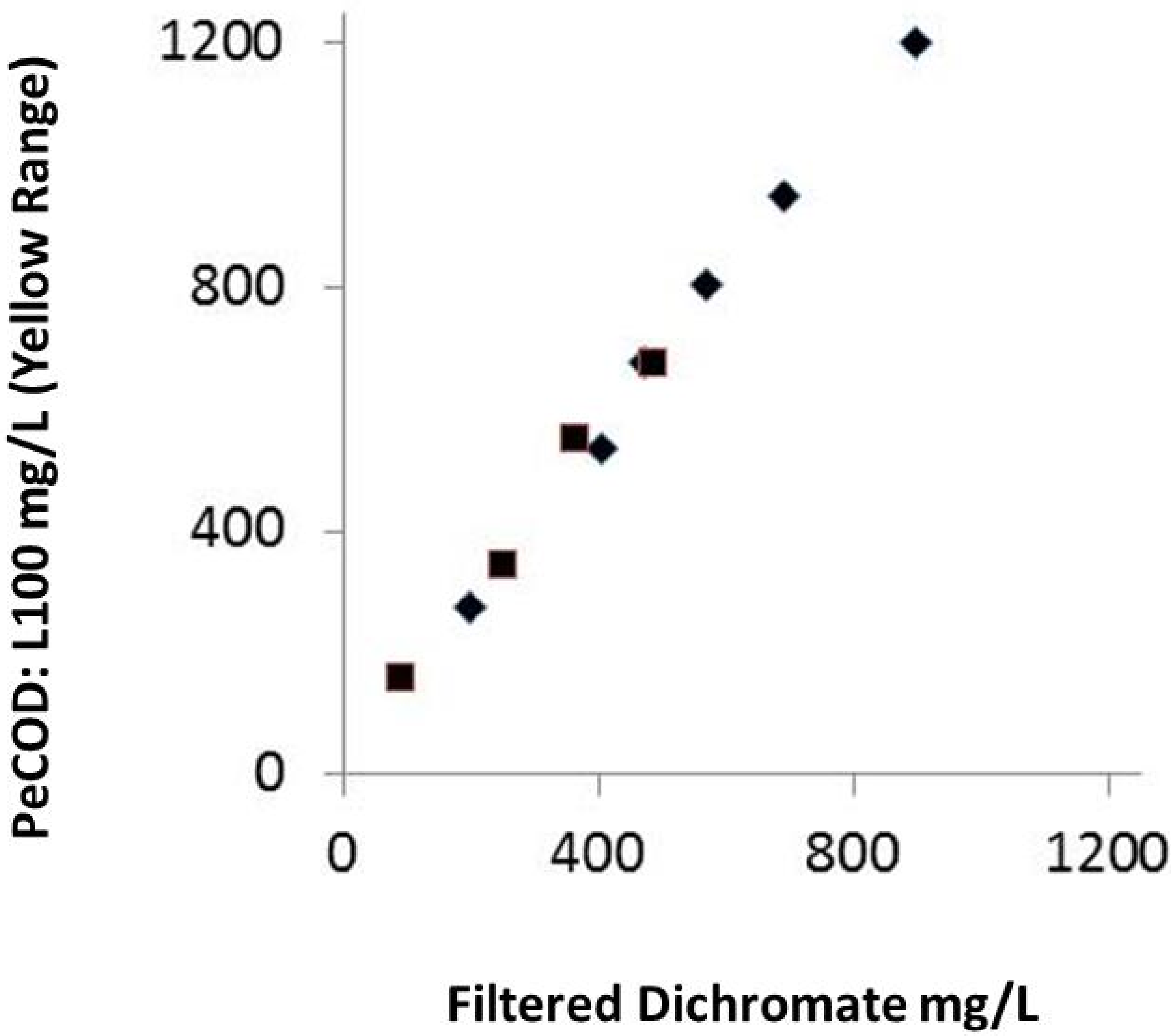


Figure 4. PeCOD P100 versus filtered dichromate COD for secondary Kraft mill effluents. Diamond (Mill A); Square (Mills B, D, E).

