ADAMSTOWN BOROUGH SEWAGE TREATMENT PLANT
LANCASTER COUNTY, PENNSYLVANIA

NPDES# PA0021865

WASTEWATER TREATMENT EVALUATION

Prepared By:

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pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WASTEWATER TECHNICAL ASSISTANCE PROGRAM

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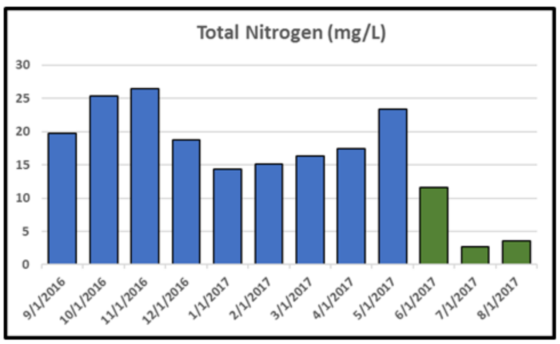
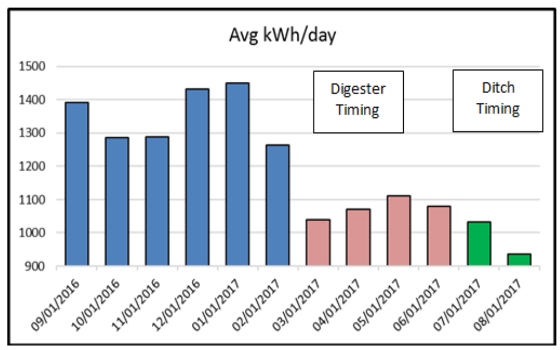
Executive Summary

In March of this year, the superintendent of public works for the Borough of Adamstown contacted US EPA Region III's outreach program for assistance in evaluating energy conservation at the borough's wastewater treatment plant located in East Cocalico Township, Lancaster County. EPA staff provided counsel and equipment in optimizing energy consumption at the facility's aerobic digesters. Subsequent to this work, the participants found that digester nitrate could be reduced to molecular nitrogen, thus decreasing the effect of sidestream nutrients on effluent quality when decanting prior to sending sludge to local farms as nonexceptional-quality sewage biosolids.

An obvious next move at the facility was for the operators and EPA staff to examine the main treatment process for energy reductions and nutrient reduction. They enlisted the instrumentation of DEP's wastewater technical assistance program (WWTAP) to monitor and optimize the secondary treatment units. DEP staff deployed equipment in mid-May and worked with Adamstown and EPA through early August.

This collaboration produced a 30% reduction in electricity costs and approximately 74% reduction in effluent total nitrogen (TN) loading, as seen in the charts shown below:





Figures: Effluent Nitrogen Reduction Electrical Consumption

Recommendations:

The evaluation demonstrated that substantial reductions in total nitrogen are possible at this facility using ON/OFF aeration cycles. Reducing digester nitrate by similar means may not be as dramatic; however, ON/OFF aeration there contributed to the overall energy reduction with the caveat that biosolids volatiles should be monitored more carefully to assure complete stabilization of the material. Continuing forward, information collected during the project suggested that:

- Installation of anoxic mixers in the two ditches may assure complete contact between facultative microorganisms, nitrate, and carbon source during the anoxic cycles;
- Installation of Oxidation/Reduction Potential probes on the downstream sides of the two ditches will assist operators in identifying anoxic conditions necessary for denitrification;
- Installation of pH probes at the two ditches will will assist operators with alkalinity and pH monitoring, where the lime addition could eventually be automated;
- More laboratory monitoring of process nitrogen species will provide information useful for setting oxic/anoxic timing cycles

Any permanent process changes may require that the facility submit Part II NPDES application for an amendment. Contact the regional DEP office for further information.

Wastewater Treatment Evaluation:

The Borough of Adamstown owns and operates a sewage treatment plant (STP) in East Cocalico Township, Lancaster County, Pennsylvania. The facility services the Borough of Adamstown and parts of surrounding East Cocalico Township, wherein it resides. With an annual average flow rate of 0.6 MGD, the facility has a design flow and organic loading of 1.6 MGD and 1,500 pounds per day. The average daily flow for the period June 2016 through June 2017 was 0.38 MGD. Treated water returns to the Chesapeake drainage basin by way of Little Muddy Creek. Dewatered and stabilized biosolids can be further dried in traditional drying beds, but it is more typically directly applied to relatively adjacent agricultural fields.

