Application of Sequencing Batch Reactor (SBR) Technology for Chicken Farm Wastewater Treatment

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1. RESEARCH BACKGROUND

With the rapid development of China's economy and the improvement of people's living standards, the demand for poultry meat and eggs has continued to grow, driving the development of the chicken industry towards intensification and large-scale operations. Large-scale chicken farms have emerged one after another, which, while ensuring market supply, have also generated a large amount of high-concentration organic wastewater. Aquaculture wastewater has become one of the main sources of agricultural non-point source pollution. Chicken farm wastewater is characterized by high concentrations of organic matter (COD, BOD), high ammonia nitrogen (NH3-N), high suspended solids (SS), high oil content, and may contain pathogenic microorganisms. If directly discharged without effective treatment, it will cause serious pollution to surface water, groundwater, soil, and the atmosphere, leading to water eutrophication, soil compaction, foul odor, and threatening public health. Traditional wastewater treatment processes (such as conventional activated sludge process, oxidation pond, etc.) generally have problems such as large floor area, high investment and operation costs, poor shock load resistance, and unstable nitrogen and phosphorus removal efficiency when treating such wastewater. However, SBR technology is considered a highly potential option for treating such wastewater due to its unique advantages. This research project aims to provide an effective technical solution to solve the industry's pain points through systematic engineering verification, which is of great significance for promoting the green and healthy development of the aquaculture industry. In photonics engineering, Tang et al. [1] designed and optimized shallow-angle grating couplers for achieving vertical emission from indium phosphide devices, advancing optical communication technologies for next-generation integrated photonics [1]. Deng [2] addressed cloud security through homomorphic encryption-based mechanisms for data integrity verification and anti-tampering protection, ensuring secure data storage in cloud environments [2], while Deng and Yang [12] extended this security research by developing multi-layer defense strategies against membership inference attacks within federated learning frameworks, addressing critical vulnerabilities in distributed machine learning systems [12]. Gong et al. [3] provided a comprehensive review of neural network lightweighting techniques, surveying various methods to reduce model complexity and computational requirements while maintaining performance, which is essential for deploying AI models on resource-constrained devices [3]. In recommendation systems, Junxi et al. [4] developed graph convolutional networks based on matrix factorization (GCN-MF) to enhance recommendation accuracy and personalization through effective integration of collaborative filtering and graph-based methods [4]. Zhang [5] applied cohesive hierarchical clustering techniques to address dynamic adaptation challenges in power emergency materials supply-demand systems, improving resource allocation during critical situations [5]. Mehta et al. [6] proposed a comprehensive national AI security framework aimed at protecting critical financial infrastructure from emerging threats, addressing the growing need for standardized security protocols in AI systems [6]. In business analytics, Zhou [7] applied gradient boosting trees to diagnose bottlenecks in international automotive sales funnels, providing insights into cross-regional team efficiency and sales optimization [7], while Li [8] developed AI-driven bid pricing models optimized for non-standard automation projects by leveraging historical financial data and machine learning algorithms to improve pricing accuracy [8]. Yi [9] contributed to digital economics by proposing real-time fair-exposure ad allocation mechanisms using contextual bandits-with-knapsacks, specifically targeting small businesses and underserved creators to promote equitable advertising opportunities [9]. For statistical methodology, Lin et al. [10] developed Bayesian frameworks for modeling multivariate degradation data with dynamic covariates, enhancing reliability engineering predictions for complex systems [10], while Lin et al. [11] contributed computational approaches for the Poisson multinomial distribution with applications spanning ecological inference and machine learning, providing foundational tools for probabilistic modeling [11]. In data visualization and human-computer interaction, Xie and Chen [13] introduced InVis, an interactive neural visualization system designed for human-centered data interpretation that enables users to better understand complex neural network outputs [13], and Xie and Chen [14] developed

CoreViz, a context-aware reasoning and visualization engine specifically tailored for business intelligence dashboards to enhance decision-making processes [14]. Zhu [15] contributed TraceLM, a temporal root-cause analysis framework utilizing contextual embedding language models to identify and diagnose system failures through time-series analysis [15]. Zhang [16] developed CrossPlatformStack, a system enabling high availability and safe deployment for products across Meta services, addressing critical challenges in large-scale platform engineering [16]. Hu [17] introduced GenPlayAds, a procedural playable 3D ad creation system leveraging generative models to automate and enhance advertising content production [17]. Finally, in computer vision, Chen et al. [18] advanced one-stage object referring with gaze estimation, developing methods that integrate visual object detection with human gaze patterns to improve human-computer interaction and visual communication systems [18].

