## Supplementary Materials

**Table S1.** The characteristics of oilfield wastewater

| Parameters | Mean value* |
|---|---|
| Total soluble salt (mg/L) | 12969.3±1058.6 |
| pH | 7.8±0.2 |
| Chemical oxygen demand (mg/L) | 249.3±45.6 |
| Biochemical oxygen demand | 21.1±5.7 |
| Oil content (mg/L) | 4.9±1.8 |
| Ammonia nitrogen (mg/L) | 5.6±1.9 |
| Total suspended solid (mg/L) | 58.5±15.1 |
| Temperature (℃) | 47.9±1.6 |
| Chloride ions (mg/L) | 2535.2±595.3 |
| Sulfide (mg/L) | 2.6±0.7 |

* The mean value for each parameter was calculated from 90 samples.

**Table S2.** Alpha diversity indices of fungal community in different biofilm samples

| Sample name | OTUs | Richness indices | | Good's coverage | Diversity indices | |
|---|---|---|---|---|---|---|
| | | ACE | Chao1 | | Simpson | Shannon |
| 9.1A | 17 | 297.83 | 291.62 | 0.995 | 0.86 | 4.21 |
| 9.1B | 22 | 279.00 | 279.00 | 0.994 | 0.96 a | 5.61 a |
| 9.1C | 22 | 318.21 | 312.43 | 0.992 | 0.96 | 5.85 |
| 9.2A | 27 | 282.00 | 282.00 | 0.994 | 0.48 | 2.15 |
| 9.2B | 22 | 265.00 | 265.00 | 0.993 | 0.52 b | 2.29 b |
| 9.2C | 11 | 145.00 | 145.00 | 0.994 | 0.39 | 1.47 |
| 9.3A | 30 | 273.93 | 268.60 | 0.994 | 0.66 | 2.91 |
| 9.3B | 14 | 208.33 | 203.62 | 0.994 | 0.60 c | 2.50 bc |
| 9.3C | 33 | 417.86 | 401.94 | 0.993 | 0.84 | 4.24 |
| 11.1A | 44 | 193.00 | 193.00 | 0.997 | 0.88 | 4.61 |
| 11.1B | 45 | 239.41 | 235.79 | 0.996 | 0.85 A | 4.20 A |
| 11.1C | 48 | 184.68 | 181.88 | 0.998 | 0.91 | 5.23 |
| 11.2A | 22 | 192.00 | 192.00 | 0.996 | 0.61 | 2.36 |
| 11.2B | 14 | 144.00 | 144.00 | 0.995 | 0.55 B | 1.87 B |
| 11.2C | 19 | 190.52 | 189.97 | 0.995 | 0.54 | 1.93 |
| 11.3A | 27 | 204.00 | 204.00 | 0.993 | 0.51 | 2.01 |
| 11.3B | 12 | 141.00 | 141.00 | 0.995 | 0.48 BC | 1.70 BC |
| 11.3C | 17 | 235.40 | 228.57 | 0.993 | 0.53 | 2.20 |

**Table S3.** Topological properties of fungal networks and Erdös–Réyni random networks

| Parameters | Sept. network | Random network | Nov. network | Random network |
|---|---|---|---|---|
| Node | 74 | 74 | 100 | 100 |
| Edge | 230 | 230 | 602 | 602 |
| Average degree (AD) | 6.216 | 6.216 | 12.04 | 12.04 |
| Clustering coefficient (CC) | 0.302 | 0.085 | 0.269 | 0.121 |
| Graph Density (GD) | 0.085 | 0.085 | 0.122 | 0.122 |
| Modularity (MD) | 0.536 | 0.304 | 0.401 | 0.206 |
| Average path length (APL) | 3.388 | 2.526 | 2.615 | 2.081 |
| Network diameter (ND) | 9.00 | 4.79 | 6.00 | 3.31 |

