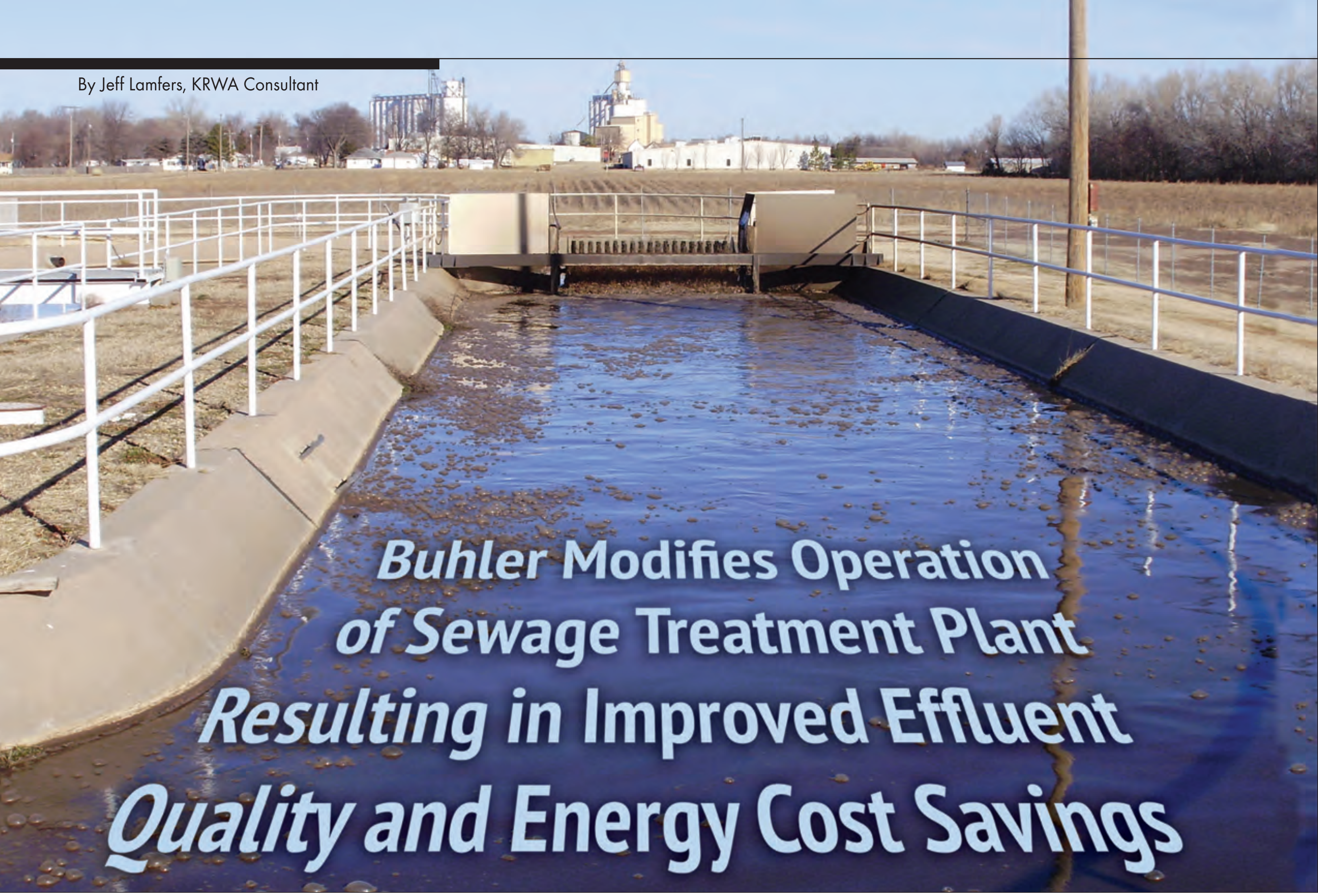
By Jeff Lamfers, KRWA Consultant

Buhler Modifies Operation of Sewage Treatment Plant Resulting in Improved Effluent Quality and Energy Cost Savings



Aerobic zone downstream of operating rotor in Buhler's oxidation ditch. The rotor is equipped with a variable-speed drive and the rpm varies based on the DO level desired in the mixed liquor.

In late 2011, the city of Buhler was referred to KRWA for technical assistance under a contract between the Kansas Department of Health and Environment (KDHE) and KRWA. Buhler is located in Reno County in central Kansas.

