ASSESSMENT OF THE POTENTIAL FOR REUSING TREATED DOMESTIC WASTEWATER FOR URBAN AGRICULTURE IN TAN UYEN CITY, BINH DUONG PROVINCE

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ABSTRACT

In the context of rapid urbanization and increasing water demand in agriculture, the reuse of treated domestic wastewater is emerging as an important solution toward developing green and sustainable cities. This study aims to assess the potential for reusing treated domestic wastewater in Tan Uyen City, Binh Duong Province. Data were collected from the city's domestic wastewater treatment system, with key analyzed parameters including BOD_5, COD, TSS, NH_4^+, NO_3^-, total nitrogen (TN), total phosphorus (TP), alkalinity, and color. The results indicate high treatment efficiency, with COD reduced by 94.49% (from 290.4 ± 0.2 mg/L to 16 ± 1 mg/L), BOD_5 by 97.1% (from 93.36 ± 0.03 mg/L to 2.706 ± 0.001 mg/L), TSS by 97.36% (from 196.8 ± 0.1 mg/L to 5.2 ± 0.1 mg/L), and Coliform by 99.69% (from 80162 ± 3 MNP/100 mL to 250.6 ± 0.1 MNP/100 mL). Additionally, NH_4^+ decreased from 40.54 ± 0.02 mg/L to 0.168 ± 0.02 mg/L (99.59% efficiency), NO_3^- from 4.58 ± 0.01 mg/L to 1.34 ± 0.03 mg/L (70.74%), total nitrogen from 39.6 ± 0.1 mg/L to 6.96 ± 0.01 mg/L (82.42%), and total phosphorus from 3.84 ± 0.01 mg/L to 1.14 ± 0.01 mg/L (70.31%). The color was significantly reduced from 427.4 ± 0.1 Pt/Co to 20.8 ± 0.1 Pt/Co (95.13%). The analysis results show that the treated water meets the requirements of QCVN 39:2011/BTNMT, and it can be reused for purposes such as irrigation of landscape greenery, vegetables, or short-term industrial crops. The study recommends enhancing post-treatment water quality monitoring and developing effective reuse models to improve water resource conservation, reduce pressure on freshwater sources, and promote sustainable urban agricultural development in Tan Uyen City.

Keywords: Treated wastewater reuse, urban agriculture, sustainable development, Tan Uyen City, domestic wastewater.

1. INTRODUCTION

Water scarcity is becoming an increasingly critical issue in the context of rapid urbanization, population growth, and climate change [1, 2]. In many developing countries, including Vietnam, the pressures on freshwater resources are growing, particularly in urban and peri-urban areas where the demand for water in domestic use, industry, and agriculture is escalating [3-5]. As freshwater sources become more limited and vulnerable to pollution, the search for alternative water sources has gained prominence in sustainable water resource management strategies.

One promising solution that has emerged is the reuse of treated domestic wastewater, especially for non-potable purposes such as landscape irrigation and agricultural production [6]. Treated wastewater, when properly managed and monitored, can provide a reliable and nutrient-rich water source, helping to reduce dependency on conventional freshwater supplies, mitigate environmental impacts, and support urban sustainability goals.

In recent years, Vietnam has made significant investments in wastewater treatment infrastructure, particularly in rapidly developing provinces such as Binh Duong. Tan Uyen City, located in Binh Duong Province, is experiencing fast-paced industrial and urban development, accompanied by a growing demand for land and water for urban agriculture. However, most of the treated domestic wastewater in the city is discharged without reuse, representing a missed opportunity in water resource recovery and circular economy development.

Although international studies have demonstrated the viability and benefits of wastewater reuse, local assessments tailored to specific environmental and socio-economic contexts remain limited [7-9]. In Vietnam, practical evaluations of wastewater reuse potential at the city level especially in emerging urban areas like Tan Uyen—are scarce. There is a clear need to bridge this knowledge gap by assessing the quality of treated wastewater and its suitability for urban agricultural reuse.

While the wastewater treatment technology applied in Tan Uyen City is not itself novel, the significance of this study lies in its localized assessment of reuse feasibility under real-world conditions. By integrating national regulatory standards (QCVN 14:2008/BTNMT, QCVN 40:2011/BTNMT, and QCVN 39:2011/BTNMT) with the unique urban-agricultural dynamics of a rapidly industrializing Vietnamese city, the research provides timely evidence to support adaptive water resource management and land-use planning.

