COOKEVILLE WASTEWATER TREATMENT FACILITY ENERGY REDUCTION CASE STUDY

in Cookeville, TN

BACKGROUND

Beginning in 2015, the Cookeville Wastewater Treatment Plant took initiative to learn and pursue innovative low-cost approaches to optimizing water quality and reducing energy consumption at its aging wastewater treatment plant through voluntary participation in TDEC's Wastewater Nutrient Plant Optimization Project. Cookeville has continued using techniques learned through its participation to achieve significant environmental and operational savings, including cost savings; nitrogen and phosphorus removal prior to discharge to surface waters; reduced electricity consumption; and production of less sludge. One year prior to the changes being made, energy and nutrient data was collected to create a baseline (monthly averages January 2014 – December 2014) for this case study.

ENERGY SAVINGS

In January 2014, Cookeville Wastewater Treatment staff were trained on nutrient reduction while reducing energy consumption. The process developed for this facility involved using less aeration equipment[1]. By reducing the use of aeration equipment, Cookeville Wastewater Treatment Facility reduced their average monthly kilowatt-hour usage by 40.1%[2]. This change alone reduced the facility's energy costs by 36%[3] during the same period of time that the cost of electricity increased by 7.7%[4].

NUTRIENT REDUCTION

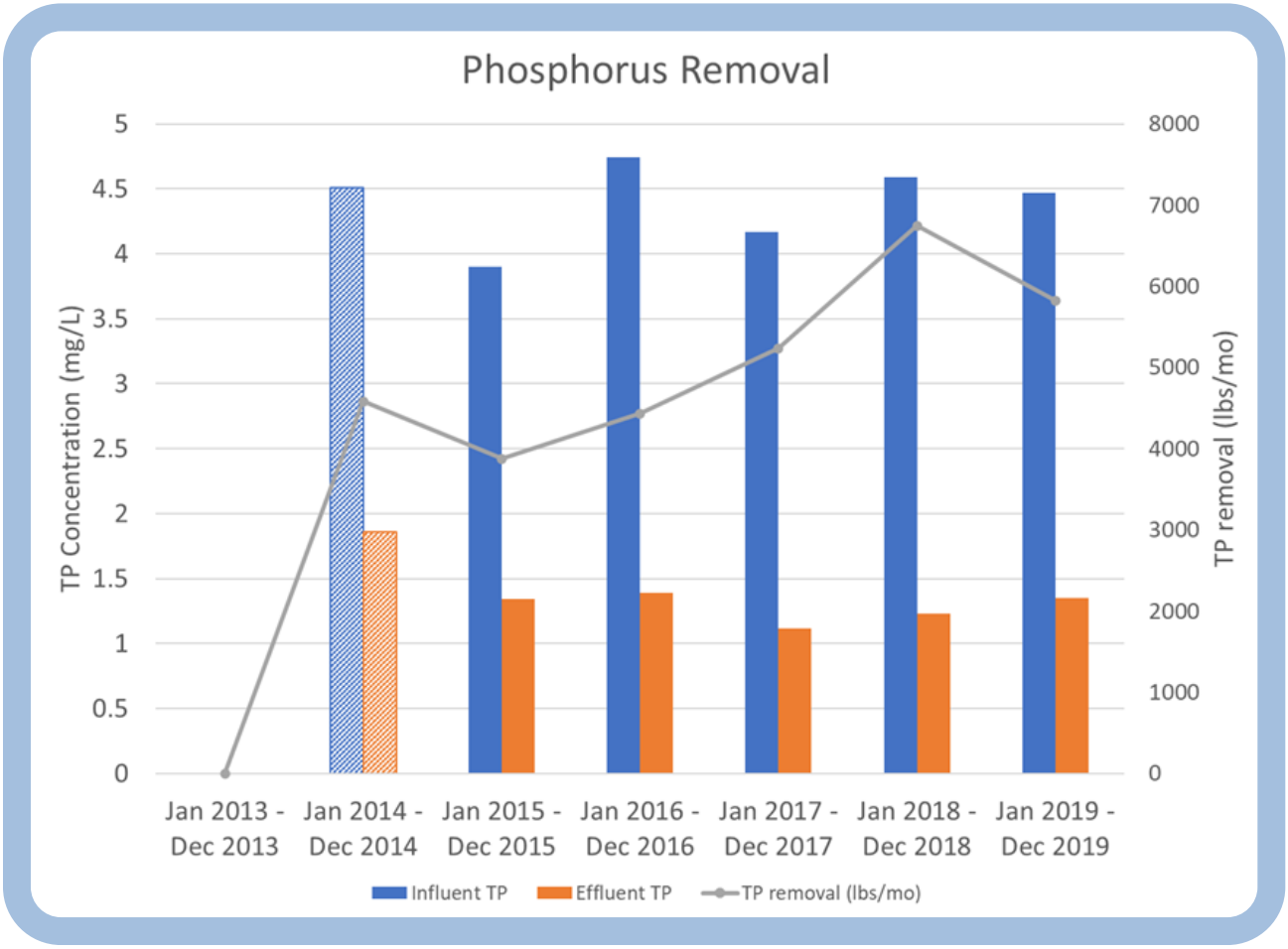
With the changes made in aeration processes, nutrient removal has increased. There has been a noticeable increase in nitrogen and phosphorus removal.

