Fly Ash Slurry Filtration Using Curlex® Blocs

Quantifying Total Suspended Solids and Turbidity Reduction

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STUDY SITE
All activities conducted for this evaluation were completed at ErosionLab® (www.erosionlab.com), which is a large-scale erosion and sediment control research laboratory located near Rice Lake, WI, USA. ErosionLab is owned and operated by American Excelsior Company®.

OBJECTIVE
Quantify reduction of total suspended solids (TSS) and turbidity of fly ash slurry when using Curlex® Enforcer® and Curlex® Blocs.

BACKGROUND
Fly ash samples were collected from First Energy in Ohio. Fly ash is residue from coal-fired plants. Fly ash can become entrained in runoff during rainfall events so it is imperative to determine earth-friendly solutions that can remove fly ash from contaminated runoff before being discharged.

METHODS
Channel simulators were built to determine the reduction of TSS and turbidity of fly ash slurry exposed to Curlex Enforcer and Curlex Bloc. A 75:1 water to fly ash slurry consisting of 60 gal of water to ≈107 oz of fly ash (227,125 ml water to 3,028 g of fly ash) was filtered when it flowed over Curlex Enforcer and through a Curlex Bloc fiber matrix. TSS and turbidity of the fly ash slurry were quantified before filtering began and every three minutes after passing through the channel simulator. Figure 1 shows the fly ash slurry being mixed.

Figure 1. Fly ash and water slurry being mixed.

Channel Simulator:

The channel simulators were built to the dimensions shown in Figures 2 – 4.

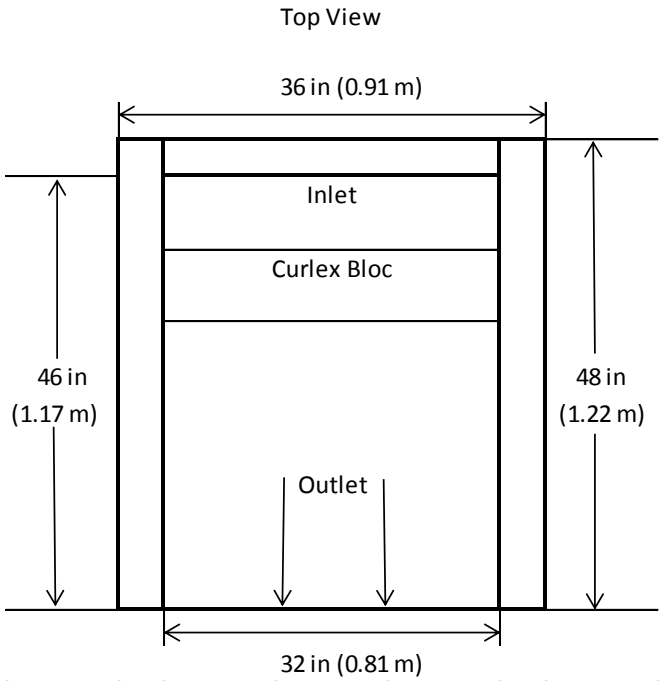

Figure 2. Top view of channel simulators.

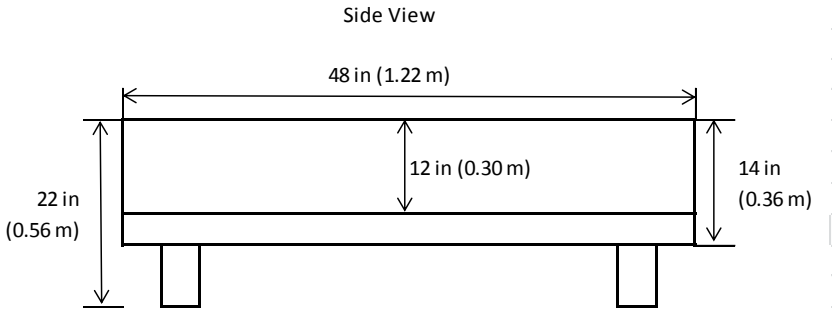

Figure 3. Side view of channel simulators.

