**Table S4.** Relative abundance of each gene among samples by QMEC analysis.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Cateories | Gene\_name | CCY02\_1 | CCY02\_2 | CCY02\_3 | CCY02\_4 | CCY05\_1 | CCY05\_2 | CCY05\_3 | CCY05\_4 | CCY10\_1 | CCY10\_2 | CCY10\_3 | CCY10\_4 |
| C degradation | abfA | 259,826.42  | 261,984.30  | 212,927.42  | 239,612.35  | 344,895.78  | 298,559.06  | 233,062.82  | 221,007.66  | 258,521.26  | 307,376.80  | 367,441.55  | 305,018.56  |
| C degradation | xylA | 196,528.68  | 219,647.74  | 207,894.42  | 208,372.01  | 255,150.94  | 279,557.43  | 300,488.93  | 30,764.35  | 259,072.08  | 297,957.91  | 302,050.99  | 324,556.96  |
| C degradation | manA | 112,005.18  | 122,558.33  | 127,123.24  | 115,931.07  | 137,194.94  | 131,346.52  | 137,266.86  | 140,813.44  | 195,697.44  | 255,568.36  | 234,481.67  | 213,564.48  |
| C degradation | gmGDH | 126,422.35  | 125,145.94  | 130,886.21  | 136,477.31  | 155,257.50  | 137,415.67  | 167,009.85  | 169,462.79  | 133,276.03  | 153,568.63  | 142,242.19  | 137,682.63  |
| C degradation | gam | 110,307.67  | 117,950.82  | 129,889.71  | 107,754.20  | 140,559.90  | 96,653.18  | 125,124.19  | 128,223.61  | 148,732.12  | 198,512.42  | 169,130.90  | 166,740.75  |
| C degradation | mnp | 42,651.49  | 52,288.91  | 51,094.79  | 45,274.79  | 79,282.38  | 80,123.35  | 97,855.46  | 8,452.74  | 90,012.47  | 102,132.16  | 95,204.53  | 87,492.08  |
| C degradation | exg | 37,972.40  | 33,923.09  | 40,903.42  | 34,395.83  | 29,173.28  | 30,584.69  | 27,590.90  | 25,357.87  | 26,798.00  | 29,958.79  | 36,646.06  | 34,940.54  |
| C degradation | glx | 12,693.79  | 14,167.74  | 14,124.66  | 12,595.03  | 26,859.50  | 24,280.73  | 28,773.12  | 21,056.30  | 31,814.36  | 44,925.36  | 33,930.52  | 35,272.19  |
| C degradation | IsoP | 7,966.71  | 8,497.70  | 80,337.67  | 7,846.07  | 13,100.61  | 9,973.43  | 14,004.10  | 10,955.39  | 15,869.28  | 17,919.43  | 18,228.97  | 19,070.11  |
| C degradation | chiA | 9,059.05  | 9,825.22  | 10,478.21  | 9,376.53  | 5,838.37  | 7,176.82  | 68,421.01  | 6,243.84  | 10,905.60  | 17,009.07  | 17,728.88  | 15,345.20  |
| C degradation | lig | 11,311.09  | 11,009.23  | 10,482.83  | 9,946.63  | 10,817.36  | 9,890.17  | 13,745.76  | 11,374.50  | 21,546.93  | 24,695.22  | 24,062.00  | 25,742.85  |
| C degradation | CDH | 6,121.67  | 6,705.11  | 6,900.60  | 5,776.89  | 9,654.98  | 12,844.17  | 10,814.00  | 11,448.08  | 12,496.31  | 13,692.93  | 14,654.75  | 12,841.35  |
| C degradation | amyA | 1,461.34  | 1,324.25  | 1,262.77  | 1,181.46  | 1,725.60  | 1,597.54  | 2,064.13  | 1,997.55  | 3,736.82  | 4,568.01  | 4,264.69  | 3,913.53  |
