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Analysis of Influent Characteristics for Optimizing the USTHB Wastewater Treatment Plant

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ABSTRACT

The operation of wastewater treatment plants poses challenges for many communities, particularly in terms of costs and energy consumption. This study focuses on two main objectives: reducing nitrogen discharge and optimizing the energy consumption of the USTHB wastewater treatment plant. By combining advanced modeling and dynamic optimization techniques, we have identified effective strategies to improve wastewater treatment and highlight the impact of certain parameters on treatment infrastructure efficiency. The aim of our work is to provide concrete recommendations for enhancing the overall performance of the plant for more sustainable water resource management.

Keywords: Wastewater, WWTP, Dynamic optimization, ASM1, energy efficiency

1 Introduction

The treatment of wastewater is a critical global challenge, where the efficiency of sewage treatment plants holds crucial importance both environmentally and economically. As emphasized by the World Health Organization (WHO) in 2017, approximately 4.2 billion people lack access to adequate sanitation services [1]. Since Wastewater treatment is a major global challenge, in both environmental and economic realms. And with the stringent new regulations worldwide have amplified this challenge, necessitating adaptation within the water treatment industry. Small-scale treatment facilities employing activated sludge processes, face significant hurdles, often requiring upgrades to meet standards, especially regarding nutrient removal. Despite the implementation of control strategies, nitrogen concentration in effluent remains problematic, along with high energy consumption. Our research aims to address these challenges by effectively regulate the nitrogen removal and enhancing wastewater treatment process performance while minimizing operational costs of the recently rehabilitated USTHB WWTP USTHB. This is achieved through advanced simulation using GPS-X and specific optimization strategies by introducing innovative aeration control and nutrient analysis strategies [2].

2 Modeling of the USTHB wastewater treatment plant

In our research, we employed GPS-X software to simulate the USTHB wastewater treatment plant's operations. We began by gathering real-world data to accurately represent the plant's setup and extensively characterized

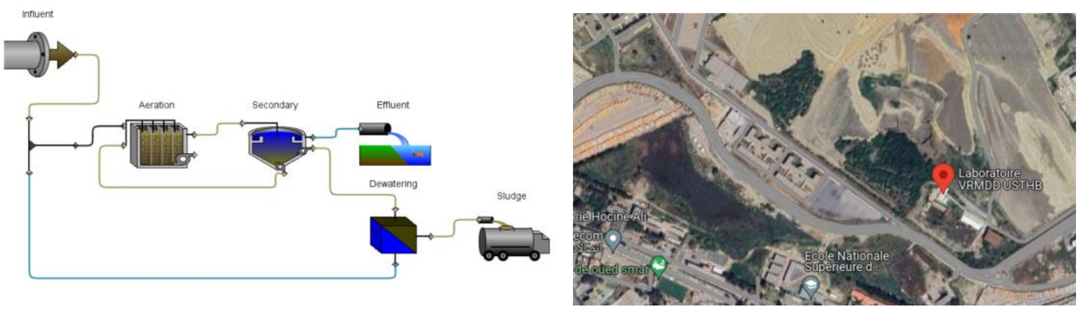

Figure 1: Geographic location and process flow diagram of the station in GPS-X.

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wastewater quality parameters. After calibrating the model to match actual effluent data, we conducted sensitivity analyses to assess parameter influences. Subsequent simulations evaluated operational impacts on plant efficiency. Utilizing the ASM1 model enabled detailed representation of organic and nitrogenous pollutant degradation. Simulation outcomes guided exploration of diverse control strategies to optimize plant operation within environmental and technical constraints. To validate the stoichiometric parameters, we compared treated effluent characteristics from the Baraki station, similar to ours in terms of wastewater composition. Our treatment goals, akin to those of the Boumerdes station, were confirmed despite the size difference. This approach boosts our model's credibility, ensuring accurate predictions of plant performance.

3 Results

Analysis of influent characteristics over a 15-day period revealed significant variations in concentrations of COD, BOD5, TSS, and NH3, as well as effluent flow rates, influenced by factors such as season and local activities. Despite notable reductions in TSS, cBOD5, and COD concentrations between raw and treated wastewater, nitrogen levels in the effluent remained high, with an elimination efficiency of approximately less than 50%.

Table 1: *Characteristics of wastewater before and after treatment*

	MLSS		VSS		cBOD5		COD		TN	
	mg/L	kg/d	mg/L	kg/d	mgO_2/L	kg/d	mgCOD/L	kg/d	mgN/L	kg/d
Influent	143,3	367,8	107,4	275,8	147,2	367,8	277,9	694,5	60	47,12
Effluent	6,6	16,7	4,1	10,4	3,2	8,0	54,9	137,7	150,6	118,5

The impact of influent flow rate and temperature on biological treatment performance was evident. Increased flow rates improved treatment efficiency, but excessive rates reduced solid retention time, disrupting treatment. For instance, increasing flow from 1000 m3/d to 2500 m3/d led to higher MLSS in the biological basin, enhancing treatment efficiency. Slight improvement in treatment at higher temperatures was observed due to increased microbial metabolic activity, albeit with disruption in nitrogen pollutant removal [3][4].

