Supporting Information

Figure S1 Pore size distribution curve of the BF (a) and PU (b) carrier

Table S1 Trace element solution composition

Table S2 Methods for water quality parameter determination

Table S3 Comparison of different biocarriers

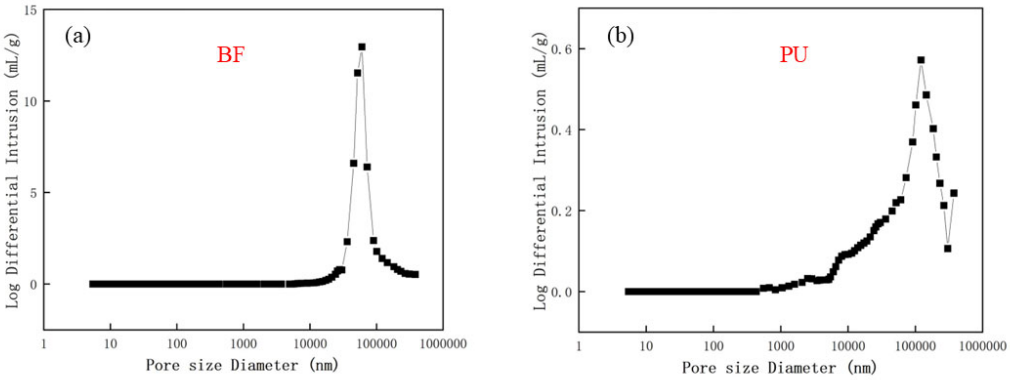

Figure S1 Pore size distribution curve of the BF (a) and PU (b) carrier

Table S1 Trace element solution composition

Trace element	**Concentration（g/L）**
$FeSO_4 \cdot 7H_2O$	0.50
$MgSO_4 \cdot 7H_2O$	0.50
$CoCl_2 \cdot 6H_2O$	0.20
$ZnSO_4 \cdot 7H_2O$	0.36
$MnCl_2 \cdot 4H_2O$	0.10
$CuCl_2 \cdot 2H_2O$	0.34
EDTA	1.00

Table S2 Methods for water quality parameter determination

Parameter	Method Standard	Reference
COD	Standard dichromate method	GB11914–89
NH_4^+–N	Nessler's reagent spectrophotometry	HJ535–2009
NO_3^-–N	Dual-wavelength ultraviolet spectrophotometry	HJ/T346–2007
NO_2^-–N	N-(1-naphthyl)-ethylenediamine photometry	GB7493–87

Table S3 Comparison of different biocarriers.

Comparison dimension	Basalt fiber felt (BF)	Polyurethane sponge (PU)	Polyethylene/polypropylene (PE/PP)	Luffa sponge	Zeolite/ceramic
Pollutant removal performance (continuous flow)	HRT=2h，COD: 87.1%, NH_4^+-N: 79.4%, TN: 75.9%	HRT=2h，COD: 78.3%, NH_4^+-N: 63.2%, TN:63.1%	COD:82.2%, NH_4^+-N: 97.2%	HRT=8-12 h, COD: 80-88%, NH_4^+-N: 80-90%, TN: 50-70%	COD: 69.5-93%, NH_4^+-N: 40.2-91.2%, TN: data scarce
Pollutant removal performance (intermittent flow)	COD: 90.5%, NH_4^+-N: 89.4%, TN: 64.5%	COD: 82.3%, NH_4^+-N: 32.7%, TN: 20.7%	Data scarce	Data scarce	Data scarce
Material characteristics	• Porosity: Extremely High (91.2%) • Mechanical Strength: Extremely High, Corrosion Resistant • Density: Low	• Porosity: Medium (33.3%) • Mechanical Strength: High, Elastic • Density: Low	• Porosity: Low/Medium • Mechanical Strength: High • Density: Medium	• Porosity: High • Mechanical Strength: Medium-Low, Easily Biodegradable • Density: Low	• Porosity: Variable • Mechanical Strength: High, but Brittle • Density: High
Environmental friendliness	• Non-toxic, no leaching risk • Inorganic material, non-biodegradable • Can be used as filler or recycled after disposal	• Non-toxic • Plastic waste, difficult to degrade • Potential microplastic release	• Major source of "white pollution" • Plastic waste, difficult to degrade • Potential microplastic release	• Biodegradable • Natural renewable resource • No chemical additives, non-toxic	• Natural/sintered material, non-toxic • Good environmental compatibility • Recyclable or safe for landfill
Economic feasibility	• Cost: ~¥300/m³ • Lifespan: Long (inorganic stability)	• Cost: ~¥800/m³ • Lifespan: Medium (ages and compresses)	• Cost: ~¥200-500/m³ • Lifespan: Medium (ages)	• Cost: Very low (agricultural by-product) • Lifespan: Short (biodegradable), requires regular replacement	• Cost: ¥500-2000/m³ (depends on processing) • Lifespan: Long
Advantages	• Superior performance in intermittent-flow condition • Low cost and long lifespan • Environmentally friendly	• Superior performance in continuous-flow condition • Mature technology	• Low price • High mechanical strength	• Fully biodegradable • Extremely low cost	• Good stability • Advantages in ammonia adsorption
Disadvantages	Engineering application cases still accumulating	Poor performance under intermittent flow	Hydrophobic, poor performance under intermittent flow	Short service life, prone to biodegradation and rotting; performance declines with decay	High density, relatively high cost, biofilm grew slowly
References	This study	This study	Al-Amshawee et al., 2020	Lago et al., 2024	Lago et al., 2024

References

1. Lago, A., Rocha, V., Barros, O., Silva, B., Tavares, T. 2024. Bacterial biofilm attachment to sustainable carriers as a clean-up strategy for wastewater treatment: A review. *Journal of Water Process Engineering*, **63**.
2. Al-Amshawee, S., Yunus, M.Y.B.M., Vo, D.V.N., Tran, N.H. 2020. Biocarriers for biofilm immobilization in wastewater treatments: a review. *Environmental Chemistry Letters,* **18**(6).