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Biofiltration of wastewater by mangrove ecosystem

Sovis W. S. N.¹, De Silva D. S. M.^{1*} and Chathurani S. H. U.²

¹Department of Chemistry, University of Kelaniya, Sri Lanka.

²National Aquatic Resources Research and Development Agency, Kadolkele, Negombo, Sri Lanka.
sujeewa@kln.ac.lk*

The mangrove ecosystem consists of salt-tolerant trees and shrubs that thrive in coastal intertidal zones. Mangroves are particularly important as natural biofilters, their dense root systems trap sediments and pollutants, while associated microorganisms break down organic matter, significantly improving water quality. This research aimed at determining the changes in water quality parameters after filtration through the mangrove ecosystem. The water samples were collected mainly in two sites as triplicates at the NARA regional center in Kadolkele, Negombo, Sri Lanka. Samples collected before filtration through the mangrove ecosystem were indicated as BMF samples, and the samples collected after filtration through the mangrove ecosystem were indicated as AMF samples. Samples were collected from August 2023 to January 2024. The data of different parameters were statistically analyzed using paired t-test in the Minitab 17 version. Ammonium ion levels were examined using the phenate method. The BMF samples (88.9 ± 20.5 ppm) indicated a significantly higher average value of ammonium ion than the AMF samples (62.7 ± 19.6 ppm) ($p < 0.05$). Phosphate levels were examined using the stannous chloride method. The BMF samples contained significantly higher phosphates (115.6 ± 12.8 ppm) than the AMF samples (75.8 ± 14.8 ppm) ($p < 0.05$). Nitrate levels were examined using the UV spectrometric screening method. The BMF samples showed a significantly higher average value of nitrate content (28.5 ± 6.2 ppm) than AMF samples (17.4 ± 6.1 ppm) ($p < 0.05$). There was no significant difference recorded between pH values of AMF and BMF samples ($p > 0.05$). The multiparameter analyzer was employed in measuring conductivity, resistivity, and total dissolved solid (TDS) levels. The BMF samples indicated higher resistivity and TDS levels than BMF samples, while the conductivity levels of AMF samples were higher than BMF samples. Average total suspended solid (TSS) levels were significantly higher in AMF samples (302.0 ± 12.3 mg/L³) than in BMF samples (272.1 ± 11.1 mg/L³) ($p < 0.05$). Heavy metal analysis was conducted by the atomic absorption spectrophotometer (AAS). Cu, Cr, Zn, Fe and Mn were the most prevalent heavy metals. Cd was not at detectable levels in both sampling sites. The average Cu level in the AMF samples (0.182 ± 0.035 ppm) was higher than BMF samples (0.172 ± 0.053 ppm), $p = 0.551$. Average Cr content was higher in BMF samples (0.105 ± 0.057 ppm) than in AMF samples (0.064 ± 0.019 ppm), $p = 0.184$. The average value of Zn in BMF samples (0.156 ± 0.066 ppm) indicated a higher value than AMF samples (0.106 ± 0.034 ppm), $p = 0.138$. But none of these were statistically significant. The average Fe content in BMF samples (0.331 ± 0.053 ppm) was significantly higher than that of AMF samples (0.131 ± 0.042 ppm), ($p < 0.05$). The average Mn level in BMF samples (0.020 ± 0.009 ppm) was significantly higher than AMF samples (0.004 ± 0.001 ppm) ($p < 0.05$). The average BOD level in AMF samples (4.0 ± 0.4 mg/L) was significantly higher than in BMF samples (3.0 ± 0.5 mg/L), ($p < 0.05$). The COD of BMF samples (185.3 ± 29.5 mg/L) indicated a significantly higher average value than AMF (150.5 ± 13.9 mg/L) samples ($p < 0.05$). The statistical analysis revealed a significant difference between AMF and BMF samples for ammonium ion, phosphate, nitrate, TSS, heavy metals (Fe, Mn), BOD, and COD, indicating the mangrove filtration's effectiveness in reducing these pollutants. However, there was no significant difference in pH levels and heavy metal concentrations of Cu, Cr, and Zn, suggesting that these parameters were not notably affected by the filtration process.

Keywords: Biofiltration, Mangrove ecosystem, Wastewater, Water quality parameters