



TUYỂN TẬP HỘI THẢO KHOA HỌC QUỐC GIA

QUẢN LÝ MÔI TRƯỜNG VÀ PHÁT TRIỂN TÀI NGUYÊN THIÊN NHIÊN

EMNR 2020



Đánh giá hiệu quả hệ thống USBF sử dụng giá thể phủ vật liệu nano TiO₂ biến tính Eu trong xử lý nước thải sinh hoạt

Nguyễn Hoàng Dũng, Nguyễn Hoàng Nam, Đào Trung Thành..... 323

Nghiên cứu thu hồi nguyên tố đất hiếm từ màn hình máy tính xách tay thải

Nguyễn Thị Hồng, Đào Trung Thành, Nguyễn Thị Anh Thư..... 331

Nghiên cứu đánh giá hàm lượng kim loại nặng trong trầm tích ven bờ khu vực đảo Cái Bầu, tỉnh Quảng Ninh

Đào Trung Thành, Nguyễn Thị Hồng, Trần Thị Ngọc..... 338

Ứng dụng mô hình Mike21 để đánh giá quá trình lan truyền bùn cát và vật chất đáy do hoạt động nạo vét tại khu vực Tân Hải qua cửa Ba Đăng trên Sông Phan, tỉnh Lâm Đồng

Nguyễn Thị Hoà, Vũ Thị Lan Anh, Nguyễn Thị Hồng..... 346

Đánh giá chất lượng môi trường đất và nước tại một số làng nghề tái chế phế liệu

Nguyễn Mai Hoa 355

Xác định điểm nóng ô nhiễm dầu do sự cố tàu vận chuyển khoáng sản tại hồ Thác Bà, tỉnh Yên Bái bằng mô hình MIKE 21

Phan Thị Mai Hoa, Trần Thị Ngọc, Nguyễn Thị Cúc 365

The application of hydrological approaches for the estimation and evaluation of minimum flow in the Huong River basin

Vu Thu Hien, Pham Khanh Huy 375

Physicochemical evolution and molecular dynamics analysis of torrefaction porous bio-char

Lê Phú Cường 384

Xác định các vị trí xảy ra trượt lở và các yếu tố ảnh hưởng tại đảo Cát Bà, thành phố Hải Phòng sử dụng ảnh viễn thám đa thời gian

Nguyễn Thị Ánh Nguyệt, Trần Thị Thu Hà, Nguyễn Quang Minh, Đào Minh Nhựt..... 396

Nghiên cứu một số thuật toán học máy đánh giá nguy cơ xảy ra tai biến địa môi trường khu vực Đồ Sơn, TP. Hải Phòng

Phan Thị Mai Hoa, Nguyễn Quốc Phi, Phương Thị Ngọc, Lê Thị Vân Anh, Nguyễn Đức Thành, Hoàng Minh Thư, Đường Thị Thanh Huế, Gabin Germon, Amin Adarzi, Đào Minh Nhựt 406

Đánh giá mức độ ô nhiễm nước mặt sông Hà Thanh, tỉnh Bình Định sử dụng công nghệ



The application of hydrological approaches for the estimation and evaluation of minimum flow in the Huong River basin

Vu Thu Hien^a, Pham Khanh Huy^{a*}

^aHanoi University of Mining and Geology, Vietnam

***Corresponding author:**

Name: Pham Khanh Huy

Contact number: (+84) 902071115

Email: phamkhanhhuy@humg.edu.vn

Abstract

Water, particularly surface water, is a vital component of the natural environment and an essential resource for human activities, ecosystems, and the socio-economic development of specific regions and river basins. In the context of declining groundwater quantity and quality, there is growing pressure on river surface water resources to meet human exploitation and usage needs. To maintain the basic functions of river ecosystems, flows must meet minimum environmental flow requirements.

In this study, hydrological methods were employed to determine the design low flow for calculating the minimum flow in the Huong River Basin, based on observed discharge data from the Thuong Nhat and Co Bi hydrological stations. The results indicate that, at a 95% design frequency, the minimum environmental flows required are 255.76 m³/s at Thuong Nhat Station and 706.64 m³/s at Co Bi Station.

Key Words: *minimum flow, environmental flow, hydrological method, design low flow*

1. Introduction

River water resources play an essential role in meeting water demands for domestic use, production, and socio-economic development within a basin. Additionally,

...rivers are critical for maintaining ecological balance, sustaining the natural functions of aquatic ecosystems, and preserving the long-term health of river systems.