| C degradation | apu | 1,643.64  | 1,778.50  | 1,850.70  | 1,590.98  | 1,973.38  | 1,810.18  | 1,292.14  | 1,539.71  | 2,498.64  | 3,568.27  | 3,037.26  | 2,870.97  |
| C degradation | naglu | 114.27  | 455.48  | 104.28  | 149.75  | 120.60  | 126.55  | 360.69  | 0.00  | 236.77  | 679.52  | 283.72  | 312.04  |
| C degradation | pox | 196.37  | 239.07  | 231.74  | 0.00  | 107.00  | 214.91  | 462.53  | 0.00  | 200.96  | 363.93  | 463.89  | 450.44  |
| C degradation | amyX | 0.00  | 0.00  | 0.00  | 0.00  | 74.39  | 0.00  | 75.24  | 0.00  | 123.69  | 134.96  | 125.26  | 170.54  |
| C fixation | acsA | 1,735,463.17  | 1,705,892.13  | 2,108,715.88  | 1,615,883.64  | 1,959,660.25  | 1,699,576.00  | 1,661,696.93  | 1,785,038.03  | 1,588,907.89  | 2,313,263.72  | 2,331,328.84  | 1,963,178.50  |
| C fixation | mct | 574,585.69  | 593,043.43  | 600,359.47  | 579,069.75  | 987,941.52  | 814,987.80  | 898,150.96  | 91,307.21  | 886,316.78  | 976,246.52  | 1,011,147.11  | 946,920.58  |
| C fixation | rbcL | 306,644.26  | 297,807.37  | 333,009.12  | 342,346.93  | 401,498.88  | 368,292.90  | 336,935.86  | 389,799.17  | 221,484.12  | 293,273.33  | 332,649.47  | 262,261.44  |
| C fixation | acsE | 193,088.55  | 224,988.33  | 207,726.08  | 198,493.82  | 268,783.51  | 203,254.27  | 441,351.39  | 44,114.09  | 346,193.29  | 390,214.05  | 401,349.77  | 366,166.75  |
| C fixation | korA | 86,975.69  | 91,698.03  | 884,023.59  | 90,375.40  | 121,206.39  | 118,922.64  | 177,540.46  | 25,142.14  | 176,054.94  | 159,528.31  | 168,827.17  | 158,516.42  |
| C fixation | frdA | 112,862.67  | 114,064.86  | 131,693.78  | 117,179.81  | 134,832.77  | 124,166.14  | 133,348.42  | 119,330.60  | 99,943.16  | 115,807.82  | 110,860.04  | 109,872.72  |
| C fixation | smtA | 74,958.95  | 79,301.02  | 77,565.21  | 76,267.95  | 100,682.23  | 95,152.35  | 115,971.29  | 111,041.20  | 147,086.94  | 150,466.71  | 148,243.25  | 158,155.05  |
| C fixation | pccA | 73,110.74  | 71,411.55  | 70,871.37  | 62,646.21  | 84,763.88  | 79,369.85  | 74,533.90  | 78,176.37  | 78,117.82  | 80,201.27  | 72,304.02  | 76,546.29  |
| C fixation | accA | 26,009.63  | 30,313.31  | 28,548.97  | 29,073.13  | 29,981.53  | 30,071.37  | 27,162.79  | 23,596.31  | 25,074.15  | 29,159.21  | 30,989.66  | 25,981.34  |
| C fixation | aclB | 20,129.77  | 20,034.38  | 21,989.71  | 19,574.25  | 23,804.84  | 17,094.13  | 23,830.31  | 22,200.14  | 39,656.95  | 44,535.88  | 41,929.42  | 39,423.71  |
| C fixation | acsB | 388.81  | 545.61  | 368.72  | 210.72  | 471.36  | 355.47  | 540.61  | 305.16  | 817.58  | 946.47  | 1,037.64  | 970.19  |
| C fixation | mcrA | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 58.56  | 0.00  | 0.00  | 197.09  | 56.00  | 0.00  | 0.00  |