2. PROJECT OVERVIEW

2.1 Design Treatment Scale

The wastewater of a certain project mainly includes empty house flushing wastewater, deodorizing wet curtain wastewater, spray tower wastewater, vehicle disinfection wastewater, employee domestic sewage, and initial rainwater, with a total wastewater production of 11866.73 t/a.

Main characteristics of flushing wastewater: The wastewater is generated intermittently. Each batch of poultry is sold after 60 days of rearing, and the second batch of chicks is introduced after 30 days of empty house flushing and disinfection. The flushing wastewater volume during the empty house period is 2646t/a (equivalent to 34.02 t/d). Characteristics of deodorizing wet curtain wastewater: Each deodorizing room is equipped with a circulating water tank, and there are 35 circulating water tanks in the entire farm. The volume of the circulating water tank is 2 m^3, with an effective volume accounting for 65%, and it is replaced every 10 days. Deodorant is only used during the breeding period, with 240 working days per year. The loss of the circulating water tank is calculated at 35%, so the deodorizing wet curtain wastewater generation is 709.8 t/a (equivalent to 2.96 t/d). Characteristics of spray tower wastewater: The spray tower is equipped with a circulating water tank with an effective volume of approximately 1.5t , and the water in the tank is updated and discharged once a month, so the spray wastewater generation is approximately 18 t/a. Main characteristics of vehicle disinfection wastewater: The project site has 3 clean road entrances and 1 dirty road entrance, with a disinfection pool at each entrance. The volume of the disinfection pool is $12\ m \times 4\ m \times 0.3\ m$, with an effective volume accounting for 60%. The clean road disinfection pool has its disinfectant water replaced once a month and supplemented once every 5 days, with each supplement amount calculated at 35% of the disinfection pool's water consumption; the dirty road disinfection pool has its disinfectant water replaced once every 5 days without separate supplementation, with 360 working days per year, resulting in 108 disinfectant water replacements per year for the entire farm. The loss during disinfection is calculated at 35%, so the vehicle disinfection wastewater generation is 606.53 t/a (equivalent to 1.68 t/d). Main characteristics of employees' domestic sewage: According to "Code for Design of Building Water Supply and Drainage" (GB50015-2019), the domestic water quota is 80 L/person·d, so the new domestic water consumption of the project is approximately 648 t/a. The loss is calculated at 20%, so the employees' domestic sewage generation is 806.4 t/a (equivalent to 2.24 t/d). Characteristics of initial rainwater: The project site area is approximately 234 mu (15.6 hm^2). After calculation, the initial rainwater volume per event is approximately 590 m^3. With 12 rainstorm events considered, the annual initial rainwater generation is 7080 m^3 (equivalent to 19.39 t/d).

The design scale of the sewage treatment station for this project is 120m3/d, which can meet the project's wastewater treatment capacity requirements with a certain margin and can also meet the sewage treatment capacity for the second phase.

2.2 Design influent and effluent water quality

The concentrations of main pollutants are approximately COD 426 mg/L, BOD5 227 mg/L, SS 369 mg/L, NH3-N 77 mg/L, TN 66 mg/L, TP 11 mg/L, fecal coliforms 6.69×106 MPN/L, and ascaris eggs 43 MPN/L.

3. TREATMENT PROCESS

The wastewater from this project is proposed to be treated using the process of "grille + collection tank + coagulation sedimentation tank + adjustment tank + SBR process + effluent disinfection", and the tail water is temporarily stored in an ecological pond for reuse in empty house flushing.

SBR is the core process for wastewater treatment in this project, and its full name is "Sequencing Batch Reactor Activated Sludge Process". It is an activated sludge wastewater treatment technology operated by intermittent aeration, with the main feature of orderly and intermittent operation. The SBR tank integrates functions such as homogenization, primary sedimentation, biodegradation, and secondary sedimentation into one tank, without a sludge return system. Its main process advantages are as follows:

The ideal plug flow process increases the driving force of biochemical reactions and improves efficiency. Anaerobic and aerobic conditions in the tank are in an alternating state, resulting in good purification effect;

Stable operation effect. Sewage precipitates in an ideal static state, requiring short time, high efficiency, and good effluent quality;

Each process in the technological process can be adjusted according to water quality and quantity, with flexible operation;