As in most instances, wastewater systems are referred to KRWA because they have problems with effluent quality and meeting permit limits. However in the case of Buhler, the referral was for a different reason. KDHE requested that KRWA assist the city in trying to improve the removal of nutrients, both nitrogen and phosphorous. In general, the Buhler treatment plant was meeting effluent limits for BOD, TSS, ammonia and E.coli. However, KDHE also has "goals" for the concentration of Total Nitrogen (TN) and Total Phosphorus (TP) in sewage effluents. These goals are 8.0 mg/L for TN and 1.5 mg/L for TP. While these goals are not currently enforceable like limits for BOD, TSS and ammonia, they are still "goals" that KDHE would like to see all plants meet if possible. Most likely, KDHE is also assessing the capability of existing treatment plants to meet goals for TN and TP should they become enforceable limits in the future. Some existing plants may be able to meet these goals through operational changes. However other plants may need construction upgrades to meet these goals.

Buhler's treatment plant consists of an oxidation ditch, two final clarifiers and UV disinfection. Sludge is processed using an aerated holding tank and belt press. The plant has a design flow of 0.168 MGD. For those not familiar with an oxidation ditch, they are often referred to as the "racetrack" type of treatment plant. They are a modified version of the activated sludge process. In conventional activated sludge plants, there is an aeration basin where raw sewage is introduced, mixed and aeration provided. However in an oxidation ditch, the mixed liquor moves through a continuous loop or oval concrete channel and aeration/mixing is usually provided by rotors that "skim" across the surface of the water. The rotors are usually mounted horizontally and are located at opposite corners of the oval channel. The rotors must provide sufficient velocity so that solids in the mixed liquor do not settle while traveling around the ditch. They must also add sufficient oxygen to create an aerobic environment for the breakdown of organic matter. Return sludge is also discharged back to the ditch from the final clarifiers.

Since their introduction, most oxidation ditches have been operated with both rotors running at close to maximum rpm. Most systems also run both rotors simultaneously most the time. The result is usually more than sufficient dissolved oxygen (DO) to lower both BOD and ammonia to acceptable levels in the plant effluent. I know for many year, operators have been taught in workshops that oxygen levels in activated sludge type plants should be maintained at high levels, usually around 2.0 ppm or greater. And that works when trying to nitrify to remove ammonia. However with such high DO levels, it is difficult if not impossible to denitrify or reduce nutrients like nitrogen and phosphorus. In order to denitrify, the treatment train must have an anoxic zone with low DO that allows for converting nitrate to gaseous nitrogen oxide. The best way to nitrify and denitrify is to have separate basins. But that was not possible in Buhler's case without significant and expensive upgrades. However another option is to operate the two rotors such that one is operated to produce an aerobic zone directly downstream and the other rotor is operated at a much lower rpm to create an anoxic zone. Consequently, the city began operating their oxidation ditch in this manner in late 2011.

In order to have accurate control of DO in an oxidation ditch for nutrient removal, additional equipment is needed. And fortunately, Buhler already had such equipment due to a past upgrading of the plant. That equipment includes variable-speed drives on both rotors, DO probes and computer controls. The computer controls take the data from the DO probes and then vary the rpm of each rotor in order to achieve the desired DO level in the mixed liquor. During my first visit with Les Teter, Buhler's plant operator, I am sure he was surprised when I suggested we begin lowering the DO downstream of one of the rotors and to shut the other rotor off completely. And while it took some time to determine what DO level was best for achieving both ammonia and nutrient removal, we finally got there. Initially we adjusted the DO setpoint for the operating rotor around 1.0-1.3 ppm. We then began lowering the setpoint by 0.1-0.2 ppm each month as long as ammonia did not increase and TN was decreasing.