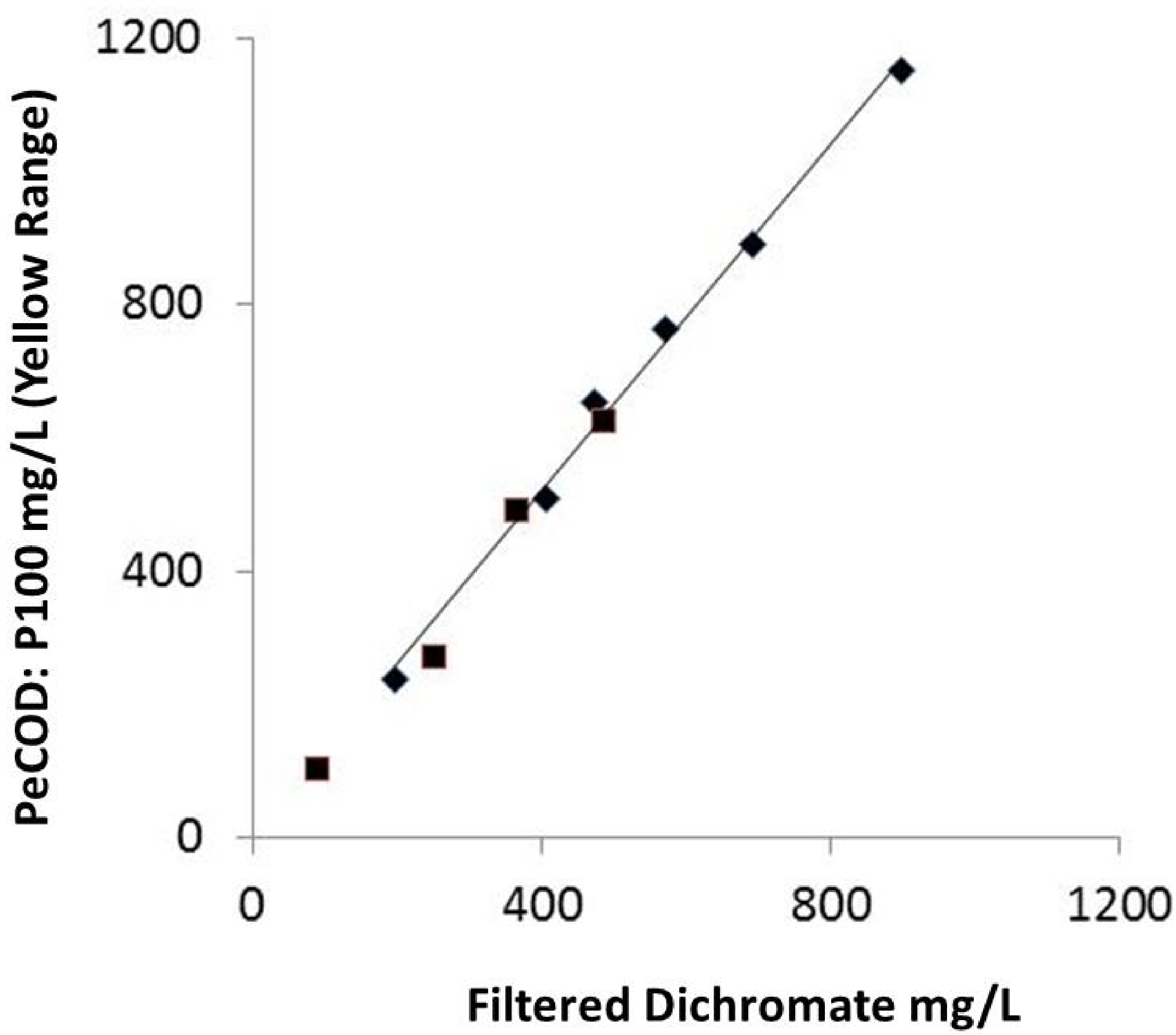


Figure 5. Comparison of PeCOD L100 versus P100 for the primary (diamonds) and secondary (squares) treated Kraft mill effluents.