1. Operating two adjacent aerator rotors out of the six in each oxidation ditch.
2. Average kWh/month percent change from baseline (May 2013 – Dec 2014) and Jan 2015 – Dec 2019
3. Monthly energy cost percent change from baseline (May 2013 – Dec 2014) and Jan 2015 – Dec 2019
4. Cost of electricity ($/kWh) from baseline (May 2013 – Dec 2014) and Jan 2015 – Dec 2019

PHOSPHORUS

During 2015, several methods were tested to increase phosphorus removal including returning waste sludge back into the stream to create fermentive conditions. With the combination of returning sludge and changing aeration process, total phosphorus in the effluent decreased by 30.8%[5]. Figure 1 below shows influent and effluent total phosphorus from years 2014 to 2019. The hashed bars in the graph below indicate baseline years before any changes were made.

Figure 1

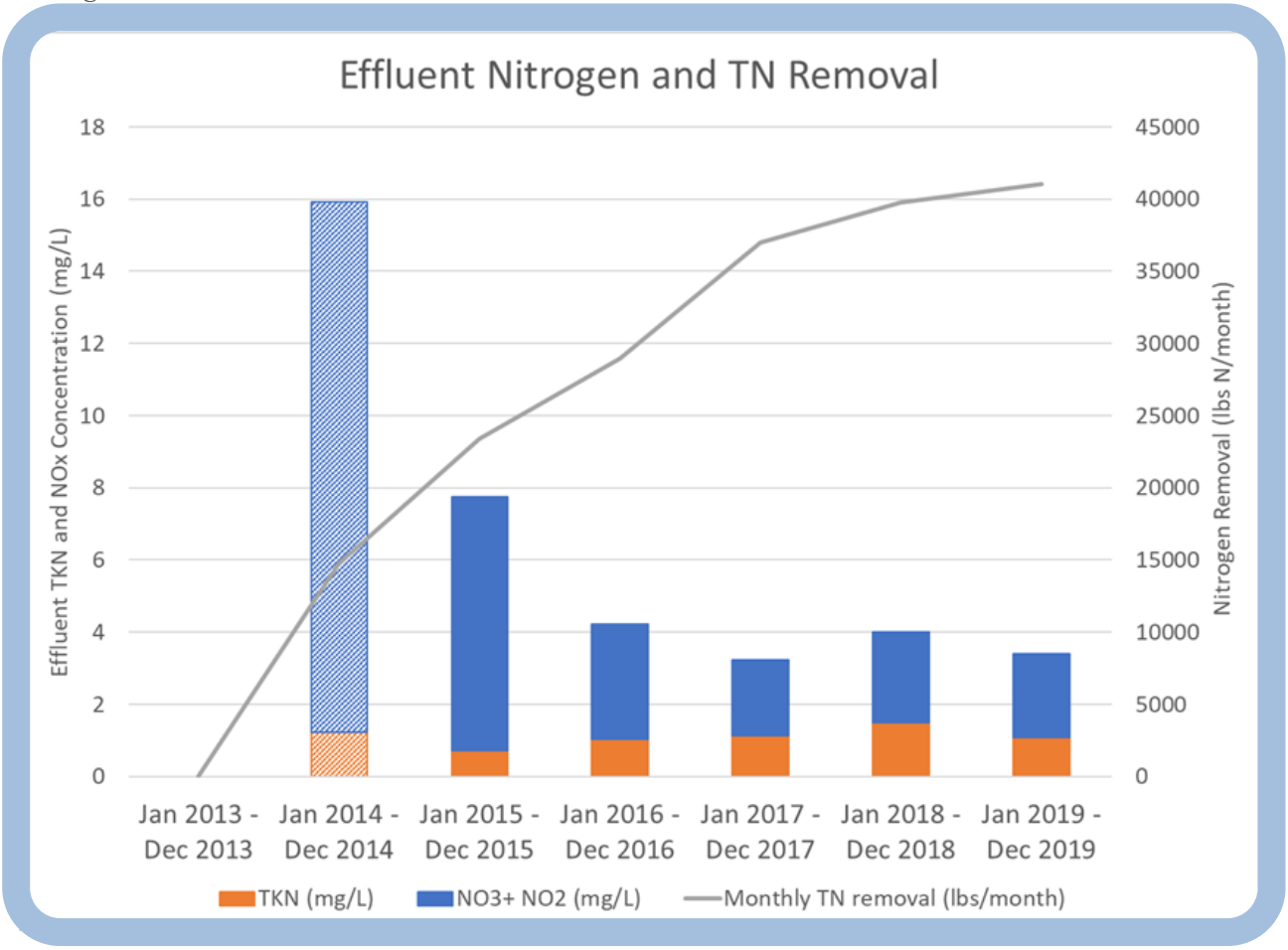


5. Average effluent total phosphorus (mg/L) from baseline (May 2013 – Dec 2014) and Jan 2015 – Dec 2019

TOTAL NITROGEN

During the training period, staff gained a strong understanding of nitrogen removal and continues to keep nitrogen effluent levels low. Average effluent compared to the baseline year has dropped by 76.7%[6]. The increase in nitrogen removal can be associated with creating a low dissolved oxygen environment through the reduction of aeration rotors used. Figure 2 below shows the reduction of effluent total nitrogen from years 2014 to 2019. The hashed bars in the graph below indicate baseline years before any changes were made.

Figure 2



6. Average effluent NO3+NO@ (mg/L) from baseline (May 2013 – Dec 2014) and Jan 2015 – Dec 2019

LESSONS LEARNED