Therefore, this study aims to evaluate the potential for reusing treated domestic wastewater for urban agriculture in Tan Uyen City. By analyzing key water quality parameters and comparing them with national standards, the research provides a scientific basis for promoting the safe and effective reuse of treated wastewater. The findings will contribute to sustainable water management policies, support green urban development, and encourage the implementation of circular economy practices at the local level.

2. MATERIALS AND METHODS

2.1 Study area

Tan Uyen City is located in the southeast of Binh Duong Province, Vietnam, and has undergone rapid urbanization and industrialization in recent years. Alongside the development of residential and industrial zones, urban agriculture remains an important component of local livelihoods, especially in peri-urban areas.

The centralized domestic wastewater treatment system in Tan Uyen City is operated by the Binh Duong Water–Environment Joint Stock Company (BIWASE), with a Phase 1 treatment capacity of 15,000 m³/day-night. The treatment process follows a comprehensive multi-stage approach, ensuring that the treated effluent complies with QCVN 40:2011/BTNMT (Column A) – the National Technical Regulation on Industrial Wastewater, which is the applicable standard for wastewater discharged into receiving sources.

Subsequent to this primary treatment, reuse potential is evaluated based on the requirements of QCVN 39:2011/BTNMT, which regulates wastewater quality criteria specifically for irrigation purposes such as watering of landscape greenery, vegetables, and

short-term industrial crops. This dual compliance strategy ensures both environmental protection and safe reuse in urban agriculture contexts.
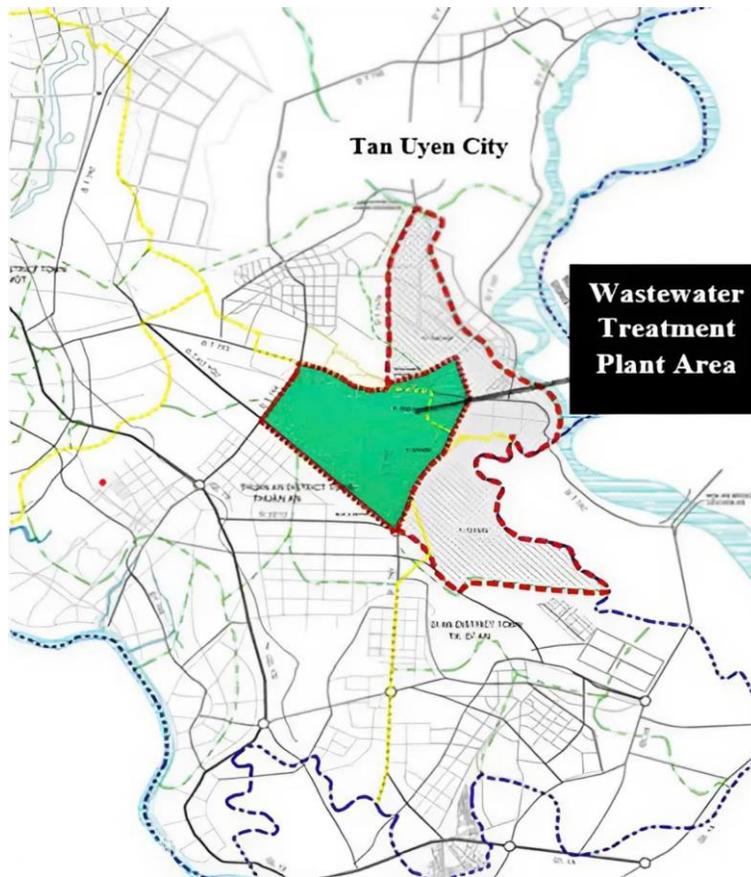

Figure 1. Map of wastewater treatment plant location

2.2 Sample collection and analytical methods

Wastewater samples were systematically collected from both the influent (raw domestic wastewater) and effluent (treated water) points of the centralized treatment plant during the dry season to minimize flow variation. Sampling was conducted during November–December 2024, representing typical operational conditions of the treatment system.

The analysis focused on key water quality indicators to evaluate treatment efficiency. All measurements were conducted following Vietnamese National Standards (TCVN), using methods aligned with international scientific practice, including spectrophotometric, titrimetric, gravimetric, and electrochemical techniques.

All laboratory analyses were performed in accredited environmental laboratories, adhering to strict quality assurance and control protocols. The performance of the wastewater treatment plant was assessed against two key national discharge standards:

QCVN 40:2011/BTNMT - Column A: National technical regulation on industrial wastewater, applicable for effluents discharged into water bodies used for domestic water supply.