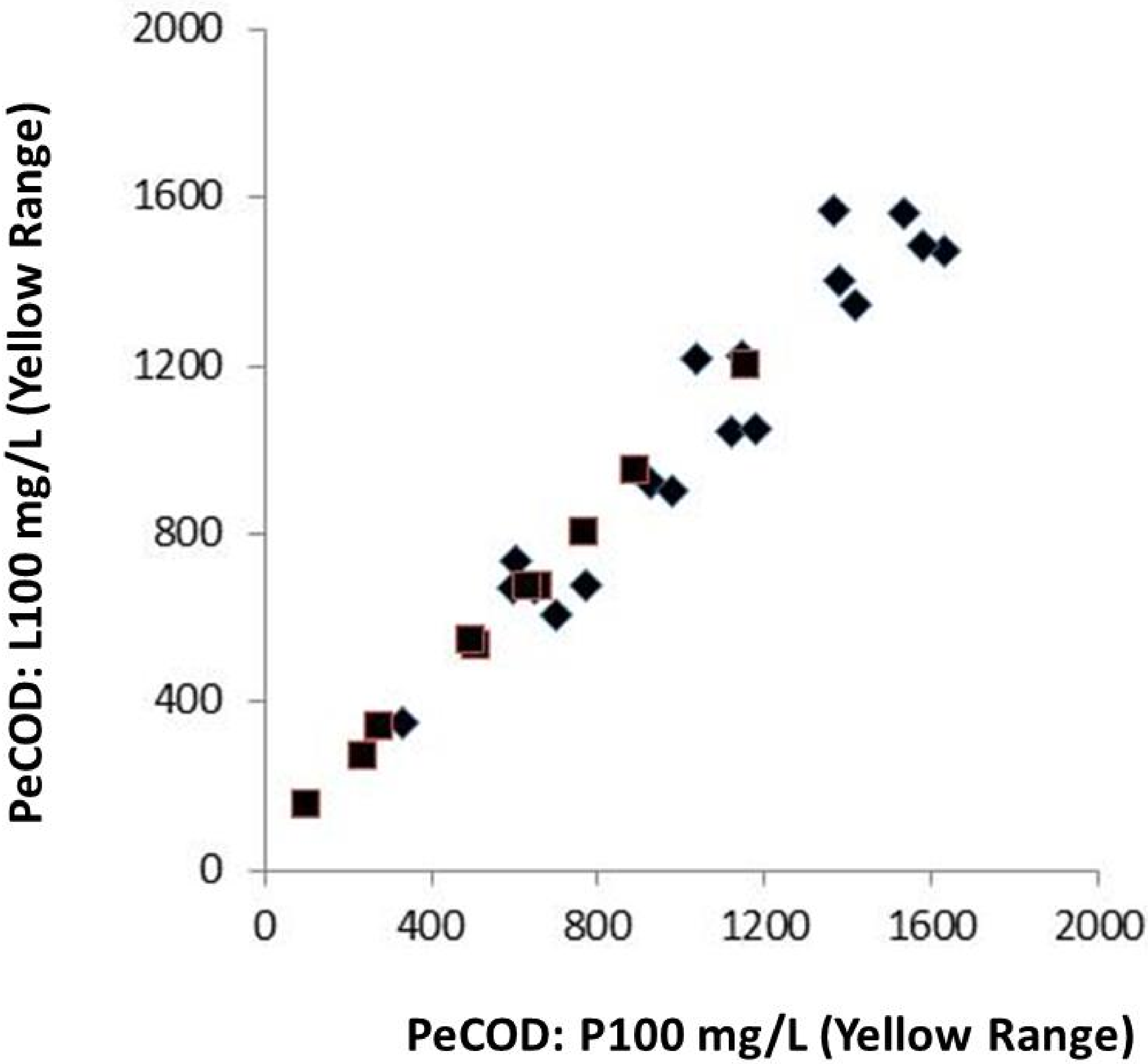


Figure 6. PeCOD L100 versus filtered dichromate COD for primary and secondary treated mechanical pulp mills. Diamond (Primary treated); Square (Secondary treated).