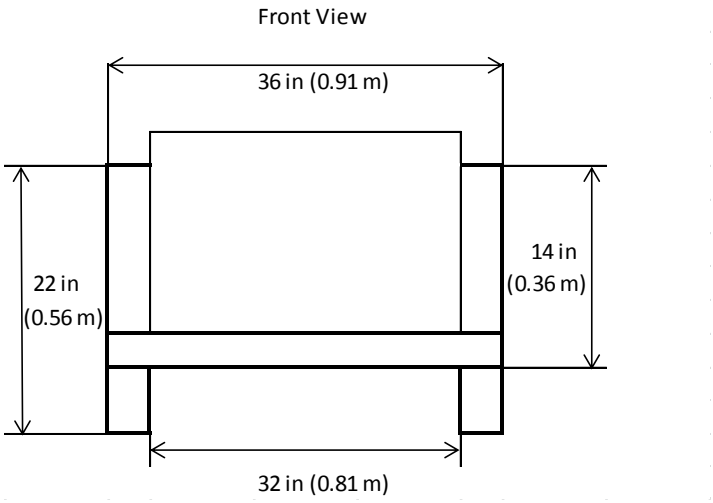

Figure 4. Front view of channel simulators.

BMP Evaluated

Curlex Enforcer and Curlex Blocs, as manufactured by American Excelsior Company, were used during the evaluation. Curlex Enforcer contains naturally seed free, renewable Great Lakes Aspen excelsior fibers that are colored green for aesthetics and bound by two layers of extra heavy-duty black UV stabilized netting. Curlex Blocs contain uncolored Great Lakes Aspen excelsior fibers encased in containment material.

Installation

Curlex Enforcer was installed on the bottom of the channel simulator and anchored with staples. A Curlex Bloc was installed on top of the Enforcer. The scaled-down Curlex Blocs were approximately 2.7 ft (.81 m) in length, but the material contained the same density as full scale Curlex Bloc to maintain the same flow through characteristics. Table 1 provides the properties of the scaled down Curlex Blocs used in the channel simulator as compared to standard sized Curlex Blocs.

Table 1. Properties of standard Curlex Blocs and scaled down Curlex Blocs that were used in the channel simulator.

Curlex Bloc Type	Nominal Dimensions (in [cm])	Length (ft [m])	Density (lb/ft^3 [kg/m^3])
Curlex Bloc HD	16 x 18 [40.6 x 45.7]	4 or 8 [1.2 or 2.4]	9 [144.1]
Scaled Down Test Bloc	16 x 18 [40.6 x 45.7]	2.7 [.81]	9 [144.1]

A 2 in (5.1 cm) x 8 in (20.3 cm) board was clamped to the top of the channel simulator to lightly anchor the Curlex Bloc to the bottom of the channel simulator (Figure 5). Spray foam was used to fill any gaps between the Curlex Bloc and the side of the channel simulator (Figure 5). The seam along the Curlex Bloc and side of channel simulator was caulked to prevent flow around the Curlex Bloc and the side wall. A 3 in (7.6 cm) x 32 in (81.3 cm) wood fixture was placed as a gasket at the interface between the Curlex Bloc and the channel bottom on the inlet side of the channel simulator (Figure 6).

Figure 5. Curlex Bloc installed in channel simulator.

Figure 6. Inlet reservoir of channel simulator.

Recirculated Channelized Flow Simulation

For each of the three simulations, a 75:1 water to fly ash slurry consisting of 60 gal of water to ≈107 oz of fly ash (227,125 ml water to 3,028 g of fly ash) fly ash was created. A 1/6 horse power pump was used to agitate the fly ash slurry. The fly ash slurry was then pumped behind the Curlex Bloc into the inlet reservoir (Figure 7). A return channel (Figure 8) on the downstream end of the channel simulator collected the water after it filtered through the Curlex Bloc then flowed across the Curlex Enforcer (Figure 9 and 10).

Figure 7. Fly ash slurry in the inlet reservoir.

Figure 8. Return channel to supply tank of channel simulator.

Figure 9. Close up of filtered fly ash slurry exiting a Curlex Bloc early in a test.

Figure 10. Flow through Curlex Bloc and across Curlex Enforcer.

Two 1/6 horse power pumps were used to recirculate the water through the channel simulator. The fly ash slurry was pumped from the supply tank into the inlet reservoir, through the Curlex Bloc, across the Curlex Enforcer, into the return channel, and back into the supply tank where the process started over. Each test ran for 90 minutes. Initial samples were collected from the mixing tank prior to the start of water being pumped through the channel simulator. Samples were then collected after the first pass through and every three minutes throughout the 90-minute test.

