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An Investigation into the Common Problems of Lagoon Wastewater Treatment in Kentucky

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INTRODUCTION

- Wastewater treatment is necessary for each city or municipality in order to manage waste and protect the waters of the US from heavy pollution.
- Lagoon wastewater treatment is common in areas that do not have the resources for typical municipal treatment.
- Lagoon treatment utilizes long detention times and natural biological processes to treat water. While lagoon wastewater is common, it is usually not as effective or efficient as typical municipal treatment.
- The US EPA and the Clean Water Act gives all permitting authority to the National Pollutant Discharge Elimination System (NPDES) [1].
- Permits provide necessary regulations for all wastewater systems. Noncompliance with these regulations can lead to fines or system shutdowns.
- Other than the treatment system investigated in this study, there are 10 lagoons systems in the state of Kentucky. 6 of these lagoons had EPA or NPDES violations in 2022 [2].
- Municipality A Wastewater Treatment Plant (MAWWTP) is the sole wastewater treatment system currently being utilized to treat all influent from Municipality A, as well as industrial waste from an industrial park near the facility.
- MAWWTP consists of two (2) lagoons, a Modified Ludzack-Ettinger (MLE), and a long-term facultative lagoon.
- Lagoon-treated waters are further treated in a disinfection stage using peracetic acid (PAA).
- MAWWTP has been unable to maintain the outlined regulations in its NPDES permit since 2020.

OBJECTIVES

- This project aims to identify and provide solutions for the ongoing problems in MAWWTP in Kentucky.
- Research conducted in this study provided numerical data to find trends that identified the issue with the treatment methods.

MATERIALS AND METHODS

- "Engineering Company 1" was hired to collect samples at several stages of the plant to determine problem areas.
- Data was collected at four different sample points, biweekly between June and August of 2022 (Figure 1 and Table 1).
- Total effluent water, after disinfection, was also collected by MAWWTP operators and analyzed by Engineering Company 1 from January 2019 to November 2022.
- Percentage removals were calculated for BOD and TSS by comparing raw influent water to final effluent before discharge.
- All analytes were tested and measured by a third-party laboratory, "Analytical Laboratory 1." Analytes tested are listed in Table 2.

MATERIALS AND METHODS (cont.)

Table 1 – Sampling Locations, Descriptions, and Flow Path

Sample Point	Description	Location in Flow Path
1	Manhole at beginning of plant	Influent from Industrial Park
2	Pipe discharging into MLE lagoon	Influent from City
3	Pump station between MLE and facultative lagoons	After MLE treatment, before facultative treatment
4	Sampling station near quiescent zone	After MLE treatment, after facultative treatment, before filtration and disinfection
5	Final effluent water before discharge	After all stages of treatment

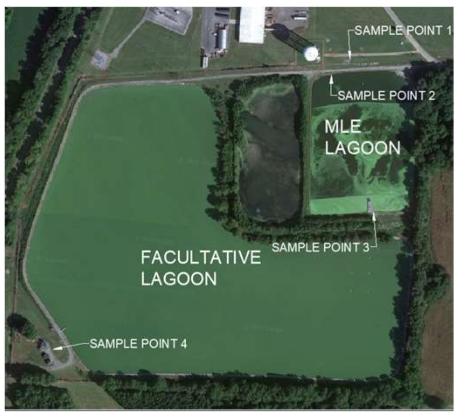

Figure 1 – Sampling Locations

*Modified Ludzack-Ettinger (MLE) Lagoon

Table 2 – Tested Analytes and Regulations

Tested Analytes		
Analyte	Regulation	Unit
pH	6-9	--
Ammonia (NH_3)	23	mg/L
Total Nitrogen (TN)	2-6	mg/L
Total Phosphorus (TP)	1	mg/L
Biochemical Oxygen Demand (BOD)	30 (monthly), 45 (weekly)	mg/L
Total Suspended Solids (TSS)	45	mg/L

- Regulations listed here are provided by the US EPA in accordance with the Clean Water Act [3].

