

Supporting Information

Text

Text S1. Electrochemical test

Electrochemical tests were performed on a CHI 760E workstation using a three-electrode system: Pt electrode as counter electrode, Ag/AgCl (saturated KCl) as reference electrode, and bare GCE as working electrode. Prior to measurement, the sludge samples required pretreatment. The specific procedure was as follows: 1.0 mL of sludge sample was centrifuged at 8,000 r/min for 5 min. After removing the supernatant, the pellet was resuspended in ultrapure water to a final volume of 1.0 mL. Then, 500 μL of the suspension was taken and mixed with 40 μL of Nafion solution. After thorough mixing, the mixture was coated onto a glassy carbon working electrode and allowed to air-dry at room temperature before measurement. The electrochemical measurement was conducted at a scan rate of $1\text{ mV}\cdot\text{s}^{-1}$ over a potential range of -0.8 to 0.6 V .

To determine the electron-accepting capacity (EAC) and electron-donating capacity (EDC) of AC and AQDS, the measurements were conducted in a buffer solution ($\text{pH} = 7$, containing 0.1 mol L^{-1} KCl and 0.1 mol L^{-1} phosphate) under N_2 purging to eliminate oxygen interference. 2,2'-Azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) was added as a redox mediator to facilitate electrochemical reduction and oxidation. The measurements were performed at redox potentials of -0.49 V for mediated electrochemical reduction (MER) and $+0.61\text{ V}$ for mediated electrochemical oxidation (MEO), respectively. The EAC and EDC values were calculated by the following Equations (Eqs. (S1) and (S2)).

$$EDC = \frac{\int I_{ox} dt}{F \bullet m} \quad (S1)$$

$$EAC = \frac{\int I_{red} dt}{F \bullet m} \quad (S2)$$

where I_{ox} and I_{red} are oxide and reduce current (A), respectively, t is the test time (s), F is the Faraday constant (96,485 C/mol e^-), and m is the mass of ESs in the sample (mg).

Text S2. High-Throughput Sequencing

To analyze the succession characteristics of the microbial community, raw inoculated sludge was collected immediately before the experiment and rapidly frozen at -80°C . After 150 days of reactor operation, the frozen samples and sludge from inside the reactor were taken for microbial analysis. These samples were entrusted to Shanghai Meiji Biomedical Technology Co., Ltd. for the completion of 16S rRNA high-throughput sequencing. The sequencing process included five main steps: PCR amplification, fluorescence quantification, Miseq library construction, machine sequencing, and sequence data optimization. The V3-V4 variable region was selected for bacterial amplification, using primers 341F (CCTACGGGNGGCWGCAG) and 805R (GACTACHVGGGTATCTAATCC), which have broad coverage and high resolution, suitable for bacterial community structure analysis in environmental samples.

Figures:

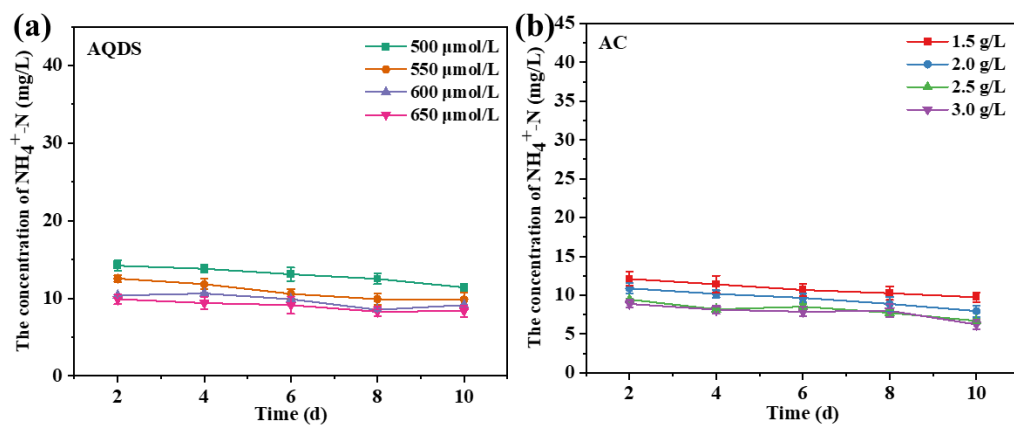


Fig. S1. The concentration of $\text{NH}_4^+\text{-N}$ in different systems with various ESs dosage.