| C fixation | cdaR | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 68.86  | 86.29  | 52.51  | 0.00  |
| N Cycling | UreC | 2,014,648.68  | 1,930,723.83  | 2,676,033.68  | 2,251,114.69  | 2,731,688.06  | 2,365,288.66  | 2,165,308.12  | 2,481,117.59  | 1,991,441.32  | 2,269,013.91  | 2,555,509.66  | 2,169,970.53  |
| N Cycling | amoA2 | 284,988.73  | 292,707.16  | 318,459.37  | 294,901.18  | 208,407.74  | 286,512.57  | 293,000.19  | 277,818.68  | 102,457.28  | 115,099.31  | 127,667.16  | 105,538.04  |
| N Cycling | gdh | 106,754.92  | 119,533.47  | 117,229.53  | 111,442.29  | 134,518.62  | 142,637.83  | 158,822.88  | 137,348.39  | 175,037.71  | 179,400.85  | 163,178.89  | 166,452.68  |
| N Cycling | amoA1 | 45,390.03  | 45,802.71  | 49,290.51  | 47,916.48  | 46,418.52  | 58,005.14  | 68,007.47  | 52,600.22  | 81,672.71  | 85,566.54  | 70,905.76  | 83,785.06  |
| N Cycling | nifH | 48,737.83  | 51,361.15  | 49,152.10  | 50,611.15  | 61,402.38  | 59,439.69  | 65,999.41  | 52,234.65  | 68,633.52  | 70,386.62  | 73,433.67  | 72,556.09  |
| N Cycling | napA | 37,923.35  | 40,286.28  | 39,470.23  | 38,377.25  | 57,985.88  | 46,818.79  | 65,930.68  | 58,727.14  | 55,043.23  | 61,334.80  | 60,308.87  | 59,341.17  |
| N Cycling | nxrA | 52,175.91  | 56,257.27  | 59,535.65  | 57,381.23  | 44,198.25  | 50,784.98  | 48,690.33  | 45,953.65  | 37,018.00  | 39,552.31  | 42,114.48  | 34,151.48  |
| N Cycling | nosZ1 | 29,445.97  | 31,767.87  | 32,961.20  | 29,844.49  | 44,251.08  | 39,089.90  | 41,369.34  | 46,280.42  | 65,658.62  | 70,916.99  | 68,190.93  | 59,354.28  |
| N Cycling | nirS1 | 24,840.64  | 25,012.71  | 28,773.22  | 24,367.53  | 34,527.30  | 34,441.11  | 36,582.30  | 32,491.83  | 50,363.77  | 57,275.89  | 55,395.79  | 49,115.85  |
| N Cycling | nirK3 | 27,796.12  | 26,141.28  | 25,813.53  | 24,309.99  | 36,891.25  | 39,475.69  | 34,184.66  | 31,719.21  | 40,569.17  | 54,475.69  | 59,244.28  | 50,462.90  |
| N Cycling | amoB | 21,020.98  | 24,595.45  | 23,059.51  | 23,011.46  | 28,478.29  | 24,038.01  | 25,275.21  | 31,651.95  | 42,872.69  | 60,382.86  | 57,521.24  | 53,182.95  |
| N Cycling | nirS2 | 9,768.65  | 10,247.11  | 10,840.42  | 9,179.47  | 16,567.21  | 12,625.72  | 10,442.96  | 13,261.06  | 19,593.23  | 22,169.67  | 25,137.50  | 21,288.68  |
| N Cycling | nirK1 | 5,170.03  | 5,793.56  | 5,477.54  | 4,972.25  | 9,131.51  | 7,812.96  | 8,787.92  | 8,835.09  | 9,599.90  | 9,885.29  | 10,268.41  | 9,839.14  |
| N Cycling | nirS3 | 5,060.66  | 6,547.95  | 5,949.49  | 5,627.24  | 5,581.19  | 5,170.32  | 5,429.24  | 5,774.55  | 9,906.36  | 11,077.25  | 12,666.50  | 10,435.57  |