However, to serve human needs for



development and daily activities, river flows are often altered by the construction of canals, dams, spillways, and other structures to supply water for agriculture and urban areas, regulate river flows, and control flooding. These interventions have significantly impacted riverine ecosystems and environmental conditions.

For example, the study by Binod Baniya demonstrated that insufficient minimum flow, combined with uncontrolled wastewater discharge and poor waste management, has led to severe pollution of the Bagmati River, affecting ecosystems, public health, and groundwater quality (Binod Baniya et al., 2019). Similarly, Alaa H. AbdUameer utilized the Tennant method and the HEC-RAS system to estimate the necessary minimum flow of the Euphrates River at Shatt Al-Hillah, revealing that reduced flow rates due to water development projects and extraction had led to serious pollution from industrial and agricultural sources (Alaa Hussein AbdUameer Abdan et al., 2023).

In Vietnam, Nguyen Thi Kim Dung employed a comprehensive approach integrating hydrological, hydraulic, and ecological factors to determine the minimum flow for the Vu Gia - Thu Bon river system,

addressing the challenges posed by hydropower operations lowering river levels and promoting saltwater intrusion (Nguyen Thi Kim Dung, 2018).

Currently, the concept and determination methods of minimum flow vary considerably. The notion of environmental flows was first introduced in *Flow: The Essentials of Environmental Flows*, translated and published by the Vietnam Water Resources Management Authority in 2007. Environmental flow refers to the portion of a river's natural flow that must be maintained to support ecosystems, biodiversity, and river functions (Megan Dyson et al., 2008). By 2012, this concept was formally incorporated into the Vietnam Water Resources Law.

The Huong River Basin plays a central role in ensuring sustainable economic, social, and environmental development in Thua Thien Hue Province. The basin provides water for domestic use in Hue City and surrounding communities, irrigation for agriculture in the midland and delta areas, and sustains the unique ecosystems of the Tam Giang - Cau Hai lagoon system the largest brackish water lagoon system in Southeast Asia.

Moreover, the Huong River helps regulate



the local climate, protect ecological environments, and support tourism and cultural activities. Given its significance, identifying and maintaining the minimum flow in the Huong River Basin is crucial for ensuring ecological functions, preventing saltwater intrusion, safeguarding water quality for domestic and agricultural use, and maintaining biological productivity in the lagoon system.

Without sufficient minimum flow, Hue City's drinking water supply would be threatened by saltwater intrusion and pollution, agricultural activities would suffer from irrigation shortages, and the lagoon ecosystems would experience biodiversity loss and increased risks of environmental disasters like drought and prolonged salinity intrusion. Therefore, studying, calculating, and stipulating minimum flow requirements for the Huong River Basin is strategically important for sustainable regional development.

2. Introduction

2.1 Study Area

The Huong River Basin is located entirely within Thua Thien Hue Province in central Vietnam, covering a natural area of approximately 2,830 km². It is a typical basin with complex topography, stretching

from the high Truong Son mountains in the west to the coastal plains in the east. The basin is separated from the Thu Bon River Basin by the Bach Ma mountain range, which runs toward the sea.

The Huong River has a total length of approximately 104 km, originating in the southern mountainous region of A Luoi District. Two major tributaries, Ta Trach and Huu Trach, converge at Bang Lang before the river flows through Hue City and discharges into the Tam Giang - Cau Hai Lagoon system. The basin's length is about 63.5 km, with an average width of 44.6 km. The average slope of the basin is 28.5%, and the mean elevation is about 330 meters above sea level.

The river network density of the basin is approximately 0.6 km/km², with significant variations between the upstream and downstream areas. In the upper basin, where the terrain is steep (with riverbed slopes exceeding 40‰), the river and stream network is dense, averaging over 1.2 km/km². In contrast, the lower basin features flat terrain with elevations below 20 meters, a meandering river course, and a network density of about 0.8 km/km². The basin's favorable catchment characteristics allow for rapid



surface runoff concentration into the river system. The total annual surface water volume in the basin is estimated at about 9.975 billion m³, serving as the primary water source for Hue City and its surrounding areas (Department of water resources management, 2009).

The basin's climate is tropical monsoon, with high annual rainfall ranging from 2,500 to 3,500 mm, primarily concentrated between September and December. Influenced by multidirectional winds and the strong northeast monsoon, the river flow exhibits distinct seasonal variations. The flood season (October - December) accounts for about 65% of the annual runoff, with the highest flow module reaching 233 l/s·km² in November. The dry season (January - September) is prolonged, with two main low-flow periods (March - April and July - August),

during which the average dry season flow module drops to around 40 l/s·km². Additionally, the downstream region's flat terrain and riverbeds lying below sea level allow tidal intrusion far inland, leading to bi-directional flow phenomena and heightened risks of saltwater intrusion during the dry season.