Nitrogen and phosphorus removal. By appropriately controlling the operation mode, alternating aerobic, anoxic, and anaerobic states can be achieved, resulting in good nitrogen and phosphorus removal effects;

Good effluent quality: The coexistence of anoxic and aerobic conditions in the reactor, high substrate concentration in the reactor, short sludge age, and high specific growth rate. The SBR method can effectively control the excessive reproduction of filamentous bacteria, thereby achieving good static sedimentation and separation effects and high effluent quality;

Simple operation and management: The SBR process flow is simple, with few structures, saving land occupation, low cost, and low equipment operation and management costs. The operation mode is flexible, and multiple process routes can be generated. The same reactor can treat wastewater of different properties only by changing the operating process parameters.

The main process flow is as follows:

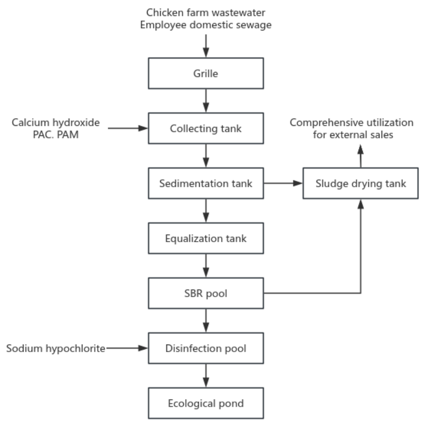

Figure 1: Process Flow Diagram

Grille: The empty house flushing wastewater and staff domestic sewage pass through the manual grille to remove large particles and long fiber impurities, then flow into the collection tank by gravity.

Collection tank: The collection tank is equipped with a collection tank lift pump, a collection tank mixer, and a collection tank liquid level controller. When the collection tank is full, the collection tank mixer is automatically started, and phosphorus remover, coagulant, and flocculant are added. After a period of reaction, the materials are pumped into the sedimentation tank by the collection tank lift pump.

Sedimentation tank: In the sedimentation tank, SS and other substances with relatively large specific gravity are precipitated into the mud hopper. The sewage after sedimentation flows into the adjustment tank by gravity; the precipitated sludge is pumped into the sludge drying tank by the sludge pump.

Adjustment tank: The adjustment tank mainly plays the following roles:

There are many wastewater sources. The water volume varies greatly in different time periods, so it adjusts the water volume;

The water quality of different water sources varies greatly, and some sewage contains disinfectants, so it adjusts the water quality.

Hydrolysis and acidification. Hydrolytic and acidifying microorganisms degrade macromolecular substances (fats, proteins, polysaccharides, etc.) into small molecular substances, which are further degraded into volatile fatty acids, laying the foundation for subsequent treatment.

SBR tank: The adjusted sewage is lifted to the SBR tank by the feed pump. In the SBR tank, COD, ammonia nitrogen, total phosphorus, etc. are removed through anaerobic, anoxic, aerobic, and sedimentation processes. The sludge settled at the bottom of the SBR tank is pumped into the sludge drying tank by the sludge pump at regular intervals;

The process flow of nitrogen and phosphorus removal operation mode of the SBR biochemical treatment process is: I (influent period, stirring without aeration) — II (reaction period, aeration) — III aeration stop and stirring period (stop aeration and stir) — IV sedimentation and sludge discharge period (standstill, no aeration, sedimentation and sludge discharge carried out simultaneously) — V effluent period — VI idle period (sludge activation)

Reaction stage I: Influent stirring. In this stage, phosphorus-accumulating bacteria perform anaerobic phosphorus release, and DO should be controlled below 0.2mg/L;

Reaction stage II: This stage is the aeration stage. In this stage, in addition to the decomposition of BOD5, nitrification and aerobic phosphorus uptake by phosphorus-accumulating bacteria are also carried out. DO should be controlled above 2.0mg/L , and the aeration time in this stage should generally be more than 4h;

Reaction stage III: This stage is the aeration stop and stirring stage, where aeration is stopped and only stirring is performed. Denitrification for nitrogen removal will be carried out in this stage. Due to the high concentration of NO3–N in this stage, it generally does not lead to secondary phosphorus release. The duration of this stage should be above 2 h . Prolonging the time, on the one hand, increases the nitrogen removal efficiency, and on the other hand, reduces the NO3–N concentration in the mixed liquor of stage I, avoiding interference with phosphorus release;

Reaction stage IV: This stage is the sedimentation and sludge discharge stage, where both solid-liquid separation and excess sludge discharge are carried out;

Reaction stage V: This stage is the effluent stage;

Reaction stage VI: This stage is the sludge activation stage.