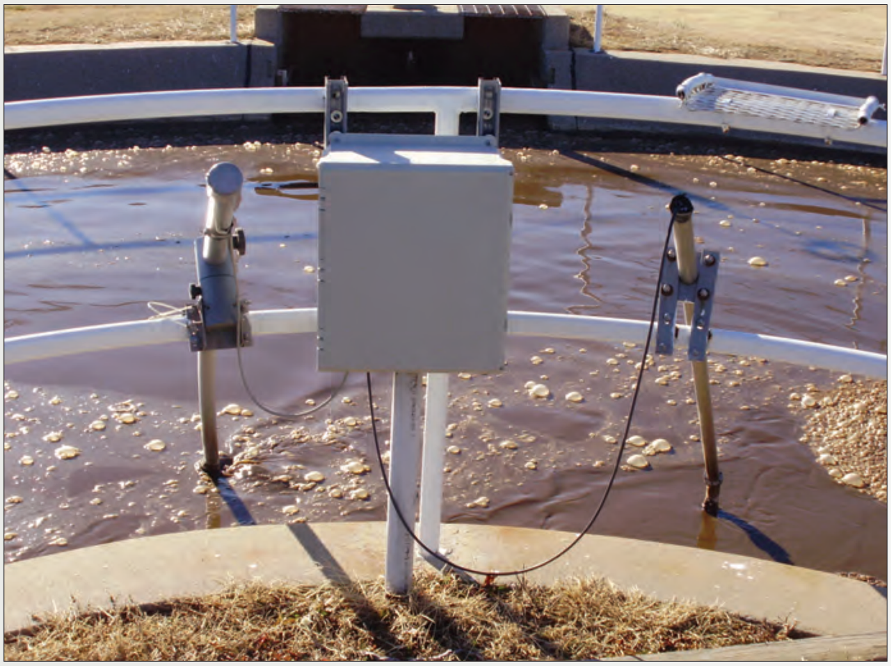
The city agreed to conduct additional monitoring (ammonia and nitrate) for several months by running effluent samples twice monthly. The city also purchased an ammonia test kit that allowed for more frequent on-site monitoring in case DO levels dropped too low and effluent ammonia increased. But as the data in Table 1 confirms, ammonia levels stayed pretty constant at around 0.5 mg/L or less during 2012 as we slowly dropped the DO level in the mixed liquor. And the TN levels slowly dropped during the year also. Most

Close-up of operating rotor which provides DO needed for aerobic zone directly downstream. The rotor rpm varies based on set-point selected by the operator. The rotor also provides mixing and ensures solids remain suspended in mixed liquor.

This "off-rotor" is operated at very low rpm so that oxygen is not increased in anoxic zone, but mixed liquor solids stay suspended.

City of Buhler Sewage Treatment Plant
Kansas Permit No. M-LA01-OO01
Effluent Summary (2011-2013)

Collection Date	BOD (mg/L)	TSS (mg/L)	Ammonia (mg/L)	TKN (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Total N (mg/L)	Total P (mg/L)
Limits	30	30	Varies	NA	NA	NA	NA	NA
1/6/2011	3.72	23.00	0.84	2.10	31.40	< 0.1	33.50	4.10
2/15/2011	5.39	15.0	< 0.5	1.68	28.90	< 0.1	30.58	4.00
3/8/2011	3.24	10.00	< 0.5	1.68	29.20	< 0.1	30.88	4.40
4/6/2011	2.44	14.00	< 0.5	1.40	33.90	< 0.1	35.30	5.20
5/10/2011	< 2.0	13.00	< 0.5	1.40	29.90	< 0.1	31.30	4.60
6/7/2011	< 2.0	5.00	0.56	1.68	13.60	0.11	15.39	5.20
7/13/2011	2.78	26.00	< 0.5	1.54	30.00	< 0.1	31.54	3.63
8/16/2011	< 2.0	13.00	< 0.5	1.82	24.00	< 0.1	25.82	2.90
9/13/2011	< 2.0	9.00	< 0.5	1.12	33.30	< 0.1	34.42	3.77
10/25/2011	< 2.0	18.00	< 0.5	1.40	24.40	< 0.1	25.80	3.03
11/15/2011	< 2.0	10.00	< 0.5	0.84	20.20	< 0.1	21.04	2.99
12/13/2011	< 2.0	7.00	< 0.5	< 0.5	13.90	0.1	14.00	2.45
1/10/2012	< 2.0	8.00	< 0.5	0.70	18.20	< 0.1	18.90	2.20
2/13/2012	2.23	5.00	< 0.5	0.56	15.00	< 0.1	15.56	2.45
2/22/2012	2.54	--	< 0.5	--	14.00	--	--	2.75
3/13/2012	3.27	11.00	< 0.5	1.12	13.60	< 0.1	14.72	2.85
3/22/2012	2.38	--	0.56	--	14.20	--	--	2.05
4/11/2012	< 2.0	3.00	< 0.5	0.84	9.46	< 0.1	10.30	2.18
4/25/2012	< 2.0	--	0.56	--	8.87	--	--	2.45
5/9/2012	< 2.0	3.00	< 0.5	0.84	8.17	< 0.1	9.01	1.65
6/5/2012	< 2.0	6.00	< 0.5	0.84	6.15	< 0.1	6.99	2.85
7/10/2012	< 2.0	7.00	< 0.5	1.26	3.20	< 0.1	4.46	2.25
8/15/2012	< 2.0	7.00	< 0.5	1.40	7.62	< 0.1	9.02	2.20
9/11/2012	< 2.0	2.00	< 0.5	1.12	2.25	< 0.1	3.37	2.75
10/9/2012	< 2.0	2.00	3.36	3.36	2.37	< 0.1	5.73	1.50
11/27/2012	2.42	10.00	3.50	3.92	1.51	< 0.1	5.43	2.20
12/4/2012	< 2.0	4.00	0.98	2.24	1.55	< 0.1	3.79	2.25
1/9/2013	< 4.0	4.00	15.70	16.50	< 1.0	< 0.1	16.50	3.40
2/13/2013	< 6.0	5.00	1.12	1.68	11.20	0.11	12.99	1.75
3/5/2013	3.51	9.00	0.84	3.64	14.60	< 0.1	18.24	2.05
4/24/2013	< 6.0	8.00	2.52	3.92	2.38	< 0.1	6.30	3.55
5/14/2013	< 2.0	5.00	< 0.5	1.12	< 1.0	< 0.1	1.12	3.90
6/18/2013	< 2.0	4.00	0.84	1.68	< 1.0	< 0.1	1.68	3.90
7/9/2013	< 2.0	5.00	0.84	1.12	1.58	< 0.1	2.70	2.75
8/13/2013	2.0	5.00	< 0.5	1.26	1.55	< 0.1	2.81	2.15