2.2 Research methods

In this study, the main methods used are:

- Collecting and processing data with long term time series (>30 years) from two hydrological stations, Thuong Nhat and Co Bi (NCFHMN, 1988-2022).
- Determine the minimum flow (Environmental Flow) by determining the design low flow (Q_{tk}) and determining the design minimum flow value (Q_{kp}).

Method for minimum flow assessment

Determining minimum flow (Environmental Flows) aims to maintain

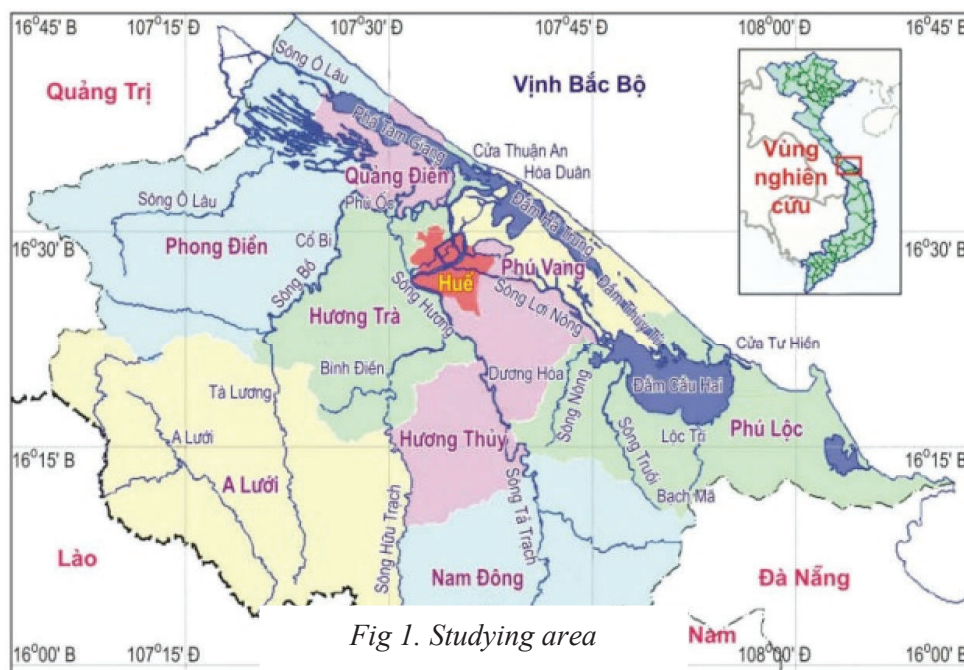


Fig 1. Studying area



the fundamental ecological processes of aquatic ecosystems, protect the natural structure and functions of rivers, streams, and associated wetlands. Unlike traditional water use sectors (e.g., domestic, agricultural, and industrial supply), the beneficiary of minimum flows is the riverine ecosystem itself. Identifying and maintaining minimum flows at critical control points along main rivers and tributaries is particularly significant for integrated water resources management, especially under current climate change and increasing water use pressures.

In this study, the Thuong Nhat and Co Bi hydrological stations were selected as bases for determining the minimum flow requirements in the Huong River Basin, specifically:

Thuong Nhat station represents the upstream area of the Ta Trach sub-basin.

Co Bi station represents the midstream region, downstream of the confluence of the main tributaries (Ta Trach, Huu Trach, and Bo Giang), and upstream of the discharge into the floodplain and Tam Giang Lagoon system.

These stations were selected based on the following criteria:

(i) Availability of long-term (over 30

years) and reliable discharge data series,

(ii) Representation of the basin's hydrological characteristics,

(iii) Strategic control roles in water exploitation and management within the basin.

The hydrological method applied for minimum flow determination followed a four-step process:

Step 1: Data collection and processing

Daily discharge series at the two stations were collected, verified for completeness, outliers were removed, and missing data were supplemented using appropriate statistical techniques to ensure data reliability for analysis (National Centre for hydro - meteorological network).

Step 2: Calculation of design flow (Q_{tk})

Annual mean discharge was calculated from the daily flow series.

Annual average discharges corresponding to 90%, 95%, and 99% frequencies were determined, representing various degrees of water scarcity. These values formed the basis for the design low flow (Q_{tk}) in subsequent minimum flow calculations.

Step 3: Determination of minimum flow indicators

Daily discharge data were sorted in descending order.