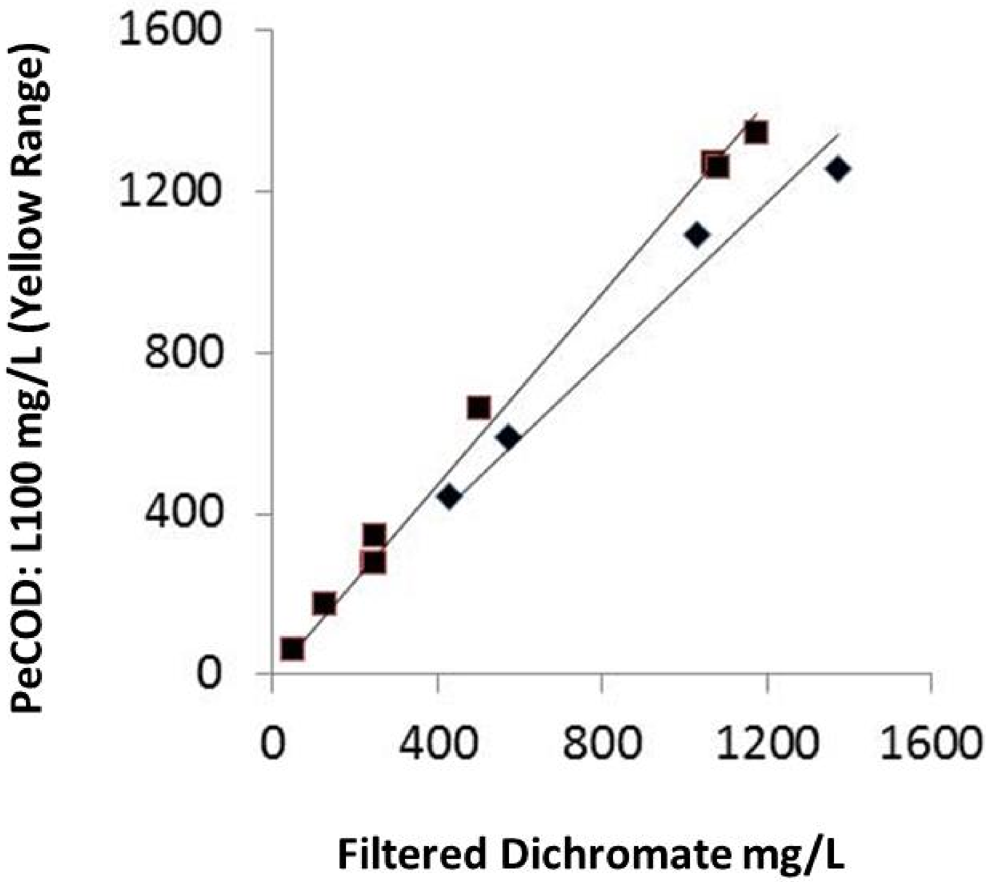


Figure 7. PeCOD P100 versus filtered dichromate COD for primary and secondary treated mechanical pulp mills. Diamond (Primary treated); Square (Secondary treated).