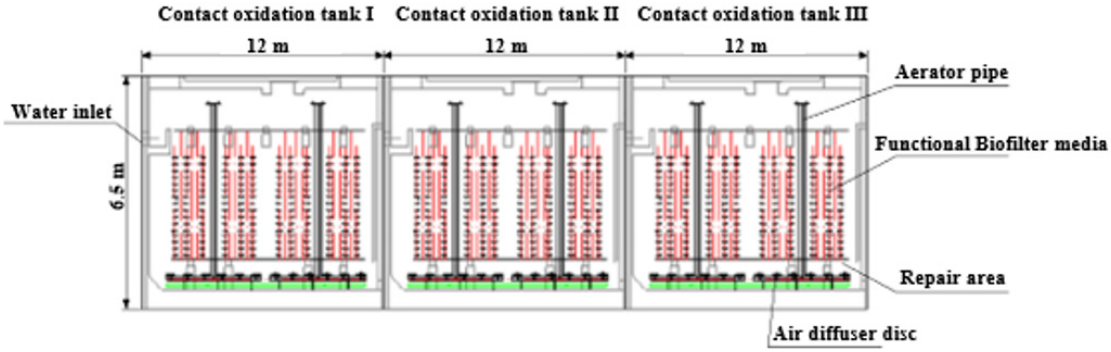


**Fig. S1.** Schematic diagram of the multistage bio-contact oxidation reactor used in this study

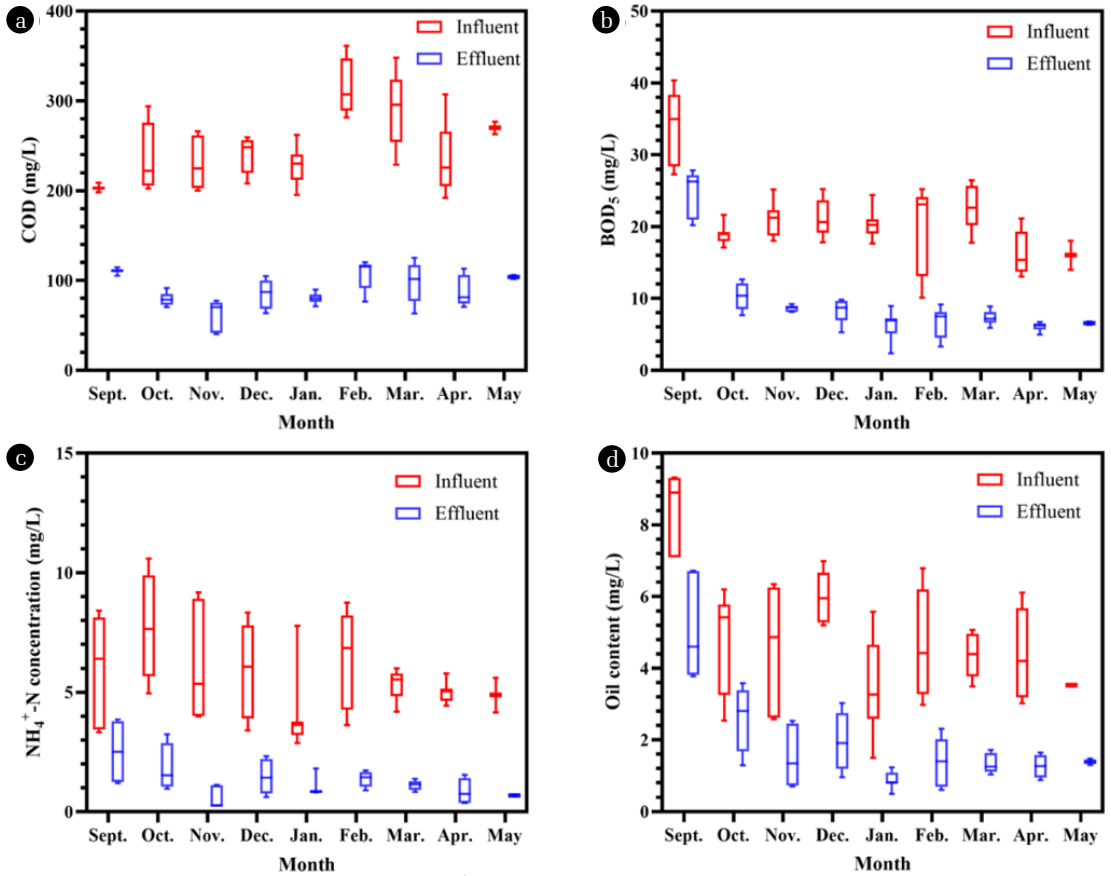


**Fig. S2.** Monthly average content of COD, $BOD_5$, $NH_4^+$-N, and oil pollutants in influent and effluent over the operation period.