QCVN 14:2008/BTNMT - Column A: National technical regulation on domestic wastewater, applied for residential wastewater that is directly discharged into surface water used for domestic purposes.

This dual-compliance approach ensures that the treated wastewater is safe for potential agricultural reuse and environmental discharge, aligning with national environmental protection goals and sustainable water resource management practices.

Table 1. Analytical methods

Parameter	Analytical Method
pH	TCVN 6492:2011 (Glass electrode method)
Temperature	TCVN 4557:1988 (Thermometric method)
Color (Pt-Co scale)	TCVN 6185:2015 (Colorimetric method)
Total Suspended Solids (TSS)	TCVN 6425:2000 (Gravimetric method)
Dissolved Oxygen (DO)	TCVN 5499:1995 (Electrochemical probe)
Chemical Oxygen Demand (COD)	TCVN 6491:1999 (Closed reflux titrimetric method)
Biochemical Oxygen Demand (BOD$_5$)	TCVN 6001-2:2008 (5-Day Incubation method)
Ammonium (NH$_4^+$-N)	TCVN 6179-1:1996 (Nessler method – Spectrophotometry)
Nitrate (NO$_3^-$-N)	TCVN 6180:1996 (UV Spectrophotometric method)
Total Nitrogen (TN)	TCVN 6498:1999 (Kjeldahl and UV spectrophotometry)
Total Phosphorus (TP)	TCVN 6202:2008 (Ascorbic acid spectrophotometric method)
Coliform	TCVN 6187-1:2009

2.3 Evaluation criteria

To evaluate the potential for safe and sustainable reuse of treated wastewater, the analytical results were benchmarked against the Vietnamese National Technical Regulation on Reuse of Treated Wastewater – QCVN 39:2011/BTNMT. Specifically, Column A standards were used as the primary criterion, as they apply to scenarios involving high exposure risk—such as irrigation of edible crops, ornamental plants, and green public spaces in urban environments. This regulatory framework provides stringent limits on key parameters, including nutrients, organic load and microbiological indicators, ensuring protection of both human health and ecological integrity.

In parallel, the treatment system's compliance was also assessed against QCVN 40:2011/BTNMT – Column A (for industrial wastewater) and QCVN 14:2008/BTNMT – Column A (for domestic wastewater), acknowledging the hybrid nature of wastewater sources in the area. This dual-compliance evaluation reinforces the technical robustness of the system and its alignment with current national environmental management goals.

The feasibility of treated wastewater reuse was further discussed in the context of Tan Uyen City's urban development trajectory, regional climatic conditions, and land-use practices, particularly with respect to expanding urban agriculture. The integration of wastewater reuse into local water resource planning supports circular economy principles and contributes to resilience in urban infrastructure under increasing water stress.

2.4. Statistical analysis and calculation methodology

To assess the performance of the wastewater treatment system, samples were collected and analyzed in triplicate (n = 3) at both influent and effluent points for each monitoring day

during November–December 2024. Analytical results for each parameter were expressed as mean ± standard deviation (SD) to indicate the central tendency and variability among replicates.

The following formulas were applied:

Mean ($\bar{x}$)

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \qquad (1)$$

Standard Deviation (SD)

$$SD = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2} \qquad (2)$$

Removal Efficiency (%)

$$RE\ (\%) = \left(\frac{C_{Inlet} - C_{outlet}}{C_{Inlet}}\right) \times 100 \qquad (3)$$

Where C_{Inlet}, C_{outlet} are the average concentrations of the parameter in the influent and effluent, respectively.

To evaluate whether differences in water quality parameters before and after treatment were statistically significant, a one-way Analysis of Variance (ANOVA) was performed using Statgraphics Centurion 19 software. The significance level was set at α = 0.05, and p-values < 0.05 were considered statistically significant. This approach strengthens the reliability of the performance evaluation by reducing the influence of random variability and measurement error [10, 11].

3. RESULTS AND DISCUSSION

3.1 Efficiency of wastewater treatment system

The evaluation of the wastewater treatment system at Tan Uyen City, based on data collected from November to December 2024, highlights its outstanding performance across key physicochemical parameters. The treated effluent demonstrated a high degree of pollutant removal, validating the effectiveness of the technological processes employed. Table 2 summarizes the average values of selected parameters before and after treatment, along with corresponding removal efficiencies.