Treatment processes include grit removal and fine-screening of inorganic trash, two oxidation ditches designed to be operated in parallel, and ultraviolet disinfection. The two ditches are aerated by mechanical mixers with automatic dissolved oxygen (DO) feedback control, with the setpoint typically at or between 1.0 – 1.5 mg/L. Due to very conservative design, the facility has successfully operated using one ditch for over a year, with good results. When hydraulic loading exceeds the capacity of a single ditch, the second ditch has been activated to ensure effluent quality is maintained. Typically, the second ditch is in service during the late winter and early spring.

Aerobic digestion of waste sludge occurs within the footprint of the original treatment facility, where some tanks remain permanently idled.

In March 2017, the superintendent successfully implemented energy savings of about $2,000 per month by adjusting the aeration timers on the aerobic digesters. No capital expenditures were involved. PPL Utilities and US EPA Region III outreach staff worked with the superintendent to implement these changes.

Subsequently, EPA staff and the facility operator turned attention to the main treatment process itself, viewing chiefly the energy savings to be had there. EPA Region III Outreach Staff contacted PA DEP's Wastewater Technical Assistance Program (WWTAP) for assistance with in-line instrumentation to provide insight into biological nitrogen removal using ON/OFF aeration in the Adamstown ditches. DEP staff provided Oxidation / Reduction Potential (ORP) probes and an SC200 controller and monitored the ditches for both ORP and DO. EPA staff also provided a Hach DR2800 portable spectrophotometer to the operators so that colorimetric nutrient tests could be done to back up the instrument record. Instrument data focused on June and July 2017, although nutrient and energy monitoring used in this study extended from mid-May through late-September.

Based on feedback from the instrumentation, the operator manipulated the timing regime from 24hr/day ON to 9.6hr/day ON to optimize denitrification (TN removal). At the close of the project, effluent Total Nitrogen (TN) and energy consumption were reduced by 74% and 30%, respectively.

Design of the Study:

Noting that the aerobic digesters could be manipulated to save energy and remove some nitrate-nitrogen by using ON/OFF aeration, facility and EPA staff directed their attention to the main oxidation ditches. The goal was to manage the process in order to remove as much total nitrogen (TN) as possible without endangering effluent quality or violating the permit. Biological nitrogen removal consists of two phases:

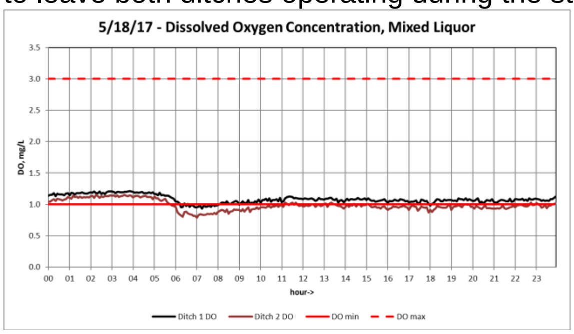
- Nitrification: where organic nitrogen and inorganic ammonium are oxidized to nitrate ion in solution; and

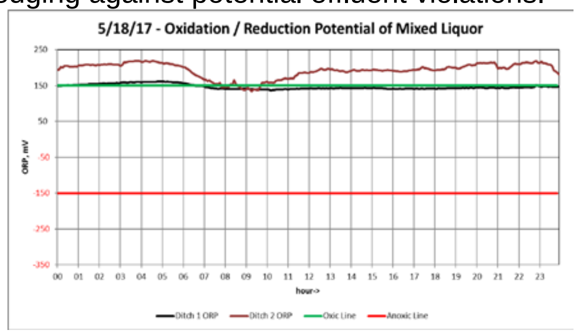
- Denitrification: where nitrate ion is reduced under anoxic conditons to molecular nitrogen gas that exits the process from the oxidation ditches and not from the secondary clarifiers.

The facility has no problems nitrifying, and operators employ lime slurry to control alkalinity. Effluent ammonia-nitrogen averaged 0.24 mg/L in calendar year (CY) 2016, while total nitrogen averaged 21.1 mg/L.

Use of dissolved oxygen probes by Adamstown has optimized oxygen addition to the treatment process for some time preceding this evaluation. It has been possible for operators to control their mechanical mixers to maintain DO within optimal range of 1.0-3.0 mg/L.