Laboratory Analyses

Grab samples obtained during testing were analyzed for TSS. Each 8.5 fl oz (250 ml) sample bottle was weighed prior to testing, after samples were collected, and after being removed from a forced air laboratory oven. Bottles were removed from the oven, which was set at 120 ˚F (49 ˚F), after all moisture had evaporated from the bottles. All samples were weighed using an Adam Equipment Model PGW 3502e Scale [max 3,500 g; d=0.01 g] (Figure 11). The PGW 3502e Scale was also utilized to measure fly ash mass that was added to water to create the slurry used in each test.

Figure 11. Adam Equipment Model PGW 3502e scale used for fly ash mass and TSS analyses.

Additional grab samples obtained during testing were analyzed for turbidity. All 1.5 fl oz (45 ml) NTU samples were measured using a LaMotte 2020we Turbidity Meter (Figure 12).

Figure 12. LaMotte 2020we Turbidity Meter used for NTU measurements.

RESULTS

Starting conditions of the fly ash slurry TSS for the three tests were 9,344.24 ppm, 6,593.94 ppm, and 8,926.38 ppm. Table 2 contains TTS measurements over time of fly ash slurry being filtered by Curlex Blocs and Curlex Enforcer in tabular format.

Table 2. TSS measurements over time of fly ash slurry being filtered by Curlex Blocs and Curlex Enforcer.

Time into Test	Test #1 (ppm)	Test #2 (ppm)	Test #3 (ppm)
Sample #1 - Tank	9,344.24	6,593.94	8,926.38
Sample #2 - First Pass	4,179.08	5,216.61	4,707.49
Sample #3 - 3 min	2,217.11	3,707.78	2,220.76
Sample #4 - 6 min	1,428.34	1,752.17	1,151.13
Sample #5 - 9 min	1,098.54	849.69	667.33
Sample #6 - 12 min	741.99	724.40	536.97
Sample #7 - 15 min	778.18	798.02	604.62
Sample #8 - 18 min	640.77	402.35	456.51
Sample #9 - 21 min	503.31	409.42	283.62
Sample #10 - 24 min	618.61	410.63	408.41
Sample #11 - 27 min	582.39	366.12	204.57
Sample #12 - 30 min	578.82	486.42	449.82
Sample #13 - 33 min	789.13	732.51	292.48
Sample #14 - 36 min	662.01	530.24	379.33
Sample #15 - 39 min	528.48	489.84	373.60
Sample #16 - 42 min	695.72	450.25	327.40
Sample #17 - 45 min	618.66	457.93	162.75
Sample #18 - 48 min	568.46	329.76	165.99
Sample #19 - 51 min	528.26	330.48	124.25
Sample #20 - 53 min	529.32	454.60	122.92
Sample #21 - 56 min	859.53	529.86	291.07
Sample #22 - 59 min	659.25	487.84	374.08
Sample #23 - 62 min	611.35	444.62	540.25
Sample #24 - 65 min	573.98	572.48	503.82
Sample #25 - 68 min	613.02	244.70	606.82
Sample #26 - 72 min	370.45	366.24	531.26
Sample #27 - 75 min	537.19	449.77	488.58
Sample #28 - 78 min	524.93	448.30	409.82
Sample #29 - 81 min	569.59	407.85	454.90
Sample #30 - 84 min	451.78	204.40	409.10
Sample #31 - 87 min	526.66	327.06	569.38
Sample #32 - 90 min	407.63	408.28	454.49

Figure 13 graphically displays the TSS reduction over time of fly ash slurry filtered by Curlex Blocs and Curlex Enforcer.