The color of the wastewater, a significant aesthetic and environmental quality indicator, was reduced from 427.4 ± 0.1 Pt/Co units to 20.8 ± 0.1 Pt/Co, corresponding to a removal efficiency of 95.13%. This significant improvement indicates the successful removal of dissolved and suspended organic substances responsible for water discoloration.

Total suspended solids (TSS), representing particulate matter, were reduced from 196.8 ± 0.1 mg/L to 5.2 ± 0.1 mg/L an impressive 97.36% removal. This reflects the efficiency of the primary sedimentation and filtration units in the system.

Ammonium (NH_4^+) concentration dropped drastically from 40.54 ± 0.02 mg/L to just 0.168 ± 0.02 mg/L, equating to a 99.59% reduction. This result confirms the high nitrification efficiency of the biological treatment stage, which is crucial for protecting aquatic ecosystems from ammonia toxicity.

Table 2. The average values of selected parameters before and after treatment

No.	Parameters	Unit	Inlet Avg.	Outlet Avg.	Removal Efficiency (%)
1	Color	Pt/Co	427.4 ± 0.1	20.8 ± 0.1	95.13
2	TSS	mg/L	196.8 ± 0.1	5.2 ± 0.1	97.36
3	NH_4^+	mg/L	40.54 ± 0.02	0.168 ± 0.02	99.59
4	NO_3^-	mg/L	4.58 ± 0.01	1.34 ± 0.03	70.74
5	COD	mg/L	290.4 ± 0.2	16.0 ± 1	94.49
6	BOD_5	mg/L	93.36 ± 0.03	2.706 ± 0.001	97.10
7	TP	mg/L	3.84 ± 0.01	1.14 ± 0.01	70.31
8	TN	mg/L	39.6 ± 0.1	6.96 ± 0.01	82.42
9	Alkalinity	mg/L	144.46 ± 0.01	30.48 ± 0.01	78.90
10	Coliform	MNP/100mL	80162 ± 3	250.6 ± 0.1	99.69

Nitrate (NO_3^-), a by-product of the nitrification process, was reduced by 70.74%, from 4.58 ± 0.01 mg/L to 1.34 ± 0.03 mg/L. Although the reduction is lower than that of ammonium, it indicates a functioning denitrification process, likely occurring under anoxic conditions.

Chemical oxygen demand (COD) and biochemical oxygen demand over 5 days (BOD_5), which represent organic pollution loads, were also significantly reduced. COD decreased from 290.4 ± 0.2 mg/L to 16 ± 1 mg/L (94.49% removal), and BOD_5 from 93.36 ± 0.03 mg/L to 2.706 ± 0.001 mg/L (97.10% removal). These reductions demonstrate the high capacity of the system to remove both biodegradable and non-biodegradable organic matter.

Total phosphorus (TP), a contributor to eutrophication, was decreased by 70.31%, from 3.84 ± 0.01 mg/L to 1.14 ± 0.01 mg/L. This level of removal reflects adequate phosphorus uptake through chemical precipitation or biological assimilation. Meanwhile, total nitrogen (TN) was reduced from 39.6 ± 0.1 mg/L to 6.96 ± 0.01 mg/L, achieving an 82.42% removal efficiency, indicating well-integrated nitrogen cycling through nitrification and denitrification.

The system also achieved a significant alkalinity reduction of 78.9%, from 144.46 ± 0.01 mg/L to 30.48 ± 0.01 mg/L. This suggests that alkalinity was consumed during nitrification reactions, a common phenomenon in biological wastewater treatment systems. Notably, the system also demonstrated a very high efficiency in removing coliform bacteria, achieving a 99.69% reduction from an average of $80,162 \pm 3$ MPN/100mL to 250.6 ± 0.1 MPN/100mL.

pH after treatment ranged from 6.40 to 6.43, with an average of 6.416, which falls well within the permitted limits (5–9 for QCVN 14:2008/ BTNMT and 6–9 for QCVN 40:2011/ BTNMT- Column A), indicating stable neutral water quality after treatment.

