SUPPLEMENTARY INFORMATION

Application of natural zeolite adsorption in cooperation with photosynthesis for the post-treatment of microbial fuel cells

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I. The degradation of NH_4^+ following treatment with MFCs

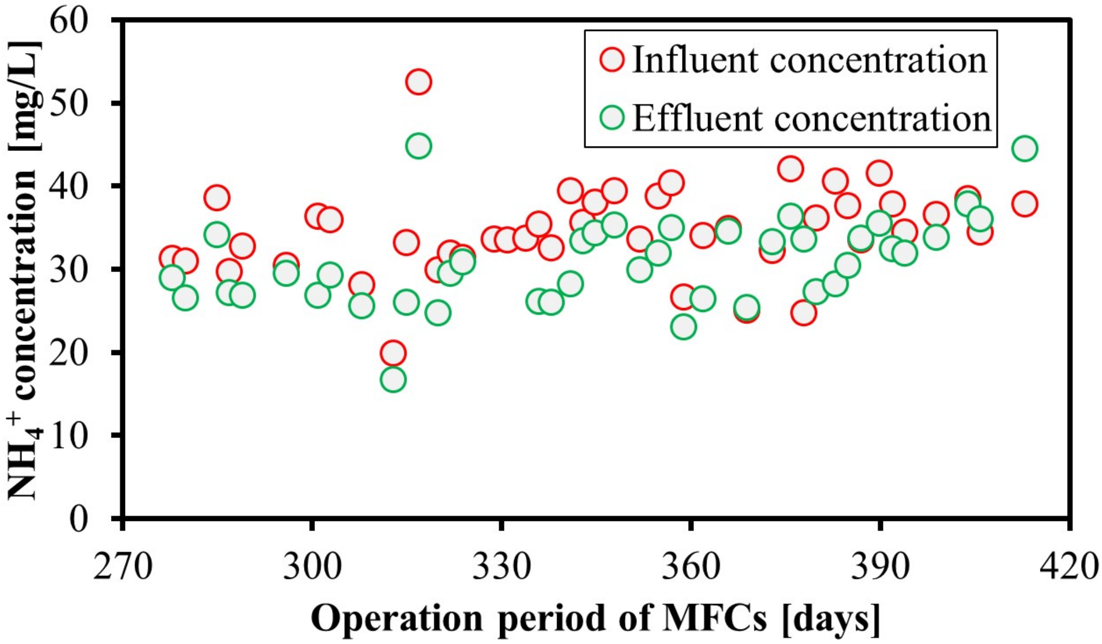

Fig S1. The degradation of NH_4^+ concentration following treatment with MFCs. The influent concentration represented the NH_4^+ concentration in sewage, while the effluent concentration indicated the NH_4^+ concentration after treatment with MFCs.

Fig S1 shows the degradation of NH_4^+ after MFCs treatment, which coincided with the period using natural zeolite adsorption and photosynthesis. The average influent concentration of NH_4^+ was approximately 35.16 mg/L, decreasing to 31.9 mg/L after passing through the MFCs. These results demonstrated that the MFCs system, which used an anion exchange membrane as a separator, was not efficient in removing NH_4^+ from sewage. Therefore, a second step was necessary for NH_4^+ removal. The integration of natural zeolite adsorption and photosynthesis clearly proved to be effective in removing NH_4^+, as shown in Fig 4(c1) and 4(c2) of the manuscript.

II. Comparison of NH_4^+ removal efficiency in this study with other reported systems

Table S1 presents the most popular combinations of MFCs with other technologies for the removal of nitrogenous compounds from wastewater. These studies achieved ammonium removal efficiencies exceeding 75%. Similar to these previous studies, our results demonstrated the effectiveness of this system in removing ammonium following MFCs treatment. Based on these review systems, the combination of MFC and membrane produced good output values. However, this approach raises several operational issues, including high costs, membrane fouling, and significant energy requirements for processes like air scouring to control bacterial growth on the membranes (Al-Asheh, Bagheri et al. 2021, Bhattacharya and Banerjee 2023). In contrast, our system showed promise due to its low cost and ease of operation. It utilized natural zeolite, which is abundant and inexpensive (Wang and Peng 2010), and did not require additional energy for operation (e.g., LED lights).

Table S1. Comparison the NH_4^+ removal of this study and other reported systems

Type of systems	Ammonium concentration [mg/L]		Highest removal-EC [%]	References
	Inf	Eff		
MFC-Membrane bioreactor	32 ±4.28	0.8 ±0.41	97.7±1.9	(Malaeb, Katuri et al. 2013)
Regular MFC-Denitrifying MFC	21.4±10.2	4.9±3.8	77	(Zhang, Ge et al. 2013)
MFC- FO	780	114.7	85.3±3.5	(Qin, Hynes et al. 2017)
MFC-CDI	21.4	0.6±0.1	97.6	(Feng, Tsai et al. 2017)
MFC-AA/O	100-130	16-25	80.7-84	(Liu, Tursun et al. 2017)
UFCW-MFC	39	3.51	91	(Oon, Ong et al. 2015)
MFC-ZP	29.6-34.7	10.4-3.1	60-84.5	This study

Inf: influent concentration; Eff: effluent concentration; EC: efficiency; FO: forward osmotic, CDI: capacitive deionization; AA/O: anaerobic–anoxic–oxic; UFCW-MFC: up-flow constructed wetland-microbial fuel cell; ZP: natural zeolite adsorption integrated with photosynthesis.

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