The total operation time of the nitrogen and phosphorus removal operation mode of the SBR biochemical treatment process is generally in the range of 10 ~14h.

Disinfection tank: After SBR treatment, the sewage flows into the disinfection tank by gravity through the decanter. Sodium hypochlorite solution is added to the disinfection tank to kill pathogens and also play a role in decolorization.

Ecological pond: The effluent from the disinfection tank is reused for empty house flushing after treatment in the ecological pond.

After the ecological pond is built and filled with water, if the pond bottom is not treated for anti-seepage, it will cause the groundwater level at the project site to rise, thereby triggering a series of environmental geological problems in the surrounding area. Therefore, anti-seepage treatment is required before the ecological pond is filled with water. The anti-seepage layer is an equivalent clay anti-seepage layer with $Mb \geq 1.5$ and a permeability coefficient of $K \leq 1 \times 10 - 7\ cm/s$. At the same time, an HDPE membrane is laid to prevent the incoming water from the sewage treatment station from seeping into the external environment.

Ecological floating islands can be configured in the ecological pond to utilize the roots of plants to absorb eutrophic substances in the water, such as total phosphorus, ammonia nitrogen, and organic matter, so as to transfer the nutrients in the water body and reduce the phenomena of water body odor and eutrophication caused by enclosure or insufficient self-circulation. If necessary, aerators can be added to increase the oxygen content in the water and prevent the pond water from deteriorating.

Sludge drying pond: Sludge from the sedimentation tank and SBR tank is regularly pumped into the sludge drying pond by sludge pump 2. A filter layer made of rice husk is laid at the bottom of the sludge drying pond. The sludge spreads evenly in the pond, and the water seeps down quickly through the filter material layer. The wastewater seeping to the bottom of the pond re-enters the collection tank for treatment. The sludge is intercepted on top of the filter material and is regularly cleaned up and sold for utilization when it accumulates to a certain extent.

4. ANALYSIS OF TREATMENT EFFECT

The treatment effect and removal rate of each process section are shown in Table 1: mature and reliable.

Table 1: Design Inlet and Outlet Water Quality and Treatment Effect of Each Sewage Treatment Facility in the Sewage Treatment Station

Structure	Category	COD	BOD5	SS	Ammonia Nitrogen	Total Nitrogen	Total Phosphorus	Fecal Coliform Count (MPN/L)	Ascaris Eggs (MPN/L)
Grille	Influent Water Quality (mg/L)	426	227	369	77	66	11	6.69×10^{6}	43
	Effluent Water Quality (mg/L)	426	227	332	77	66	11	6.69×10^{6}	43
	Removal Rate%	-	-	10	-	-	-	-	-
Collection Tank	Effluent Water Quality (mg/L)	426	227	332	77	66	11	6.69×10^{6}	43
	Removal Rate%	-	-	0	-	-	-	-	-
Sedimentation Tank	Effluent Water Quality (mg/L)	426	227	33	77	66	11	6.69×10^{6}	43
	Removal Rate%	-	-	90	-	-	40	-	-
Regulation Tank	Effluent Water Quality (mg/L)	426	227	33	77	66	7	6.69×10^{6}	43
	Removal Rate%	-	-	-	-	-	-	-	-
SBR Tank	Effluent Water Quality (mg/L)	34.08	9.08	2.3	5.39	13.2	2	1.34×10^{6}	43
	Removal Rate%	92	96	93	93	80	70	80	-
Disinfection Tank	Effluent Water Quality (mg/L)	40	15	18	10	15	5	1	0.44
	Removal Rate%	-	-	-	-	-	-	99.99	91
Ecological Pond Influent Concentration (mg/L)		40	15	18	10	15	5	2	2
Ecological Pond Incoming Water Quality Requirement (mg/L)		100	15	70	10	/	5	/	/
Ecological Pond	Effluent Water Quality (mg/L)	40	15	18	10	15	5	2	0.44
	Removal Rate%	-	-	-	-	-	-	-	-
Reclaimed Water Concentration (mg/L)		40	15	18	10	15	5	3	1

Structure	Category	COD	BOD5	SS	Ammonia Nitrogen	Total Nitrogen	Total Phosphorus	Fecal Coliform Count (MPN/L)	Ascaris Eggs (MPN/L)
Reclaimed Water Quality Requirement (mg/L)		/	15	/	10	/	/	3	/