Compared to previous studies, the research results at the Tan Uyen Wastewater Treatment Plant show that the treatment efficiency is comparable to or even higher than that reported by Nguyen Quang Tuan et al. (2020) at the Di An Wastewater Branch. Specifically, the removal efficiencies for color (95.13%), COD (94.49%), BOD_5 (97.10%), NH_4^+ (99.59%), and NO_3^- (70.74%) at Tan Uyen were higher than those at Di An. The total nitrogen removal efficiency at Tan Uyen reached 82.42%, comparable to 84.6% at Di An, while the total phosphorus removal at Tan Uyen (70.31%) was lower than at Di An (88.65%). Notably, the coliform removal efficiency at Tan Uyen achieved 99.69%, equivalent to the UV disinfection efficiency at Di An. These results demonstrate that the Tan Uyen system operates effectively, meeting discharge standards and supporting potential water reuse applications [12].

Collectively, these results demonstrate the system's robustness and suitability for meeting dual discharge and reuse standards: both QCVN 40:2011/BTNMT – Column A (industrial wastewater discharge) and QCVN 14:2008/BTNMT – Column A (domestic wastewater discharge). The high removal rates, particularly for nitrogen compounds, organic matter, and solids, also indicate the system's potential to meet QCVN 39:2011/BTNMT thresholds for safe reuse in urban agriculture and landscape irrigation. The wastewater treatment plant in Tan Uyen City proves to be an effective and reliable infrastructure for managing urban wastewater, offering both environmental protection and circular water reuse potential.

3.2 Suitability for urban agriculture

The analysis results of the treated effluent from the Tan Uyen City wastewater treatment plant in November–December 2024 show that the water quality meets high standards and is fully suitable for reuse in urban agriculture. The assessment is based on three regulatory standards: QCVN 14:2008/BTNMT (Column A), QCVN 40:2011/BTNMT (Column A) – which set limits for wastewater discharged into surface water for domestic use, and particularly QCVN 39:2011/BTNMT, the national technical regulation on water quality for agricultural irrigation.
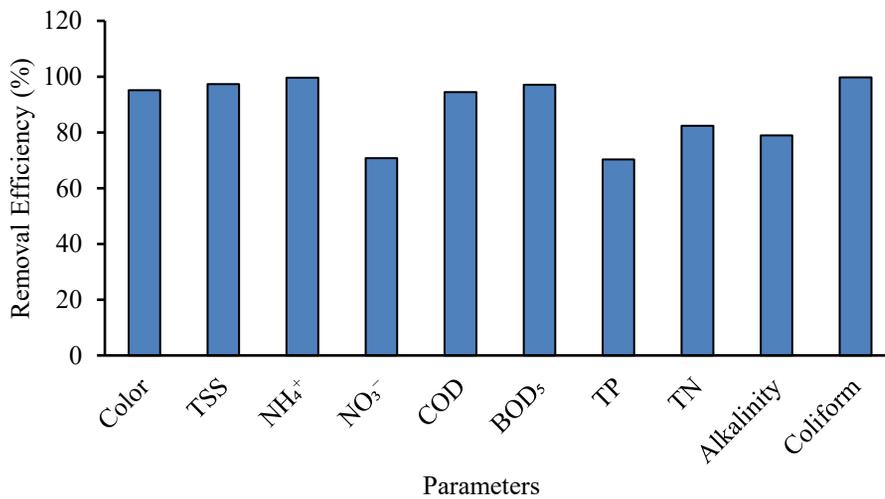

Figure 2. Removal efficiency

The results of table 2 and figure 2 show that: pH averaged 6.416, falling within the 5.5 – 9 range required by QCVN 39:2011/BTNMT, suitable for the growth of most crops.

Total Suspended Solids (TSS) remained very low, averaging 5.2 ± 0.1 mg/L – significantly below the 50 mg/L limit (QCVN 40:2011/ BTNMT), ensuring soil porosity and minimizing root clogging.

Ammonium (NH_4^+) averaged 0.168 ± 0.02 mg/L, and Nitrate (NO_3^-) 1.34 ± 0.03 mg/L – both at safe levels that neither pose pollution risks nor inhibit crop growth; they also serve as accessible nutrient forms for plants.

COD (16 ± 1 mg/L) and BOD_5 (2.706 ± 0.001 mg/L) levels indicate minimal organic residue, posing no risk to soil health or plant roots.

Total Nitrogen (TN) and Total Phosphorus (TP) averaged 6.96 ± 0.01 mg/L and 1.14 ± 0.01 mg/L respectively – both are essential nutrients that can enhance soil fertility in circular farming systems.

Total Alkalinity averaged 30.48 ± 0.01 mg/L – contributing to soil pH stabilization and improved nutrient exchange.