| N Cycling | narG | 4,995.61  | 5,445.03  | 5,735.59  | 3,745.83  | 6,699.70  | 6,581.59  | 6,927.94  | 7,098.16  | 8,540.34  | 8,224.02  | 10,773.83  | 9,269.78  |
| N Cycling | nirK2 | 1,877.21  | 1,741.01  | 1,950.59  | 1,862.96  | 3,316.00  | 3,763.94  | 4,008.50  | 3,232.67  | 4,174.21  | 5,063.56  | 6,138.42  | 4,368.82  |
| N Cycling | hzsB | 1,375.72  | 1,278.11  | 1,090.38  | 1,231.82  | 2,960.00  | 3,033.44  | 3,552.36  | 3,236.01  | 2,997.07  | 4,566.14  | 3,872.31  | 3,695.89  |
| N Cycling | nasA | 598.53  | 675.39  | 572.55  | 134.88  | 633.25  | 424.97  | 932.44  | 471.90  | 1,852.79  | 1,075.80  | 1,186.35  | 1,853.29  |
| N Cycling | hao | 350.54  | 496.48  | 472.30  | 294.57  | 666.85  | 627.01  | 814.57  | 758.96  | 785.03  | 1,090.63  | 836.58  | 1,064.45  |
| P Cycling | bpp | 7,235.13  | 8,514.08  | 9,329.57  | 7,292.50  | 8,498.72  | 7,307.67  | 7,928.49  | 8,963.58  | 9,143.69  | 11,287.58  | 11,092.12  | 11,214.48  |
| P Cycling | cphy | 0.00  | 45.62  | 0.00  | 0.00  | 52.31  | 52.90  | 126.13  | 0.00  | 150.40  | 205.43  | 178.74  | 151.70  |
| P Cycling | phnK | 361,563.14  | 367,400.47  | 466,363.85  | 322,650.13  | 384,422.41  | 403,000.21  | 480,102.90  | 398,609.89  | 456,092.74  | 509,734.26  | 497,872.05  | 453,132.54  |
| P Cycling | phoD | 446,614.48  | 467,476.91  | 594,421.22  | 448,340.87  | 514,723.09  | 537,206.97  | 563,830.32  | 545,471.65  | 565,126.90  | 590,167.77  | 533,427.78  | 557,457.90  |
| P Cycling | phoX | 13,755.35  | 14,775.57  | 14,926.23  | 13,134.48  | 23,484.13  | 25,492.17  | 20,363.63  | 2,237.53  | 27,865.40  | 29,431.75  | 31,644.35  | 26,189.19  |
| P Cycling | pqqC | 40,019.40  | 42,374.59  | 38,584.03  | 44,473.23  | 54,686.10  | 49,169.23  | 59,306.90  | 53,361.77  | 53,967.03  | 57,490.16  | 52,113.04  | 54,810.68  |
| S Cycling | apsA | 82,155.37  | 913,449.54  | 99,855.86  | 90,850.16  | 93,039.64  | 83,109.30  | 95,798.63  | 97,784.60  | 174,339.02  | 168,652.63  | 182,112.02  | 172,784.59  |
| S Cycling | dsrA | 5,795.01  | 5,996.39  | 6,533.36  | 5,297.09  | 5,751.68  | 5,745.19  | 5,236.22  | 5,257.08  | 9,406.62  | 10,750.73  | 8,834.84  | 9,539.20  |
| S Cycling | dsrB | 204.58  | 220.72  | 178.48  | 283.12  | 290.38  | 296.80  | 226.68  | 291.93  | 580.41  | 593.87  | 593.89  | 713.98  |
| S Cycling | SoxY | 86,148.07  | 89,574.06  | 79,787.57  | 73,743.38  | 105,320.84  | 101,264.53  | 117,705.26  | 11,985.59  | 177,857.69  | 169,358.76  | 190,276.38  | 170,988.31  |
| S Cycling | YedZ | 84,955.59  | 104,461.43  | 104,155.65  | 91,911.63  | 159,928.35  | 154,149.10  | 154,133.07  | 15,620.05  | 141,466.28  | 173,901.73  | 189,212.25  | 167,386.85  |