While only one of two ditches has been operated during the growing season, the operator chose to leave both ditches operating during the study, hedging against potential effluent violations.



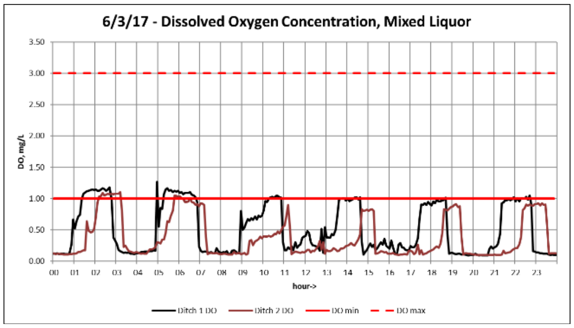


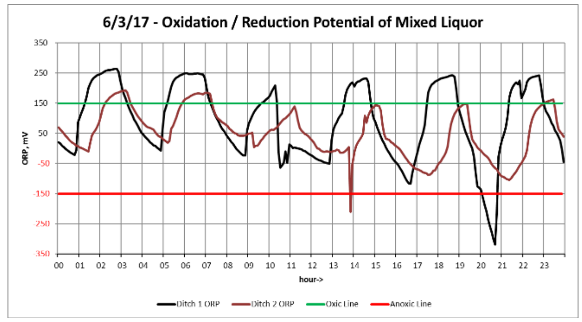
Figures: Process DO prior to evaluation: already good ORP continually in the oxic / nitrification range

Effective denitrification requires anoxic conditions, so that facultative bacteria will use nitrate ion instead of molecular oxygen as a terminal electron receptor. Conditions require pH range of 7-8.5 s.u., available alkalinity greater than 100 mg/L (ideally, 220 mg/L,) a nitrate-rich environment, available organic carbon, and anoxic mixing. In the case of Adamstown's facility, denitrification was expected to occur mostly in the region immediately upstream of the mechanical mixers, which would be de-energized. The only mixing available under these conditions had been from the raw wastewater inflow and (possibly) from sludge return.

The evaluation began with two weeks of background data collection, followed by short "OFF" periods (two hours OFF / two hours ON,) gradually increasing OFF time to a total sixteen hours per day (four hours OFF / two hours ON cycles.) At the latter extreme, ammonia nitrogen concentration increased from 0.15 mg/L to approximately 5 mg/L. This may have been due to short circuiting in the ditch, but it was most likely that the effective treatment limits had been surpassed, given that no regular anoxic mixing had been occurring. The final, most effective cycle at the end of the project was a total fourteen hours, twenty-four minutes OFF per day (three hours OFF / two hours ON, in cycles.) The operator with EPA and DEP staff agreed that this cycle schedule was most effective during warm weather months.

As a result of the four months for which ON/OFF aeration was used, the facility experienced a net reduction of effluent total nitrogen of 7,100 lb. between reporting year (RY) 2017 and 2016. This is significant in that borough will not have to buy as many nutrient credits, and if the practice continues with improvements, the borough may meet its nutrient limits without purchasing credits in subsequent years.





Figures: Process DO at end of evaluation: oxic/anoxic cycles ORP comfortably in nitrification & denitrification ranges

Caveats: The study did not evaluate the difference in operational costs between operating both ditches simultaneously in ON/OFF aeration, versus operation of just one ditch for most of the previous year. All parties deemed it safer practice to keep both ditches in operation while adjusting aeration time to optimize total nitrogen removal.

It was generally agreed that, moving forward, addition of mechanical anoxic mixers would be needed to achieve optimal nitrogen removal. Further, the evaluation team noted that nitrification becomes inefficient at lower water temperatures, requiring the operators to find more optimal cycle times for oxic/anoxic periods under those conditions, or perhaps to only optimize when nitrification is at its best. For the purposes of finding those limits, it was recommended that, in late autumn and through winter, the operators reduce cycle times dramatically and continue experimenting with the aeration / anoxic cycle times.

Summary of Findings:

At this facility, it is possible to achieve useful biological nitrogen removal in older oxidation ditch treatment facilities by employing varying cycle times of ON/OFF aeration, without significant process changes or capital improvements. In this evaluation, DEP and EPA staff, working with facility operators, achieved effluent nitrogen reduction of 74% and energy reductions of approximately 30% during the warm-weather months.