Notably, the coliform concentration decreased dramatically to an average of 250.6 ± 0.1 MPN/100 mL, achieving a removal efficiency of 99.69%. This value is significantly below the threshold set by QCVN 39:2011/BTNMT, affirming that the microbiological quality of the treated water is safe for reuse in agricultural activities, especially for non-food crops and ornamental plants.

In comparison with the threshold values set by QCVN 39:2011/BTNMT, the treated wastewater in Tan Uyen meets all criteria for agricultural reuse, including models such as leafy vegetable cultivation, fruit trees, herbs, ornamental plants, or greenhouse farming. The low and stable environmental indicators also support the development of recirculating hydroponic systems in urban areas.

When compared with the study by Kihila et al. (2014) in Moshi (Tanzania), where treated wastewater from waste stabilization ponds and constructed wetlands showed average TDS levels of 587–627 mg/L, Nitrate-Nitrogen levels of 2.35–9.19 mg/L, and high fecal coliform counts ranging from 1000 to 4626 CFU/100 mL, the treated wastewater from Tan Uyen demonstrated significantly superior quality in both nutrient and microbial parameters. This indicates a safer potential for reuse, minimizing public health risks as highlighted by Kihila and colleagues [13].

Moreover, in comparison with the study by Miller-Robbie et al. (2017) conducted in Hyderabad (India), where findings suggested that treated wastewater reuse in agriculture could reduce system-wide greenhouse gas emissions by 33% but nutrient recovery remained limited (<1% due to land constraints), the data from Tan Uyen also suggest that wastewater reuse primarily provides benefits in freshwater conservation and pollution reduction. However, to optimize nutrient recovery and ensure food safety, it is necessary to focus more on post-harvest management and changing farmer practices, consistent with the recommendations by Miller-Robbie et al [14].

Reusing treated water not only helps reduce pressure on municipal water supplies, but also promotes a circular water economy – a key strategy in the context of resource scarcity and the sustainable development goals of Binh Duong province. Nevertheless, to ensure long-term effectiveness and safety, policies on regular water quality monitoring, technical irrigation guidelines, and public awareness campaigns on the benefits of reused water in agriculture should be implemented.

3.3 Proposed solutions for reusing treated wastewater in urban agriculture

Based on the analysis of both influent and effluent water quality at the Tan Uyen City wastewater treatment plant, and in comparison with national technical standards (QCVN 14:2008/BTNMT, QCVN 40:2011/BTNMT, and QCVN 39:2011/BTNMT), the following solutions are proposed to enhance the sustainable reuse of treated wastewater in urban agriculture:

Promote the reuse of treated wastewater in agriculture: As the treated effluent complies with the criteria outlined in QCVN 39:2011/BTNMT for irrigation purposes, local authorities should actively promote its reuse in urban agriculture. This includes applications in non-edible crops, ornamental plants, and selectively in edible crops under strictly monitored conditions. Such reuse not only optimizes water resources but also reduces reliance on freshwater sources.

Develop guidelines for safe reuse: Local environmental agencies should formulate and disseminate specific technical guidelines for the safe application of treated wastewater in various agricultural systems (e.g., soil-based farming, hydroponics, and greenhouse

cultivation). These guidelines should cover appropriate dilution ratios, irrigation frequencies, and buffer zones to minimize environmental and health risks.

Raise awareness and provide training: Educational programs and public awareness campaigns should be implemented to inform farmers, agricultural cooperatives, and local communities about the economic, environmental, and health benefits of using treated wastewater. These initiatives should also address social and psychological barriers to acceptance.

Encourage research and innovation: It is essential to support pilot programs and scientific research that investigate the long-term effects of wastewater reuse on soil health, crop yield, and ecosystem integrity in Tan Uyen and neighboring areas. The findings from such studies will serve as a scientific basis for future policies and broader implementation.

Integrate circular economy strategies: Treated wastewater reuse should be embedded within the broader circular economy and climate resilience strategies of Binh Duong Province. This approach contributes to the Net-Zero 2050 target by reducing water extraction, lowering operational treatment costs, and promoting sustainable agricultural practices.

By implementing these recommendations, Tan Uyen City can become a leading example in the safe and efficient reuse of wastewater for urban agriculture, ensuring water security and contributing to national environmental and sustainable development goals.