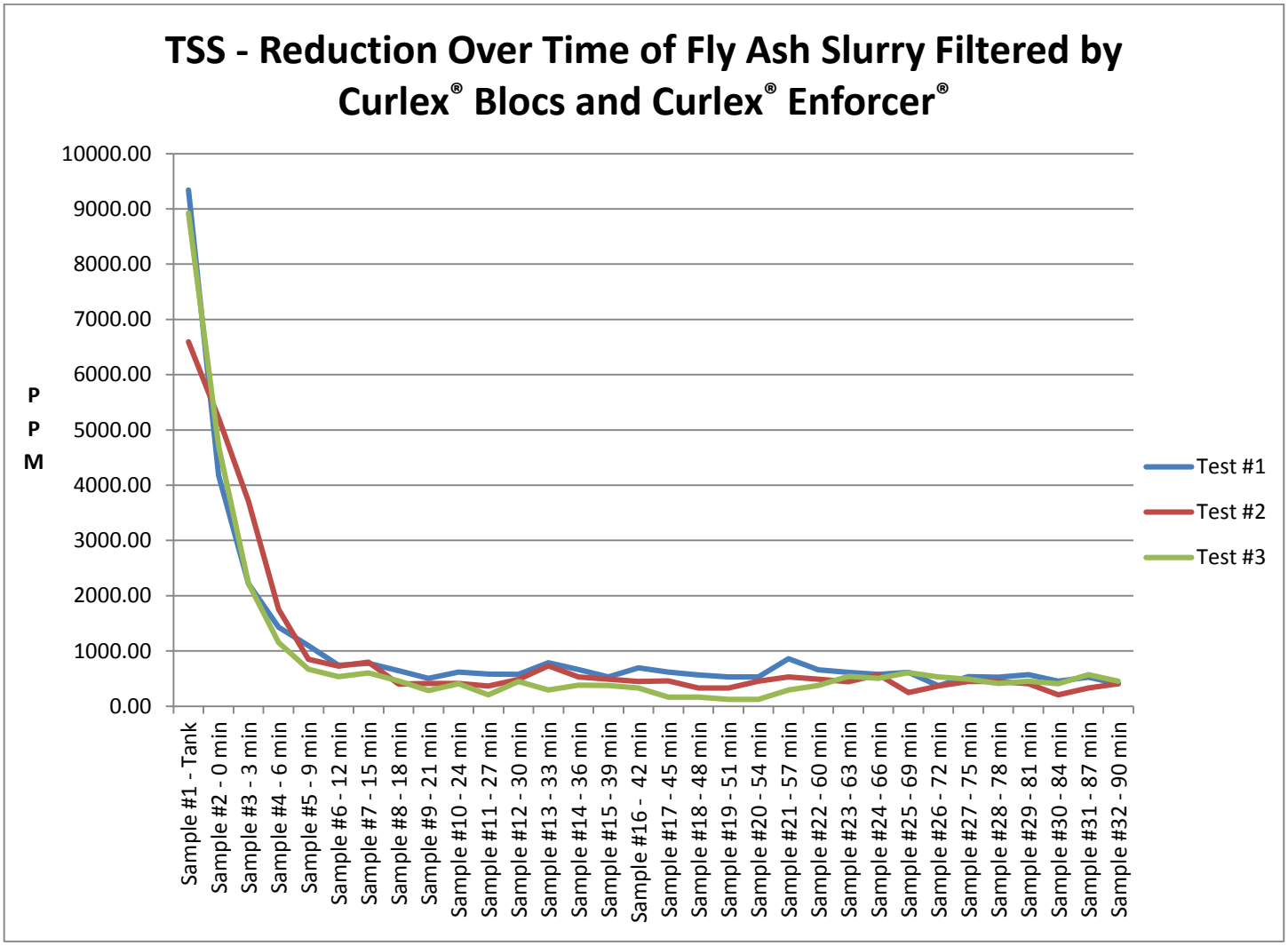

Figure 13 - TSS reduction over time of fly ash slurry filtered by Curlex Blocs and Curlex Enforcer.

Starting conditions of the fly ash slurry NTU for the three tests were 5,036 NTU, 4,960 NTU, and 5,218 NTU. Table 3 contains NTU measurements over time of fly ash slurry being filtered by Curlex Blocs and Curlex Enforcer in tabular format.

Table 3. NTU measurements over time of fly ash slurry being filtered by Curlex Blocs and Curlex Enforcer.