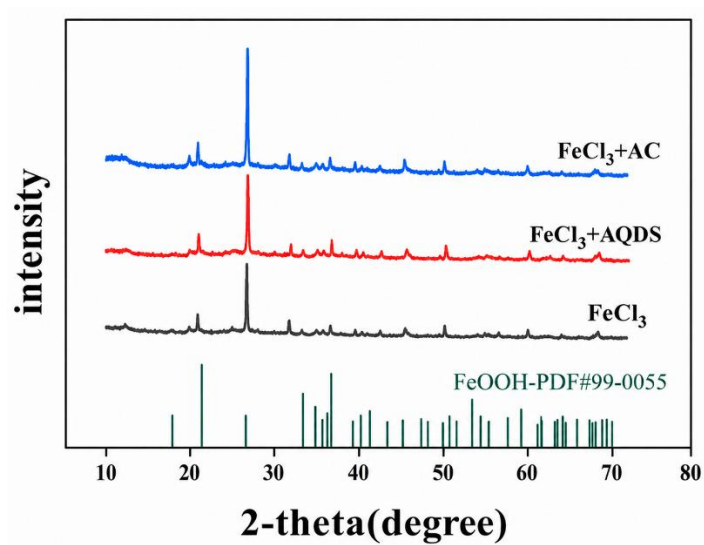


Fig. S2. The XRD spectra of iron minerals in sludge.

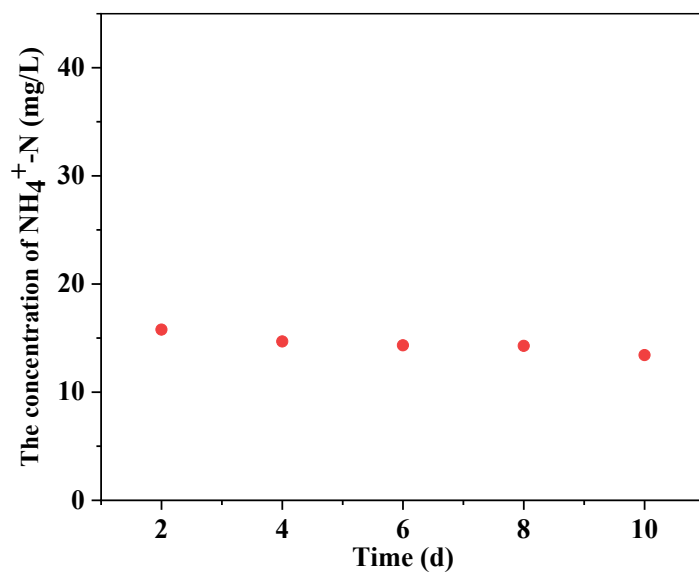


Fig. S3. The concentration of NH₄⁺-N in FeOOH system.

Table S1 Components of artificial water distribution.

	Components	Concentration (mg/L)
Inorganic salt solution	NH ₄ Cl-N	40
	FeCl ₃ -Fe	30
	NaHCO ₃	500
	KH ₂ PO ₄	100
	CaCl ₂ .H ₂ O	50
	MgCl ₂ .6H ₂ O	50
microelement (1 mL/L)	EDTA	500
	ZnSO ₄ .7H ₂ O	430
	COCl ₂ .6H ₂ O	240
	NaSeO ₄	109.3
	CuSO ₄ .5H ₂ O	250
	NaMoO ₄ .2H ₂ O	220
	NiCl ₂ .6H ₂ O	190
	H ₃ BO ₃	11.2