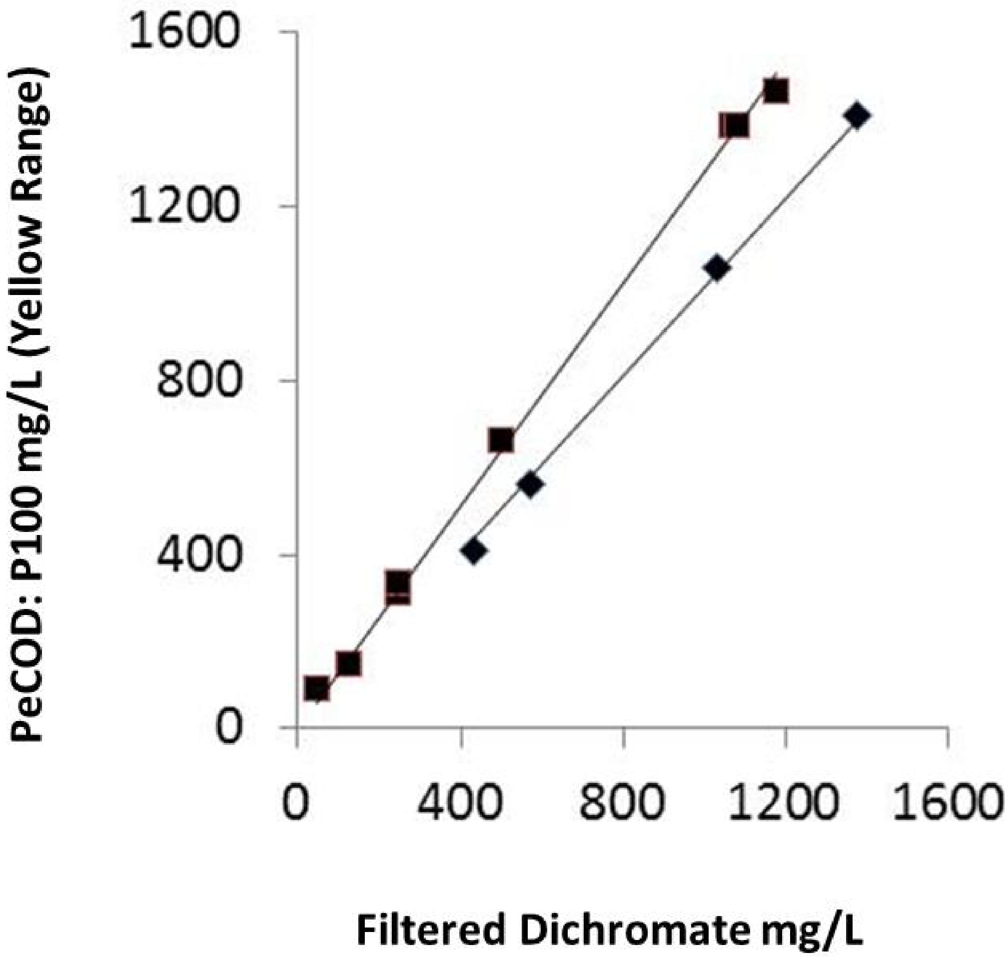
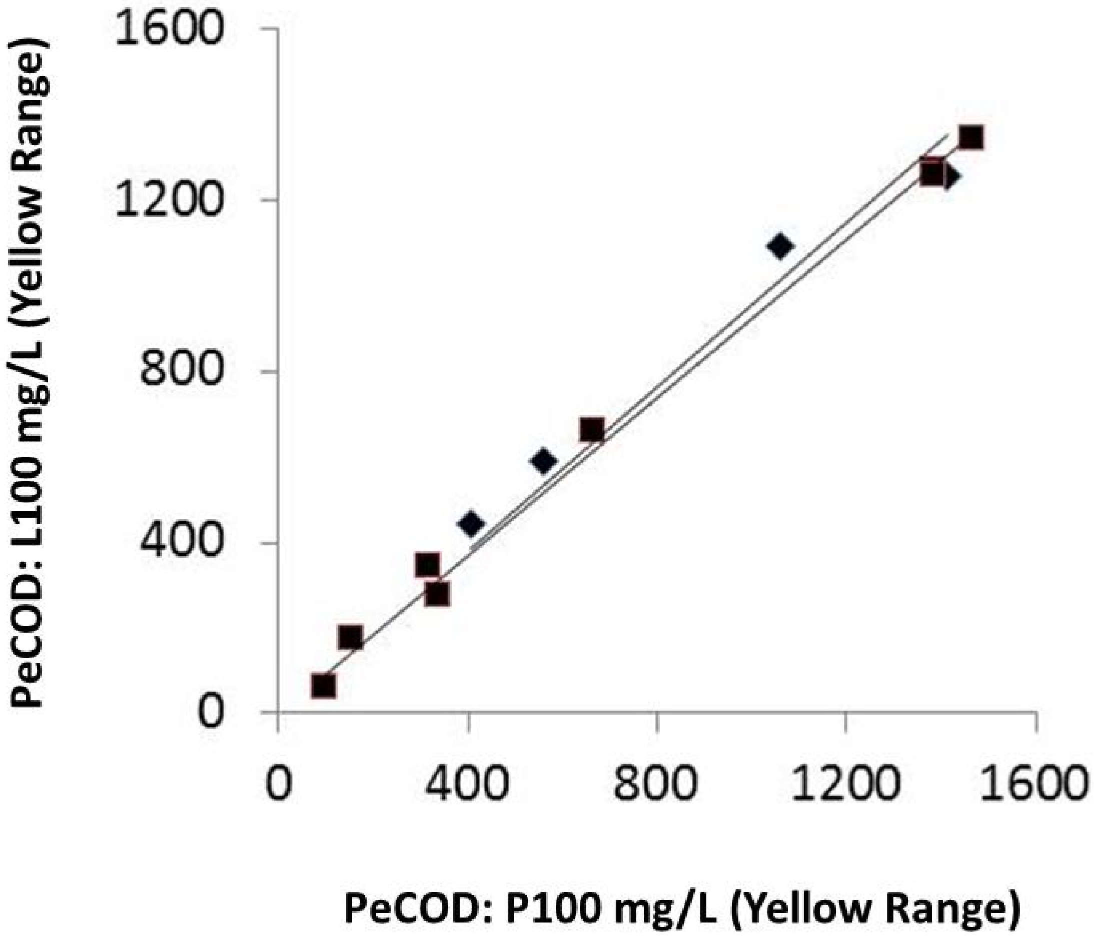