Time into Test	Test #1 (NTU)	Test #2 (NTU)	Test #3 (NTU)
Sample #1 - Tank	5,036	4,960	5,218
Sample #2 - First Pass	2,641	2,080	2,934
Sample #3 - 3 min	1,420	1,947	810
Sample #4 - 6 min	798	1102	661
Sample #5 - 9 min	721	732	642
Sample #6 - 12 min	635	704	663
Sample #7 - 15 min	600	620	596
Sample #8 - 18 min	636	602	620
Sample #9 - 21 min	642	643	602
Sample #10 - 24 min	721	691	643
Sample #11 - 27 min	744	674	682
Sample #12 - 30 min	639	689	651
Sample #13 - 33 min	651	631	633
Sample #14 - 36 min	620	623	726
Sample #15 - 39 min	620	666	741
Sample #16 - 42 min	641	696	714
Sample #17 - 45 min	693	742	702
Sample #18 - 48 min	664	736	686
Sample #19 - 51 min	708	728	639
Sample #20 - 53 min	661	654	602
Sample #21 - 56 min	763	642	597
Sample #22 - 59 min	789	611	553
Sample #23 - 62 min	743	597	528
Sample #24 - 65 min	755	640	523
Sample #25 - 68 min	728	644	619
Sample #26 - 72 min	691	627	604
Sample #27 - 75 min	684	660	596
Sample #28 - 78 min	640	547	582
Sample #29 - 81 min	667	640	576
Sample #30 - 84 min	675	623	552
Sample #31 - 87 min	656	630	549
Sample #32 - 90 min	686	640	541

Figure 14 graphically displays the NTU reduction over time of fly ash slurry filtered by Curlex Blocs and Curlex Enforcer.