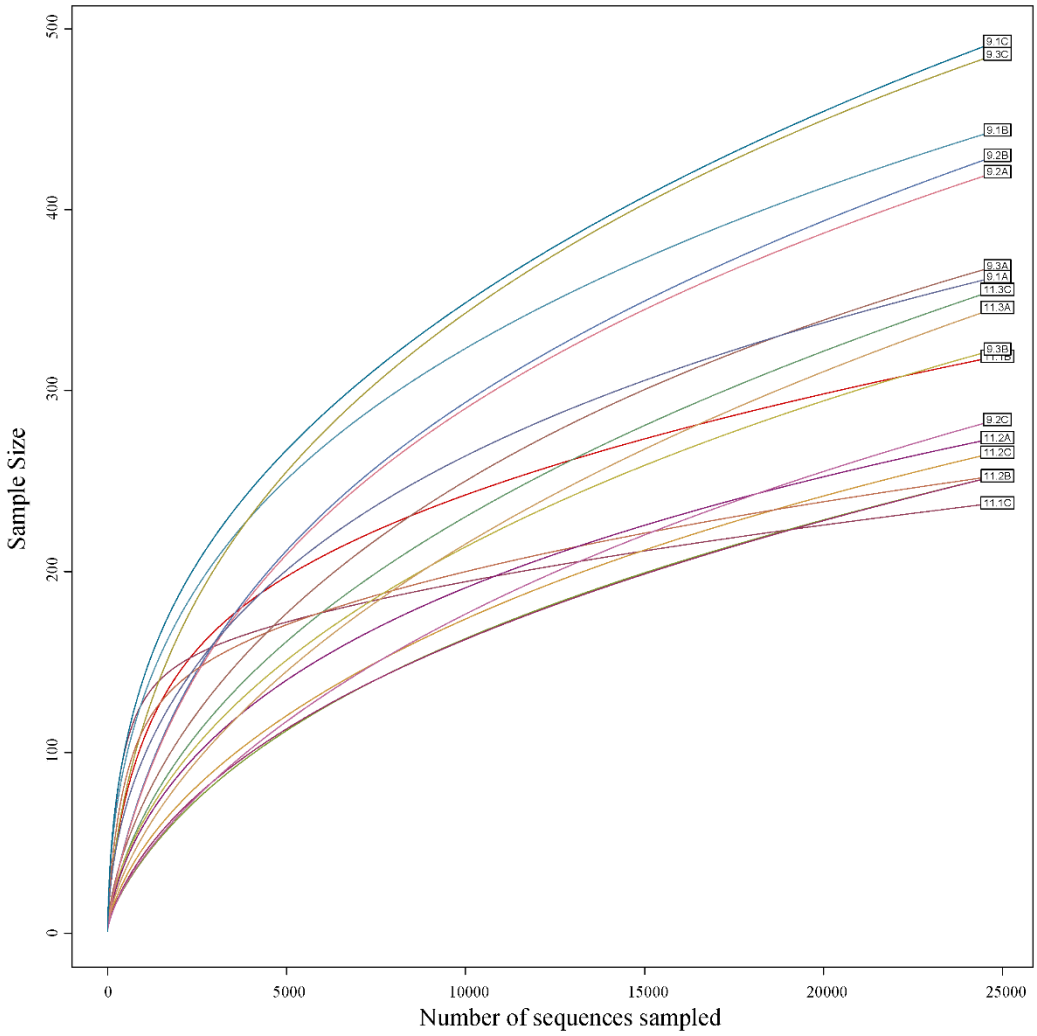


**Fig. S3.** The rarefaction curves of different biofilm samples

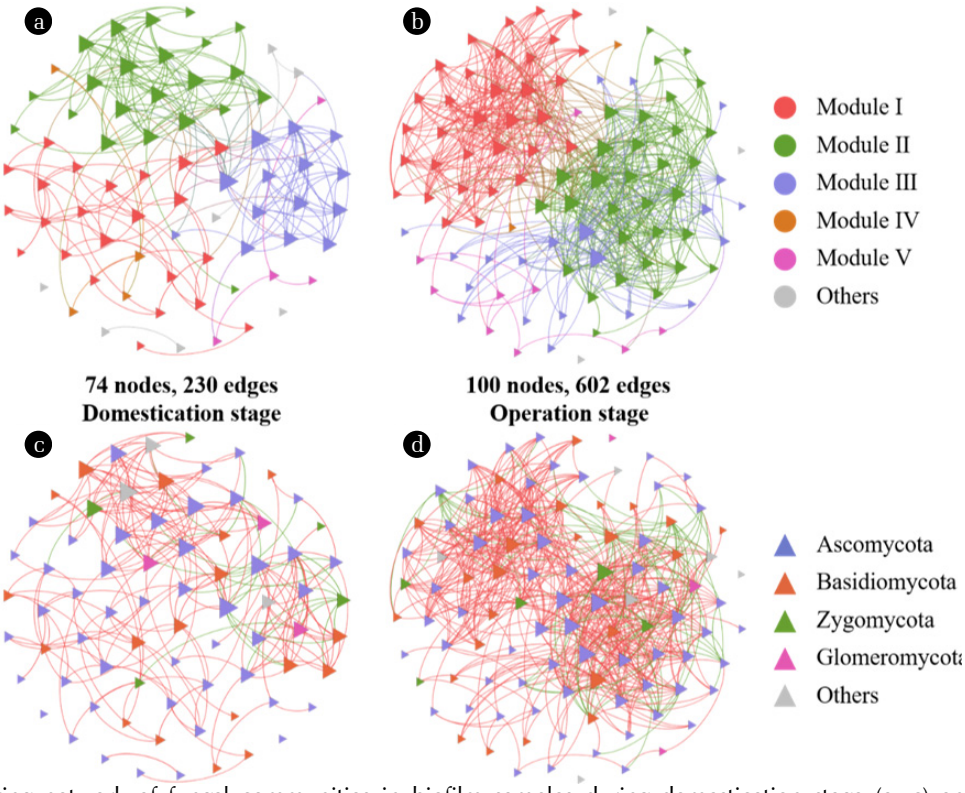


**Fig. S4.** Co-occurring network of fungal communities in biofilm samples during domestication stage (a, c) and operation stage (b, d) based on correlation analysis. a, b: nodes were colored by