By operating two adjacent aerator rotors out of the six in each oxidation ditch, Cookeville staff maintains three distinct stratified habitats. The surface layer (approximately one-third of the 12 foot depth of their ditches) remains aerobic. Excellent BOD removal is provided (June 2014 CBOD averaged (1.7 mg/L)) and complete nitrification occurs (June 2015 NH3 maximum: (0.04 mg/L). The middle one-third of each tank is sufficiently anoxic to provide complete denitrification; during June 2014 the effluent total-Nitrogen concentration averaged less than 5 mg/L. The bottom layer is anaerobic with an ORP of -250 mV. Inconsistent but vastly improved phosphorus removal is now occurring. During June, the effluent total-P was as low as 0.17 mg/L but was as high at 2.14 mg/L.

Intermittent aeration of the sludge holding tanks, coupled with a feeding of animal rendering plant wastes has created excellent conditions for nitrate removal (denitrification). As a result, the belt filter press filtrate contains almost zero nitrate; prior to the changes the nitrate concentration was often greater than 100 mg/L.

CONCLUSION

The Cookeville wastewater treatment operators were able to reduce phosphorus in effluent by 30% and maintain levels of TKN below 1.5 mg/L while reducing energy consumption. These improvements also reflected in the water quality of the receiving stream. Achievement of these results would not have been possible without the commitment of Cookeville City leadership and plant operator's dedication to the voluntary Tennessee Plant Optimization Program. This success story is a great example of how even small systems can improve nutrient reduction while reducing energy costs.

CONTACT INFORMATION

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