Probes for monitoring DO and mixed liquor suspended solids are located approximately 100 feet downstream of the operating rotor. Selecting a desired DO concentration on the computer keypad results in the rotor rpm ramping up or down to keep a constant DO level.

months, the TN concentration met the goal of 8.0 mg/L. TP levels dropped also but never less than the goal of 1.5 mg/L. Unfortunately, reducing phosphorus is more of a challenge, especially if trying to do so biologically in an oxidation ditch. Chemical precipitation would probably be more effective.

Prior to December 2011, effluent TN concentrations were often greater than 30 mg/L. But by the end of 2012, we had dropped effluent TN concentrations to less than 5.0 mg/L most months. The city did experience a problem during January, February and March 2013 when TN levels increased. It is believed that we may have dropped the DO level too far as effluent ammonia jumped to 15.70 mg/L in January 2013. In order to again reduce ammonia below permit limits, Les increased the DO level and consequently effluent TN levels increased the following months. Increasing DO probably raised the DO in the anoxic zone too much, adversely affecting denitrification. It is also possible that we did not have an adequate mixed liquor concentration during those months to off set the microbes being less effective during colder winter months.

The Buhler plant is now operating with the setpoint in the aerobic zone around 0.25 mg/L and the setpoint in the anoxic zone at less than 0.1 mg/L. It should be noted that the DO probe in the aerobic zone is located approximately 100 feet downstream of the rotor, so the DO level immediately downstream of the operating rotor is much higher. I have checked the DO immediately downstream of the operating rotor in the past with a portable DO meter and found readings around 0.6-0.8 mg/L, but still nowhere near 2.0 mg/L or higher. And at that DO level, ammonia reduction is very adequate. So basically the plant is running with a DO range in the aerobic zone of 0.6-0.8 mg/L, dropping down to 0.25 mg/L before entering the anoxic zone. DO in the anoxic zone starts out around 0.25 mg/L before dropping below 0.1 mg/L. Again, checking the DO in the anoxic zone with a DO meter indicates that DO in this zone drops as low as 0.05 mg/L. It should also be noted that the "off-rotor" is now in operation at very low rpm, if only to keep mixed liquor solids suspended. This rotor is idling at very low rpm so there is no turbulence causing DO to increase, but ensuring sufficient velocity to keep solids from settling.

Finally, it should be noted that operating Buhler's plant in this fashion has resulted in a savings in electrical costs. Since only one rotor is running any significant amount of time, and that rotor also ramps up and down to keep DO levels constant, less electricity is required to operate the plant. And this is accomplished without any degradation in effluent quality. In fact, effluent quality has improved with the reductions in TN and TP.

Rod Geisler, Chief of the Municipal Programs Section, BOW, in Topeka provided me an analysis of the city's electrical usage for the plant. This analysis is based on data provided by City Clerk Merrill Peterson. The analysis compares calendar year 2010 (before nitrification) to 2013 (using the first seven months and annualizing). The data indicates that the operational change has reduced electrical usage by 23,000 KWH per year. At a current cost of 9.13 cents per KWH, that equates to an approximate savings of $2,100 per year.

Hopefully this article has dispelled the myth that higher DO levels automatically result in better effluent quality. The experience with Buhler's plant proves the exact opposite. If DO levels are too high, the denitrification process is compromised and effective nutrient removal is not possible.

Jeff Lamfers began work for KRWA in November 2008. Jeff has more than thirty years of regulatory experience in the oversight and operation of water and wastewater systems with the Kansas Department of Health and Environment. He is a graduate of the University of Kansas with a degree in Environmental Studies with an emphasis in aquatic biology.