4. CONCLUSIONS

This study assessed the potential for reusing treated domestic wastewater from the Tan Uyen City centralized treatment system for urban agricultural purposes. By analyzing influent and effluent water quality data collected during November–December 2024 and benchmarking against Vietnamese national standards (QCVN 14:2008/BTNMT, QCVN 40:2011/BTNMT, and QCVN 39:2011/BTNMT), several key conclusions can be drawn:

The influent wastewater exhibited elevated levels of pollutants such as TSS, COD, BOD_5, NH_4^+, total nitrogen, total phosphorus, and coliform bacteria, exceeding the permissible thresholds for both discharge and reuse. However, the treatment process achieved consistently high removal efficiencies, bringing all parameters within the allowable limits especially under QCVN 39:2011/BTNMT, which governs wastewater reuse for irrigation purposes.

The effluent quality indicates that the treated water is technically suitable for reuse in urban agriculture, particularly for non-edible crops, ornamental plants, or edible crops under controlled and monitored conditions. The application of reuse in this context contributes to water conservation, enhances local agricultural resilience, and supports circular economy principles.

While the results are promising, this study was limited to laboratory-based quality assessment and did not evaluate the long-term environmental, agronomic, or public health impacts of continuous reuse. Key concerns such as seasonal variation, soil nutrient accumulation, pathogen persistence, and potential microbial resistance were beyond the scope of this work. Therefore, we recommend that future research include: Full-scale field trials to monitor the impacts on soil and crop health over time; Economic feasibility assessments to quantify costs and potential water savings; Evaluation of social acceptance and public health risks under real-world reuse scenarios; Inclusion of wet-season data to account for seasonal variability in wastewater quantity and composition.

In conclusion, the reuse of treated wastewater in Tan Uyen City represents a viable and environmentally sound strategy for supporting sustainable urban agriculture. When implemented with proper guidelines, monitoring, and stakeholder engagement, this approach

could significantly reduce freshwater consumption, lower environmental discharge loads, and contribute to Binh Duong Province's Net-Zero 2050 goals.

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REFERENCES

1. McDonald, R.I., Green, P., Balk, D., Fekete, B.M., Revenga, C., Todd, M., & Montgomery, M. - Urban growth, climate change, and freshwater availability, Proceedings of the National Academy of Sciences **108** (15) (2011) 6312-6317. https://doi.org/10.1073/pnas.1011615108

2. Smith, A. - Urbanization and Water Scarcity: Sustainable Solutions (2023).

3. Schramm, S. - Semicentralised water supply and treatment: Options for the dynamic urban area of Hanoi, Vietnam, Journal of Environmental Assessment Policy and Management **13** (02) (2011) 285-314. https://doi.org/10.1142/S1464333211003882

4. Izah, S.C., Jacob, D.E., Nelson, I.U., & Avez, S. - Urban Water Crisis in the Global South. In Water Crises and Sustainable Management in the Global South, Springer Nature (2024) 45-83. https://doi.org/10.1007/978-981-97-4966-9_2

5. Truong Duc Toan - Research on establishing water resource use rights and forming a market for buying and selling water resource use rights in river basins in water-scarce areas of Vietnam, Journal of Water Resources and Environmental Science and Technology **69** (6) (2020) 3-11.

6. Christou, A., Beretsou, V.G., Iakovides, I.C., Karaolia, P., Michael, C., Benmarhnia, T., ... & Fatta-Kassinos, D. - Sustainable wastewater reuse for agriculture, Nature Reviews Earth & Environment **5** (7) (2024) 504-521. https://doi.org/10.1038/s43017-024-00560-y

7. Molinos-Senante, M., Hernández-Sancho, F., & Sala-Garrido, R. -Cost–benefit analysis of water-reuse projects for environmental purposes: A case study for Spanish wastewater treatment plants, Journal of Environmental Management **92** (12) (2011) 3091-3097. https://doi.org/10.1016/j.jenvman.2011.07.023

8. Akpan, V.E., Omole, D.O., & Bassey, D.E. -Assessing the public perceptions of treated wastewater reuse: opportunities and implications for urban communities in developing countries, Heliyon **6** (10) (2020) 1-7. https://10.1016/j.heliyon.2020.e05371

9. Jaramillo, M.F., & Restrepo, I. -Wastewater reuse in agriculture: A review about its limitations and benefits, Sustainability **9** (10) (2017) 1-19. https://doi.org/10.3390/su9101734