Flow rates Q90%, Q95%, and Q99% were identified, corresponding to flow levels that are exceeded 90%, 95%, and 99% of the time during the year, respectively.

Step 4: Selection and proposal of minimum flow

Q90% was proposed for maintaining continuous flow and support.

Porting basic ecological functions under moderate water use conditions.

Q95% was deemed suitable for higher ecological conservation needs, particularly in the midstream and downstream reaches of the Huong River.

Q99% was recommended for areas requiring strict environmental protection, such as the highly sensitive Tam Giang Lagoon ecosystem.

The proposed minimum flow values were cross-checked with design year flow conditions and adjusted within reasonable

margins to balance environmental protection needs with socio-economic development objectives.

Step 5: Determine the design low flow (Q_{kp})

This is the lowest flow rate corresponding to the design frequency P within a defined period (day, month, dry season). Typically, levels like 90% are the guaranteed minimum flow rate for 90% of the time, while 95% is a very unfavorable minimum flow rate.

3. Results and discussion

Based on the observed daily discharge data at Thuong Nhat and Co Bi hydrological stations during the period from 1988 to 2022, the average discharge (Q_{bq}) at Thuong Nhat Station was found to be 482.13 m³/s, while at Co Bi Station it was 2,717.38 m³/s.

The design low flow (Q_{kp}) values,

Table 1. Design low flow discharges

Parameter	Thuong Nhat Hydrological Station			Co Bi Hydrological Station		
Design Frequency, P (%)	90	95	99	90	95	99
Kp Coefficient	0.63	0.53	0.38	0.38	0.26	0.12
Design Low Flow, Q _{kp} (m ³ /s)	304.02	255.76	183.38	1032.79	706.64	326.14

Note: The Kp coefficients were determined based on the Kritski–Menkel frequency distribution chart (National Standard TCVN 13615:2022).



corresponding to assumed water scarcity levels at 90%, 95%, and 99% probabilities, were determined and summarized in the table 1 below.

The results at both Co Bi and Thuong Nhat stations show that the K_p coefficient decreases as the design frequency increases, which consequently causes the design low flow values to decline accordingly. Specifically, at Co Bi Station, the corresponding design low flows are 1,032.79 m^3/s (90%), 706.64 m^3/s (95%), and 326.14 m^3/s (99%). Similarly, at Thuong Nhat Station, the flows are 304.02 m^3/s (90%), 255.76 m^3/s (95%), and 183.38 m^3/s (99%).

The decreasing trend of discharge with increasing frequency reflects the hydrological characteristics of the basin and highlights the increased risk of water shortages under more extreme low-flow conditions. These calculated design low flows provide a scientific basis for establishing minimum environmental flows, contributing to the maintenance of ecological functions in aquatic ecosystems and ensuring the stability of water resources in the Huong River Basin. From the calculated low flow values at the two stations, the study proposes adopting the

discharge corresponding to a 95% probability as the minimum environmental flow for the respective locations within the Huong River Basin. The selected environmental flow ensures the stability of aquatic ecosystems and provides sufficient water to meet other needs, including domestic use, agriculture, and industry.

Specifically: At Thuong Nhat Station, the minimum environmental flow is determined to be $Q = 255.76 \text{ m}^3/\text{s}$, and at Co Bi Station, it is $Q = 706.64 \text{ m}^3/\text{s}$.

These selected flow values are considered reliable for defining minimum environmental flows and form the foundation for future management, maintenance of riverine ecosystems, and sustainable water resources protection efforts in the Huong River Basin.

4. Conclusion

This study applied conventional hydrological methods to determine the minimum flow for the Huong River Basin, based on long-term observed discharge series at Thuong Nhat and Co Bi hydrological stations during the 1988–2022 period. By calculating the design low flows corresponding to 90%, 95%, and 99% design frequencies, the study identified a decreasing trend in



discharge with increasing design frequency. This trend aligns with the basin's hydrological characteristics and reflects the growing risk of water scarcity under extreme low-flow conditions.

The calculated discharge values corresponding to the 95% design frequency were selected as the basis for determining the minimum environmental flows, with the corresponding minimum environmental flow values being: 255.76 m^3/s at Thuong Nhat Station, and 706.64 m^3/s at Co Bi Station.

These values are sufficient to support the basic ecological functions of the Huong River system while also meeting requirements for domestic water supply, production, and environmental protection in the downstream lagoon areas.

Comparisons with previous studies show that the methodology applied in this research yields highly reliable results with minimal errors and strong practical applicability. This affirms the effectiveness of the hydrological method, particularly in basins with relatively complete hydrological monitoring datasets and increasing demands for sustainable water resources management.