In combination with the characteristics of the project's sewage, the wastewater treatment process evaluated in this study is "grille + collection tank + coagulation sedimentation tank + adjustment tank + SBR process + effluent disinfection + ecological pond". Based on the above analysis, this process flow has high shock load resistance and stable operation; the operation and management are simple, and it is technically

REFERENCE

[1] Tang, Y., Kojima, K., Gotoda, M., Nishikawa, S., Hayashi, S., Koike-Akino, T., ... & Klamkin, J. (2020). Design and Optimization of Shallow-Angle Grating Coupler for Vertical Emission from Indium Phosphide Devices.

[2] Deng, X. (2025). Homomorphic Encryption-Based Data Integrity Verification and Anti-Tampering Mechanism in Cloud Storage Environment.

[3] Gong, Z., Zhang, H., Yang, H., Liu, F., & Luo, F. (2023). A Review of Neural Network Lightweighting Techniques. Innovation & Technology Advances, 1(2), 1–24. https://doi.org/10.61187/ita.v1i2.36

[4] Junxi, Y., Wang, Z., & Chen, C. (2024). GCN-MF: A graph convolutional network based on matrix factorization for recommendation. Innovation & Technology Advances, 2(1), 14–26. https://doi.org/10.61187/ita.v2i1.30

[5] Zhang, X. (2024). Research on Dynamic Adaptation of Supply and Demand of Power Emergency Materials based on Cohesive Hierarchical Clustering. Innovation & Technology Advances, 2(2), 59–75. https://doi.org/10.61187/ita.v2i2.135

[6] Mehta, R., Patwar, N., Wei, X., Saunders, E., Zhu, X., & Liu, J. (2026). Towards a National AI Security Framework for Financial Infrastructure Protection. International Journal of Advance in Applied Science Research, 5(2), 39–50. Retrieved from https://h-tsp.com/index.php/ijaasr/article/view/251

[7] Zhou, Z. (2026). Bottleneck Diagnosis in International Automotive Sales Funnels Using Gradient Boosting Trees: Evidence from Cross-Regional Team Efficiency Evaluation. Journal of Computer Technology and Applied Mathematics, 3(1), 11-18.

[8] Li, W. (2026). Optimizing AI-Driven Bid Pricing Models for Non-Standard Automation Projects: Leveraging Historical Financial Data and Machine Learning Algorithms.

[9] Yi, X. (2025, October). Real-Time Fair-Exposure Ad Allocation for SMBs and Underserved Creators via Contextual Bandits-with-Knapsacks. In Proceedings of the 2025 2nd International Conference on Digital Economy and Computer Science (pp. 1602-1607).

[10] Lin, Z., Liu, X., Xiang, Y., & Hong, Y. (2025). Modeling multivariate degradation data with dynamic covariates under a Bayesian framework. Reliability Engineering & System Safety, 111115.

[11] Lin, Z., Wang, Y., & Hong, Y. (2023). The computing of the Poisson multinomial distribution and applications in ecological inference and machine learning. Computational Statistics, 38(4), 1851-1877.

[12] Deng, X., & Yang, J. (2025, August). Multi-Layer Defense Strategies and Privacy Preserving Enhancements for Membership Reasoning Attacks in a Federated Learning Framework. In 2025 5th International Conference on Computer Science and Blockchain (CCSB) (pp. 278-282). IEEE.

[13] Xie, Minhui, and Shujian Chen. "InVis: Interactive Neural Visualization System for Human-Centered Data Interpretation." Authorea Preprints (2025).

[14] Xie, Minhui, and Shujian Chen. "CoreViz: Context-Aware Reasoning and Visualization Engine for Business Intelligence Dashboards." Authorea Preprints (2025).

[15] Zhu, Bingxin. "TraceLM: Temporal Root-Cause Analysis with Contextual Embedding Language Models." (2025).

[16] Zhang, Yuhan. "CrossPlatformStack: Enabling High Availability and Safe Deployment for Products Across Meta Services." (2025).

[17] Hu, Xiao. "GenPlayAds: Procedural Playable 3D Ad Creation via Generative Model." (2025).

[18] Chen, J., Zhang, X., Wu, Y., Ghosh, S., Natarajan, P., Chang, S. F., & Allebach, J. (2022). One-stage object referring with gaze estimation. In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (pp. 5021-5030).