10. Montgomery, D.C.-Design and analysis of experiments. John wiley & sons (2017).

11. Zar, J.H.-Biostatistical analysis. ed. Princeton-Hall, New Jersey (1999).

12. Nguyen, Q.T., Truong, Q.M. - Survey and assessment of treatment effectiveness of the wastewater treatment system at Di An wastewater branch. Thu Dau Mot University Science Journal **6** (49) (2020) 36-41. https://doi.org/10.37550/tdmu.VJS/2020.06.093

13. Kihila, J., Mtei, K.M., & Njau, K.N. - Wastewater treatment for reuse in urban agriculture; the case of Moshi Municipality, Tanzania. Physics and Chemistry of the Earth, Parts A/B/C, **72** (2014) 104-110. https://doi.org/10.1016/j.pce.2014.10.004

14. Miller-Robbie, L., Ramaswami, A., & Amerasinghe, P. - Wastewater treatment and reuse in urban agriculture: exploring the food, energy, water, and health nexus in Hyderabad, India. Environmental Research Letters **12** (7) (2017) 1-12. https://doi.org/10.1088/1748-9326/aa6bfe

TÓM TẮT

ĐÁNH GIÁ TIỀM NĂNG TÁI SỬ DỤNG NƯỚC THẢI SINH HOẠT PHỤC VỤ NÔNG NGHIỆP ĐÔ THỊ TẠI THÀNH PHỐ TÂN UYÊN, TỈNH BÌNH DƯƠNG

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Trong bối cảnh đô thị hóa diễn ra nhanh chóng và nhu cầu sử dụng nước trong nông nghiệp ngày càng tăng, việc tái sử dụng nước thải sinh hoạt sau xử lý đang trở thành một giải pháp quan trọng hướng tới phát triển đô thị xanh và bền vững. Nghiên cứu này nhằm đánh giá tiềm năng tái sử dụng nước thải sinh hoạt đã qua xử lý tại thành phố Tân Uyên, tỉnh Bình Dương. Dữ liệu được thu thập từ hệ thống xử lý nước thải sinh hoạt của thành phố, với các thông số chính được phân tích gồm: BOD_5, COD, TSS, NH_4^+, NO_3^-, tổng nitơ (TN), tổng phốt pho (TP), độ kiềm và màu sắc. Kết quả cho thấy hiệu quả xử lý đạt mức cao: COD giảm 94,49% (từ 290,4 ± 0,2 mg/L xuống 16 ± 1 mg/L), BOD_5 giảm 97,1% (từ 93,36 ± 0,03 mg/L xuống 2,706 ± 0,001 mg/L), TSS giảm 97,36% (từ 196,8 ± 0,1 mg/L xuống 5,2 ± 0,1 mg/L), và Coliform giảm 99,69% (từ 80.162 ± 3 MNP/100 mL xuống 250,6 ± 0,1 MNP/100 mL). Ngoài ra, nồng độ NH_4^+ giảm từ 40,54 ± 0,02 mg/L xuống 0,168 ± 0,02 mg/L (hiệu suất 99,59%), NO_3^- giảm từ 4,58 ± 0,01 mg/L xuống 1,34 ± 0,03 mg/L (70,74%), tổng nitơ giảm từ 39,6 ± 0,1 mg/L xuống 6,96 ± 0,01 mg/L (82,42%), và tổng phốt pho giảm từ 3,84 ± 0,01 mg/L xuống 1,14 ± 0,01 mg/L (70,31%). Màu sắc nước cũng giảm đáng kể từ 427,4 ± 0,1 Pt/Co xuống 20,8 ± 0,1 Pt/Co (95,13%). Kết quả phân tích cho thấy nước sau xử lý đạt yêu cầu theo quy chuẩn QCVN 39:2011/BTNMT và có thể được tái sử dụng cho các mục đích như tưới cây cảnh, rau màu hoặc cây công nghiệp ngắn ngày. Nghiên cứu kiến nghị cần tăng cường công tác giám sát chất lượng nước sau xử lý và xây dựng các mô hình tái sử dụng hiệu quả nhằm góp phần bảo vệ tài nguyên nước, giảm áp lực lên nguồn nước ngọt và thúc đẩy phát triển nông nghiệp đô thị bền vững tại thành phố Tân Uyên.

Từ khóa: Tái sử dụng nước thải sau xử lý, nông nghiệp đô thị, phát triển bền vững, thành phố Tân Uyên, nước thải sinh hoạt.