Figure 8. Comparison of PeCOD L100 versus P100 for the primary (diamonds) and secondary (squares) treated mechanical pulp mill effluents.



5. APPENDIX

Table 4. Effluent Characterization for Kraft Primary Treated Effluents Comparison

Mill Sample ID	L100 (% SD)	P100 (% SD)	BOD	Turbidity MTU	Chloride mg/L	Sulfate mg/L	pH
A1	353 (1.3)	334 (5.9)		8.4	63	650	6.76
A2	670 (2.1)	647 (1.5)		21.9	123	1259	6.80
A3	922 (1.6)	924 (0.2)	199	28.4	213	1910	7.16
A4	1224 (1.4)	1148 (3.7)		78.1	260	2700	6.91
A5	1567 (1.4)	1531 (2.8)		137.5	361	3740	7.00
B1	739 (0.6)	602 (1.4)		70.8	TBD	TBD	6.42
B2	672 (1.3)	595 (0.3)		73.3	TBD	TBD	6.62
C1	1405 (0.9)	1379 (2.4)		12.4	TBD	TBD	8.41
A7 (+Cond)	1045 (1.0)	1120 (1.1)		57.3	80	412	7.18
A8 (+Cond)	1348 (0.4)	1416 (0.8)		62.0	184	914	7.18
A9 (+ cond)	608 (1.1)	701 (0.3)		NA	NA	NA	NA
A10 (+ cond)	903 (0.8)	975 (1.1)		NA	NA	NA	NA
A11 (+ cond)	1476 (0.6)	1632 (2.2)		NA	NA	NA	NA
A12 (+WBL)	1216 (1.8)	1033 (0.7)		34.2	186	934	7.65
A13 (+WBL)	1568 (0.6)	1368 (2.5)		31.3	183	923	8.80
A14 (+WBL)	680 (1.0)	769 (1.8)		NA	NA	NA	NA
A15 (+ WBL)	1051 (0.3)	1177 (0.4)		NA	NA	NA	NA
A16 (+WBL)	1489 (1.2)	1578 (1.1)		NA	NA	NA	NA