RESULTS

- All tested analytes in final effluent were above the acceptable limit at least once from 2020-2022.
- It was determined that the most common non-compliance analyte was the percent removals of BOD and TSS (Figure 2).

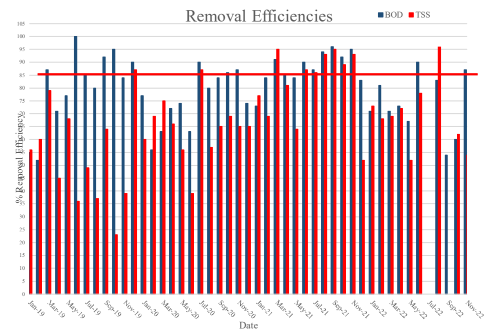

Figure 2 – BOD and TSS Removal Efficiencies

- There was a significant excess of nutrients in the facultative lagoon, shown by elevated levels of TP and TN (Figure 3).

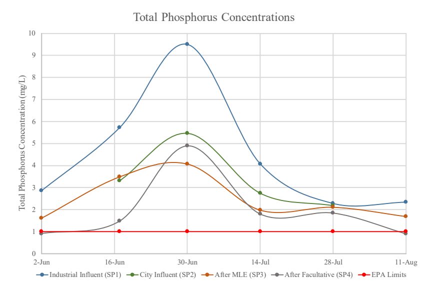

Figure 3 – Phosphorus Concentrations

- It was determined that the excess in TP was likely the cause of harmful algal blooms (HABs) forming in the lagoons.
- HABs can lead to a much higher BOD than acceptable. They are also likely the cause in the increase in BOD from MLE stage to facultative stage (Figure 4).

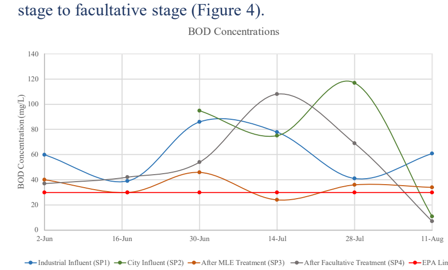

Figure 4 – BOD Concentrations

RESULTS (cont.)

- Results from MAWWTP were compared with other lagoon systems in Kentucky.
- 6 out of 10 (60%) of lagoon systems identified by the EPA were in noncompliance of their regulations in 2022 (Table 3).

Table 3 – Comparison to Other KY Lagoons

Plant Location/Name	Violation Type	BOD_5	BOD_5 % removal	Carbon-aceous BOD	Carb. BOD % Removal	TSS	TSS % removal
Kuttawa	Violation	No	Yes	No	No	Yes	Yes
Hardin	Violation	No	No	Yes	Yes	Yes	Yes
Brandenburg	Violation	No	No	No	No	Yes	Yes
Clinton	Non-compliance	No	No	Yes	Yes	Yes	Yes
Lewis County	Violation	No	No	No	No	Yes	Yes
Wingo	Non-compliance	No	No	Yes	Yes	Yes	Yes

CONCLUSIONS

- It was concluded that the excess nutrients in the lagoons were promoting growth of HABs.
- HABs were causing the lagoons to have a significant increase in BOD from treatment stage 2 to 3.
- Increase in BOD from treatment stage 2 to treatment stage 3 indicates that there is nutrient excess in the facultative lagoon.
- It was recommended that MAWWTP add metal salts or lime to cause the excess nutrients to precipitate and sink to the bottom of the facultative lagoon where they can be removed.
- When comparing with other lagoon systems in Kentucky, it is common to find the same elevated analytes and it is suggested that HABs could be the source of these problems as well.

REFERENCES

[1] US EPA, 2022. *NPDES Permit Basics.* National Pollutant Discharge Elimination System. Accessed 3-1-2023.

[2] US EPA, 2022. *Lagoon Inventory 2022.* Accessed 1-21-2023.

[3] Code of Federal Regulations, Title 40, Section 403. *Legal code: Clean Water Act.* Accessed 1-21-2023.

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