modules; c, d: nodes were colored by fungal phyla. A connection stands for a strong (Spearman's $\rho > 0.65$) and significant ($P < 0.05$) correlation. The size of each node is proportional to its degree.

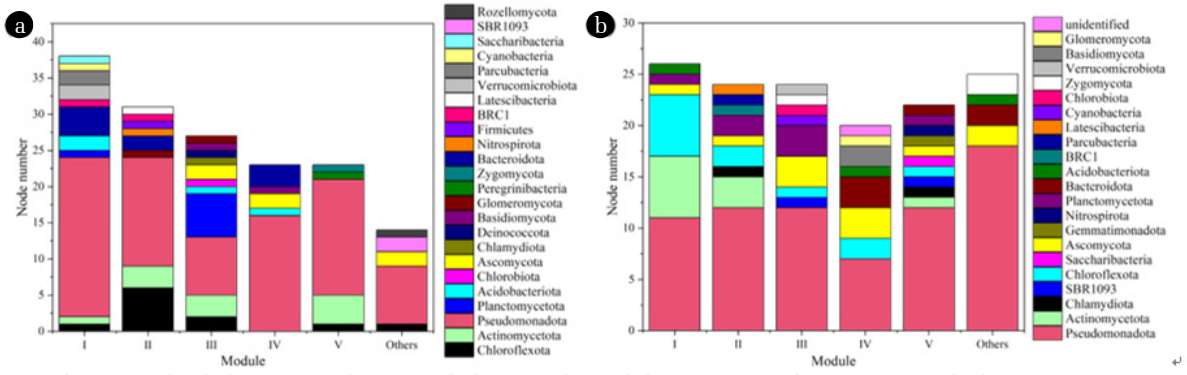


**Fig. S5.** Number of nodes belonging to different phyla in each module in D-network (a) / O-network (b).