However, to improve accuracy and better

meet ecosystem protection requirements under climate change and socio-economic development pressures, future research should integrate hydraulic, ecological, and modeling approaches. This will provide a more comprehensive scientific foundation for establishing minimum environmental flows and for the integrated management of water resources in the Huong River Basin.

References

1. Alaa Hussein AbdUlameer Abdan and Ali Omran Al-Sulttani, 2023 Evaluation of the Minimum Instream Flow: A Case Study of Shatt-Al Hillah River in Babylon, Governorate International Journal of Design & Nature and Ecodynamics Vol. 18, pp. 485 – 491
2. Binod Baniya, Nitesh Khadka, Shravan Kumar Ghimire, Hom Baniya, Shankar Sharma, Yam Prasad Dhital, Ranjana Bhatta and Bishnu Bhattarai, 2019. Water quality assessment along the segments of Bagmati River in Kathmandu valley, Nepal, Nepal Journal of Environmental Science Vol. 7, pp.1 - 10
3. Department of water resources management. Report on Water Resources Planning for the Huong



- River Basin and surrounding areas, năm 1988 - 2022
2009. Cục quản lý Tài nguyên nước. Báo cáo Quy hoạch tài nguyên nước lưu vực sông Hương và vùng phụ cận, 2009
4. Megan Dyson, Ger Bergkamp and John Scanlon. Flow - The essentials of environmental flows. IUCN, Gland, Switzerland 2008
5. Nguyen Thi Kim Dung, Some results of minimum flow calculations for the Vu Gia - Thu Bon river system using a comprehensive approach to hydrological, hydrological, and ecological factors. Journal of water resources science and technology Vol. 42, 2018, pp. 1 - 9. Nguyễn Thị Kim Dung, 2018. Một số kết quả tính toán dòng chảy tối thiểu cho hệ thống sông Vu Gia - Thu Bồn theo cách tiếp cận tổng hợp các yếu tố thủy văn, thủy lực và sinh thái. Tạp chí Khoa học và Công nghệ Thủy lợi số 42.
6. National Centre for hydro - meteorological network, hydrological data from Thuong Nhat and Co Bi monitoring stations, 1988 - 2022. Trung tâm quan trắc khí tượng thủy văn Quốc gia, Số liệu đo đạc thủy văn của các trạm quan trắc Thượng Nhật, Cỏ Bi
7. National Standard TCVN 13615:2022 on calculation of design hydrological characteristics. Tiêu chuẩn quốc gia TCVN 13615:2022 về Tính toán các đặc trưng thủy văn thiết kế

First submission: 14/3/2025

Date of acceptance: 24/12/2025



Physicochemical evolution and molecular dynamics analysis of torrefaction porous biochar

Phu-Cuong Le ^{a*}

^aDepartment of mechanical engineering, National Kaohsiung University of Science and Technology, Taiwan

***Corresponding author:**

Name: LE Phu Cuong

Contact number: (+886) 971143286

Email: lephucuong.taiwan@gmail.com

Abstract

This study investigates the fuel characteristics and energy potential of torrefied corncob biochar using a combined experimental and molecular dynamics (MD) simulation approach. Corncob biomass was torrefied at temperatures of 200, 250, and 300°C with holding times of 1, 2, and 3 hours to evaluate the effects of thermal severity on physicochemical properties and energy performance. Experimental analyses reveal that increasing torrefaction temperature and residence time significantly reduced moisture and volatile matter contents while enhancing fixed carbon content and aromaticity. Although mass yield decreased with increasing severity, energy yield and energy density improved markedly. The optimal condition was identified at 300°C and 2 hours (BC3002), yielding a high higher heating value of $6,805.25 \pm 724.90$ kcal kg⁻¹, a mass yield of $50.18 \pm 1.21\%$, and an energy yield of 76.05%, indicating strong potential as a solid biofuel. To complement the experimental results, MD simulations were conducted to examine carbon microstructure and porosity evolution at the atomic scale. Carbon-hydrogen interactions were modeled using the adaptive intermolecular reactive empirical bond order (AIREBO) potential with a Lennard-Jones cutoff of 2.5 Å and activated REBO, Lennard-Jones, and torsional terms. The simulations successfully reproduced porous carbon network formation, providing atomistic insight into pore development during thermal treatment. This integrated experimental computational study demonstrates that controlled torrefaction is an



FACULTY OF ENVIRONMENT
HANOI UNIVERSITY OF MINING AND GEOLOGY
HANOI, VIETNAM



ISBN: 978-604-76-3296-1



SÁCH KHÔNG BÁN