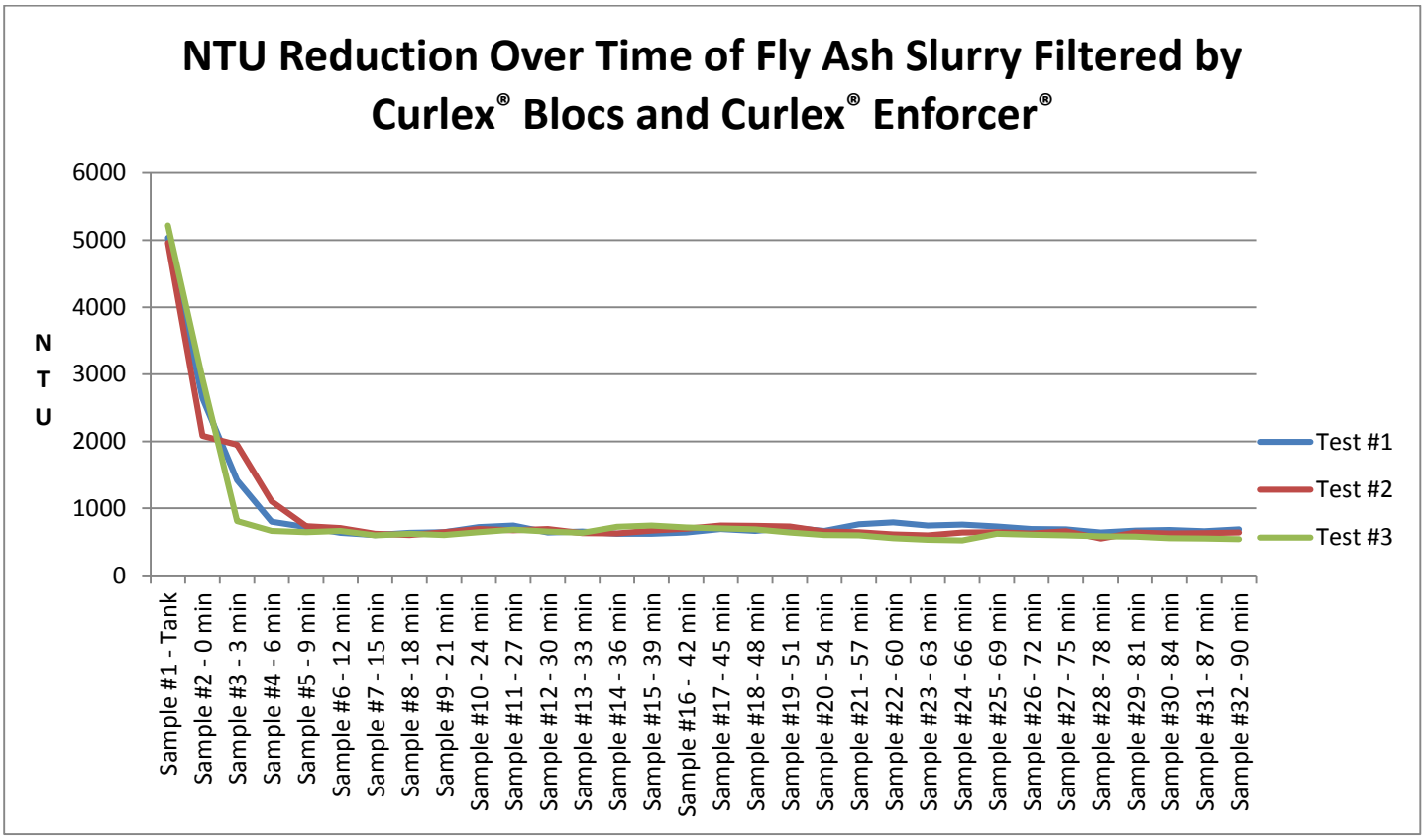

Figure 14. NTU reduction over time of fly ash slurry filtered by Curlex Blocs and Curlex Enforcer.

OBSERVATIONS

- The Curlex Bloc and Curlex Enforcer removed fly ash from the slurry throughout the duration of the test. Fly ash was collected within the Curlex Bloc excelsior fiber matrix and within and under the Curlex Enforcer (Figures 15-17).

- TSS samples settled at least 48 hours before decanting. The fly ash adhered to the bottom of the bottle, which helped with decanting.

CONCLUSION

- Curlex Blocs and Curlex Enforcer reduced the TSS of the fly ash slurry by an average of 94.8% based on the three replicates.

- Curlex Blocs and Curlex Enforcer reduced the turbidity of the fly ash slurry by an average of 87.7% based on the three replicates (Figure 18).

Figure 15. Fly ash on Curlex Bloc and between Curlex Enforcer (shown after Curlex Bloc was removed from channel bottom following a test).

Figure 16. Fly ash collection within Curlex Bloc.

Figure 17. Fly ash within Curlex Enforcer following a filtration test.

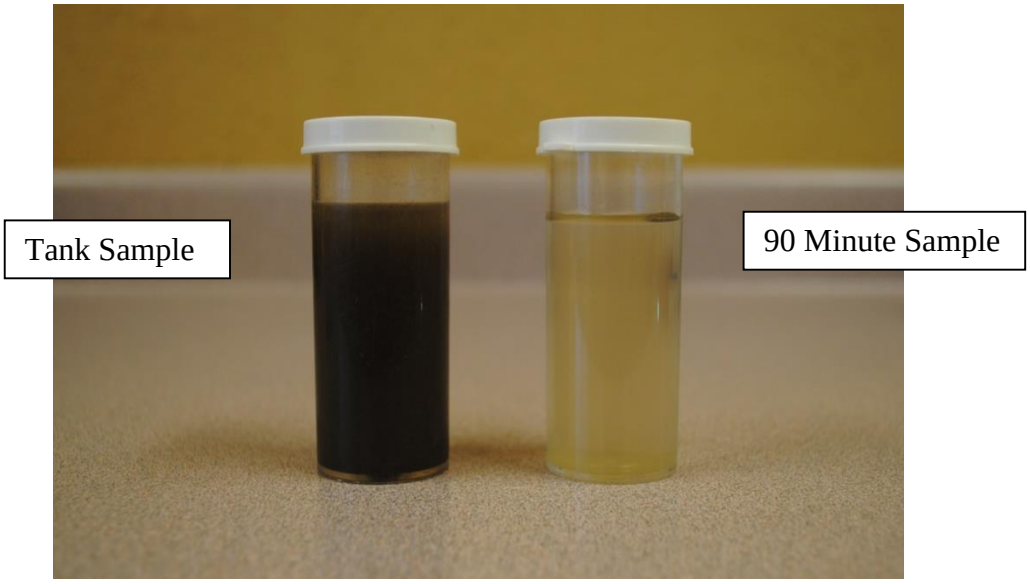

Figure 18. Typical turbidity samples showing reduction over time from filtering by Curlex Blocs and Curlex Enforcer.