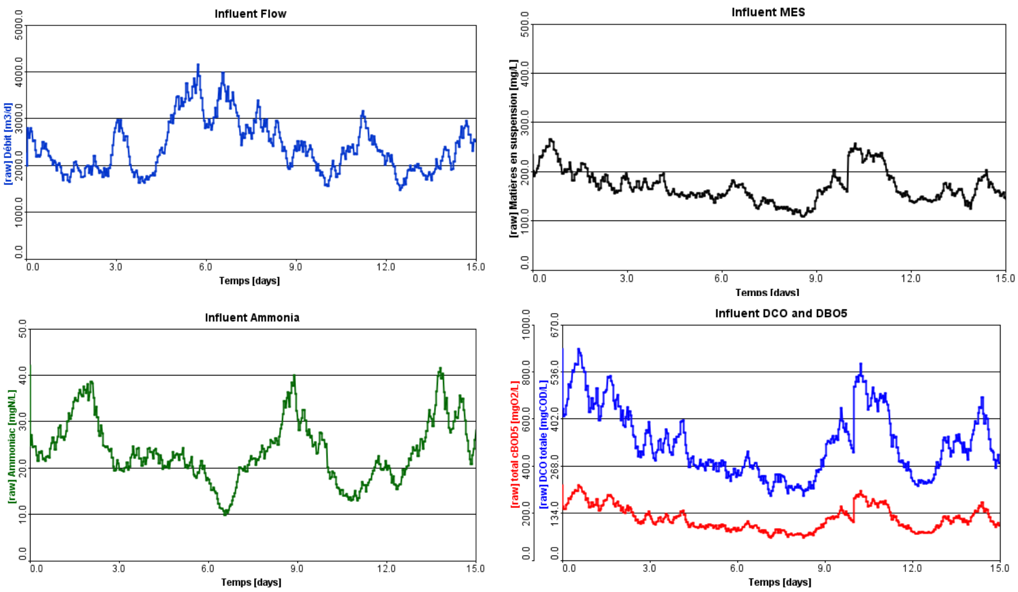

Figure 2: Evolution of the characteristics of wastewater entering the station over a period of 15 days

Energy consumption analysis revealed aeration as the most energy-intensive unit, accounting for 70.8% of total power usage. Costs associated with sludge disposal and aeration were significant, representing 51.6% and 46.7% of total costs, respectively, underscoring the need for energy efficiency optimization. Increased air flow in the biological basin boosted microbial activity, but excessive flow led to over-aeration,

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compromising overall treatment performance. For instance, air flow exceeding 25,000 m3/d resulted in excessive dissolved oxygen levels up to 5 mg/l, disrupting nitrogen compound removal [5]. Based on these findings, implementing a PID DO aeration controller was addressed, showing improved treatment performance, although total nitrogen concentration remained high. However, coupled with a cyclic ON/OFF aeration control approach, dynamic optimization of control parameters significantly enhanced treatment efficiency, achieving real removal efficiencies of 81.03% for total nitrogen (TN) and 75.61% for ammonia, surpassing theoretical predicted efficiencies.

4 Conclusion

Effective wastewater management is a major global challenge, with significant environmental and economic implications. Our study focused on optimizing energy performance and reducing operational costs at the USTHB wastewater treatment plant. Additionally, our findings revealed that the current aeration system accounts for 70.8% of the total power used, highlighting the importance of energy efficiency optimization. By employing an integrated approach combining advanced modeling and dynamic optimization techniques, we identified effective strategies to reduce aeration energy consumption while ensuring high elimination rates. We opted for a PID DO aeration controller and an ON/OFF cyclic control approach. The results of this approach led to a significant improvement in treatment efficiency, with an actual elimination rate of 81.03% for total nitrogen (TN) and 75.61% for ammonia, surpassing the projected theoretical yields. These results provide practical recommendations for more sustainable water resource management and are crucial for wastewater treatment plant operators and decision-makers in addressing wastewater treatment challenges.

References

[1] G. Ryder, "The United Nations world water development report, 2017: Wastewater: the untapped resource," 2017. [https://unesdoc.unesco.org/ark:/48223/pf0000247419]

[2] M. Fikar, B. Chachuat, Latifi M.A.. Optimal operation of alternating activated sludge processes. Control Engineering Practice, 2005, 13 (7), pp.853-861. https://doi.org/10.1016/j.conengprac.2004.10.003

[3] Shahzad, M.; Khan, S.J.; Paul, P. Influence of Temperature on the Performance of a Full-Scale Activated Sludge Process Operated at Varying Solids Retention Times Whilst Treating Municipal Sewage. *Water* 2015, *7*, 855-867. [https://doi.org/10.3390/w7030855]

[4] Balku Ş (March 1, 2018) Influence of Temperature on Activated Sludge Systems. Celal Bayar University Journal of Science 14 1 77–80. [https://doi.org/10.18466/cbayarfbe.357348]

[5] Gerardi, M.H. (2002). Nitrogen: Environmental and Wastewater Concerns. In Nitrification and Denitrification in the Activated Sludge Process, M.H. Gerardi (Ed.). https://doi.org/10.1002/0471216682.ch1

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