Table 5. Effluent Characterization for Kraft Secondary Treated Effluents

Mill Sample ID	**L100** (% SD)	**P100** (% SD)	**BOD**	**Turbidity** MTU	**Chloride** mg/L	**Sulfate** mg/L	**pH**
A1	276 (0.6)	238 (2.6)		2.3	107	641	7.09
A2	**535 (0.3)**	**509 (0.5)**	**4**	**4.4**	**219**	**1304**	**7.06**
A3	678 (1.7)	653 (2.3)		14.8	220	1445	6.80
A4	806 (1.8)	763 (2.7)		14.5	220	1600	6.70
A5	951 (1.6)	890 (2.3)		30.8	312	2187	6.91
A6	1202 (0.9)	1151 (0.6)		50.8	375	2807	6.96
B1	159 (3.8)	102 (5.1)		2.76	TBD	TBD	7.76
D1	552 (1.3)	492 (1.2)		7.26	TBD	TBD	7.18
D2	677 (2.8)	626 (1.1)		20.4	TBD	TBD	7.28
E1	345 (1.7)	272 (4.9)		13.6	TBD	TBD	7.16

Table 6. Effluent Characterization for Mechanical Primary and Secondary Treated Effluents

Mill Sample ID	L100 (% SD)	P100 (% SD)	BOD	Turbidity MTU	Chloride mg/L	Sulfate mg/L	pH
Primary Treated Effluents							
F1 – TMP	1253 (0,5)	1411 (3.6)		197	7.7	69	6.42
F2 – TMP	1093 (1.4)	1059 (1.6)		112	4.4	46	6.37
F3 –TMP	591 (0.9)	561 (4.6)		56.5	2.7	26	6.46
F4 - TMP	442 (0.2)	407 (1.7)		40.3	2.1	20	6.46
Secondary Treated Effluents							
F1 -TMP	664 (2)	661 (3.4)		3.78	42.0	181	7.68
F2 – TMP	348 (0.7)	315 (1.6)		1.63	21.2	92	7.64
F3 – TMP	176 (0.4)	151 (4)		0.87	12.6	53	7.58
F4 – TMP	62 (1.1)	94 (9)		0.56	6.03	25	7.31
J1 – TMP	281 (1.3)	334 (0.9)		6.00	31.0	95	7.83
J2 – TMP	278 (0.9)	334 (2.4)		11.5	21.2	111	7.59
I1 – BCTMP	1346 (0.9)	1465 (2.1)		26.0	12.0	451	8.63
I2 – BCTMP	1275 (0.1)	1383 (0.9)		15.5	8.4	292	8.14
I3 - BCTMP	1264 (1.7)	1384 (0.4)		38.5	8.3	363	7.77

FPInnovations®

Head Office

Pointe-Claire
570, Saint-Jean Blvd
Pointe-Claire, QC
Canada H9R 3J9
T 514 630-4100

Vancouver
2665 East Mall
Vancouver, BC.
Canada V6T 1Z4
T 604 224-3221

Québec
319, rue Franquet
Québec, QC
Canada G1P 4R4
T 418 659-2647

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