These improvements occurred in the absence of anoxic mixing. Installing anoxic mixers into the ditches should produce improved results, as more effective

ON/OFF aeration may be effective for controlling sidestream nitrate in aerobic digesters. The original work by the borough and EPA staff to reduce nitrate in digester decant water saw a modest reduction of 4% in nitrate load; however, the change in monthly TN effluent loading was negligible. This is likely due to that substantial difference between decant flow and raw wastewater flow. The reduction in electric consumption of 21% between the quarter where digester cycling occurred and the quarter prior to that may be where the real savings are, if one considers greenhouse gas produced in power generation.

Equipment Installation and Observations:

a. The facility operator installed timers for each of the aerators. DEP Oxidation Reduction Potential sensors were temporarily installed to monitor oxic and anoxic conditions. The project team needed to determine the length of the OFF phase that was needed to achieve anoxic conditions. ORP levels before cycling the aeration were mostly in the oxic range (>= +150mV), as assumed. ORP levels appeared to drop into the anoxic range (+150mV to -150mV) when the aeration was off for 2 hours.

b. EPA lent the operator a spectrophotometer for quick and accurate process control (nitrogen) testing.

Conclusions:

a. By cycling the aeration ON and OFF the plant was able to reduce the total nitrogen discharge by 74%. Seasonal adjustments will be necessary as cold weather during winter months may reduce the removal efficiency.
b. Anoxic mixing is critical to optimize TN removal and also to avoid short-circuiting ammonia-nitrogen, which could cause a violation. The cost of two mixers may pay for themselves reasonably quick due to the decreased nitrogen credits needed to be purchased annually.
c. Energy Savings of approximately 30% were realized. This may decrease during the cool months assuming the aeration ON time may have to be increased and also if the mixers are installed and running. The overall savings will still be significant.
d. This was a successful project that was very educational to all parties involved. Borough staff expressed their appreciation for the assistance.

ATTACHMENT A

PROJECT TEAM

--for the Borough of Adamstown		*--for PA DEP*
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ATTACHMENT B

Data

Effluent Total Nitrogen (TN) range was reduced by 74%. Test results are below:

Annual Total Nitrogen Values	Total Nitrogen	Total Nitrogen
Month	Effluent Conc, mg/L	Effluent Load, lb/mo
Oct-16	25.4	1,597
Nov-16	26.4	1,872
Dec-16	18.8	1,454
Jan-17	14.3	1,324
Feb-17	15.1	894
Mar-17	16.3	1,399
Apr-17	17.4	1,572
May-17	23.4	1,758
Jun-17	11.6	780
Jul-17	2.7	223
Aug-17	3.7	313
Sep-17	3.1	306
Annual Total in lb.		13,492

Yellow highlight denotes period of nitrate reductions.

Calculated Energy Savings

Year	Annual Electricity Cost	Annual Electricity Used (kWh)
2015	$47,984.00	556320
2016	$43,187.31	538480
Avg. 2015 and 2016	$45,585.66	547400
Avg. March 2017 to August 2017	$29,325.82	380480
Cost Savings	16,259.835	166920
Percent Savings	36%	30%

ATTACHMENT C

PHOTOGRAPHS

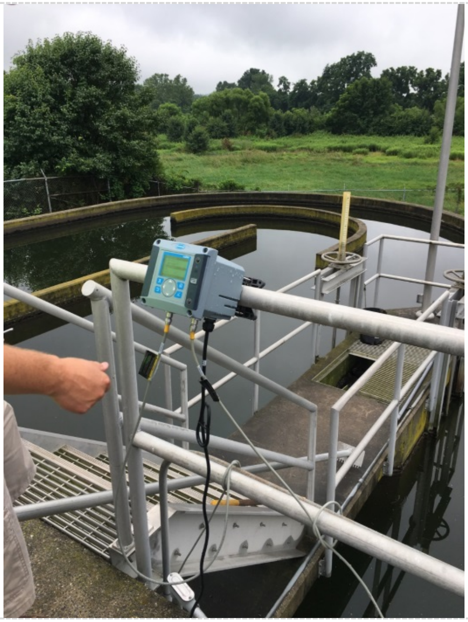

Photo 1: SC200 Controller

Photo 2: New ORP and Existing DO probes

ATTACHMENT D

TREATMENT SCHEMATIC