Light-dominated selection shaping filamentous cyanobacterial assemblages drives odor problem in a drinking water reservoir

Supplementary Material

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# Supplementary Material

All data analysis and illustration were performed using R 4.01. Data pretreatment and summary were performed using the **dplyr**2 and **base** packages in R, regression analysis including linear and generalized linear models were performed using the **stats** package1, generalized additive modelling was performed using the **mgcv** package3,4 quantile regression analysis was performed using the **quantreg** package5; contour figures were created by the **graphics** package1, other figures were prepared using the **ggplot2** package6.

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| Fig. S1 Seasonal dynamics of MIB of Yangtze River water (inlet) from 2011 to 2015” |

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| Fig. S2 Composition of filamentous cyanobacteria and *Microcystis* in QCS Reservoir |

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| Fig. S3 Seasonal dynamics and long-term trends of *Planktothrix*, *Pseudanabaena*, *Lyngbya*, *Phormidium* and *Microcystis* in QCS Reservoir |

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| Fig. S4 Seasonal dynamics and long-term trends of nutrients (total nitrogen, nitrate, ammonia and total phosphorus) in QCS Reservoir |

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| Fig. S5 Correlation between factors and filamentous abundances |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Year | Season | Min | Max | Median | IQR | Mean | SD | SE | CI | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 2013 | Spring | 0.037 | 0.078 | 0.055 | 0.013 | 0.055 | 0.010 | 0.002 | 0.004 | | 2013 | Summer | 0.033 | 0.139 | 0.058 | 0.018 | 0.063 | 0.023 | 0.003 | 0.006 | | 2013 | Autumn | 0.035 | 0.127 | 0.067 | 0.027 | 0.065 | 0.021 | 0.004 | 0.007 | | 2013 | Winter | 0.028 | 0.201 | 0.053 | 0.089 | 0.088 | 0.064 | 0.021 | 0.050 | | 2014 | Spring | 0.045 | 0.107 | 0.071 | 0.019 | 0.074 | 0.016 | 0.002 | 0.005 | | 2014 | Summer | 0.032 | 0.093 | 0.059 | 0.016 | 0.061 | 0.013 | 0.001 | 0.003 | | 2014 | Autumn | 0.024 | 0.105 | 0.044 | 0.027 | 0.051 | 0.019 | 0.003 | 0.007 | | 2014 | Winter | 0.034 | 0.183 | 0.067 | 0.024 | 0.078 | 0.034 | 0.007 | 0.015 | | 2015 | Spring | 0.034 | 0.104 | 0.069 | 0.019 | 0.068 | 0.016 | 0.003 | 0.006 | | 2015 | Summer | 0.033 | 0.109 | 0.058 | 0.022 | 0.062 | 0.016 | 0.002 | 0.005 | | 2015 | Autumn | 0.039 | 0.077 | 0.054 | 0.008 | 0.056 | 0.011 | 0.003 | 0.007 | | 2015 | Winter | 0.022 | 0.081 | 0.053 | 0.028 | 0.052 | 0.022 | 0.009 | 0.023 |   Table S1 Descriptive statistics of ammonia nitrogen in QCS Reservoir (unit: mg L-1) |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Year | Season | Min | Max | Median | IQR | Mean | SD | SE | CI | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 2013 | Spring | 1.213 | 1.702 | 1.415 | 0.179 | 1.431 | 0.118 | 0.024 | 0.05 | | 2013 | Summer | 0.759 | 1.665 | 1.110 | 0.269 | 1.137 | 0.194 | 0.025 | 0.05 | | 2013 | Autumn | 0.843 | 1.71 | 1.029 | 0.445 | 1.140 | 0.281 | 0.047 | 0.095 | | 2013 | Winter | 1.390 | 1.828 | 1.557 | 0.167 | 1.600 | 0.136 | 0.045 | 0.105 | | 2014 | Spring | 1.578 | 2.162 | 1.796 | 0.121 | 1.800 | 0.130 | 0.019 | 0.038 | | 2014 | Summer | 0.944 | 1.737 | 1.293 | 0.176 | 1.306 | 0.163 | 0.019 | 0.038 | | 2014 | Autumn | 1.159 | 1.707 | 1.309 | 0.119 | 1.352 | 0.129 | 0.023 | 0.047 | | 2014 | Winter | 1.561 | 2.362 | 2.008 | 0.196 | 2.008 | 0.189 | 0.039 | 0.082 | | 2015 | Spring | 1.157 | 1.793 | 1.485 | 0.271 | 1.474 | 0.186 | 0.033 | 0.068 | | 2015 | Summer | 0.895 | 1.867 | 1.411 | 0.414 | 1.333 | 0.264 | 0.037 | 0.074 | | 2015 | Autumn | 0.729 | 1.365 | 1.145 | 0.234 | 1.092 | 0.189 | 0.052 | 0.114 | | 2015 | Winter | 1.595 | 1.774 | 1.708 | 0.131 | 1.694 | 0.078 | 0.032 | 0.082 |   Table S2 Descriptive statistics of nitrate nitrogen in QCS Reservoir (unit: mg L-1) |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Year | Season | Min | Max | Median | IQR | Mean | SD | SE | CI | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 2013 | Spring | 1.008 | 1.469 | 1.326 | 0.156 | 1.313 | 0.113 | 0.023 | 0.048 | | 2013 | Summer | 0.683 | 1.411 | 1.126 | 0.150 | 1.094 | 0.153 | 0.020 | 0.040 | | 2013 | Autumn | 0.319 | 1.592 | 1.006 | 0.583 | 1.052 | 0.351 | 0.059 | 0.119 | | 2013 | Winter | 1.367 | 1.735 | 1.543 | 0.161 | 1.542 | 0.132 | 0.044 | 0.101 | | 2014 | Spring | 1.478 | 2.265 | 1.808 | 0.217 | 1.795 | 0.164 | 0.024 | 0.048 | | 2014 | Summer | 0.808 | 1.705 | 1.237 | 0.192 | 1.228 | 0.195 | 0.023 | 0.045 | | 2014 | Autumn | 0.959 | 1.601 | 1.236 | 0.125 | 1.250 | 0.142 | 0.025 | 0.052 | | 2014 | Winter | 1.361 | 2.429 | 2.073 | 0.337 | 1.974 | 0.259 | 0.054 | 0.112 | | 2015 | Spring | 1.234 | 1.875 | 1.419 | 0.191 | 1.450 | 0.154 | 0.028 | 0.056 | | 2015 | Summer | 0.718 | 1.654 | 1.317 | 0.355 | 1.292 | 0.223 | 0.031 | 0.063 | | 2015 | Autumn | 0.726 | 1.348 | 1.013 | 0.135 | 1.017 | 0.156 | 0.043 | 0.094 | | 2015 | Winter | 1.348 | 1.75 | 1.59 | 0.279 | 1.581 | 0.177 | 0.072 | 0.186 |   Table S3 Descriptive statistics of total nitrogen (TN) in QCS Reservoir (unit: mg L-1) |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Year | Season | Min | Max | Median | IQR | Mean | SD | SE | CI | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 2013 | Spring | 0.053 | 0.095 | 0.077 | 0.016 | 0.078 | 0.012 | 0.003 | 0.005 | | 2013 | Summer | 0.033 | 0.25 | 0.064 | 0.023 | 0.07 | 0.036 | 0.005 | 0.009 | | 2013 | Autumn | 0.046 | 0.121 | 0.070 | 0.017 | 0.072 | 0.015 | 0.003 | 0.005 | | 2013 | Winter | 0.055 | 0.095 | 0.060 | 0.018 | 0.067 | 0.013 | 0.004 | 0.010 | | 2014 | Spring | 0.050 | 0.133 | 0.089 | 0.022 | 0.089 | 0.019 | 0.003 | 0.005 | | 2014 | Summer | 0.047 | 0.118 | 0.081 | 0.024 | 0.079 | 0.017 | 0.002 | 0.004 | | 2014 | Autumn | 0.056 | 0.126 | 0.084 | 0.011 | 0.088 | 0.013 | 0.002 | 0.005 | | 2014 | Winter | 0.058 | 0.133 | 0.092 | 0.037 | 0.091 | 0.021 | 0.004 | 0.009 | | 2015 | Spring | 0.042 | 0.115 | 0.073 | 0.023 | 0.073 | 0.019 | 0.003 | 0.007 | | 2015 | Summer | 0.046 | 0.222 | 0.077 | 0.022 | 0.083 | 0.027 | 0.004 | 0.007 | | 2015 | Autumn | 0.065 | 0.092 | 0.072 | 0.012 | 0.075 | 0.008 | 0.002 | 0.005 | | 2015 | Winter | 0.069 | 0.096 | 0.075 | 0.006 | 0.078 | 0.010 | 0.004 | 0.010 |   Table S4 Descriptive statistics of total phosphrus (TP) in QCS Reservoir (unit: mg L-1) |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Year | Season | Min | Max | Median | IQR | Mean | SD | SE | CI | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 2013 | Spring | 11.208 | 24.642 | 19.468 | 5.594 | 19.475 | 4.088 | 0.834 | 1.726 | | 2013 | Summer | 24.563 | 30.343 | 28.701 | 1.977 | 28.348 | 1.609 | 0.208 | 0.416 | | 2013 | Autumn | 11.564 | 27.028 | 21.502 | 7.032 | 20.788 | 5.019 | 0.836 | 1.698 | | 2013 | Winter | 3.927 | 9.514 | 5.846 | 4.501 | 6.853 | 2.403 | 0.801 | 1.847 | | 2014 | Spring | 12.100 | 25.821 | 20.99 | 6.767 | 20.322 | 4.091 | 0.591 | 1.188 | | 2014 | Summer | 25.688 | 28.549 | 27.386 | 0.832 | 27.367 | 0.691 | 0.08 | 0.159 | | 2014 | Autumn | 12.874 | 26.943 | 21.812 | 7.086 | 21.447 | 4.271 | 0.767 | 1.567 | | 2014 | Winter | 7.19 | 11.001 | 8.403 | 1.759 | 8.637 | 1.168 | 0.244 | 0.505 | | 2015 | Spring | 11.17 | 25.049 | 22.13 | 3.92 | 20.856 | 4.131 | 0.742 | 1.515 | | 2015 | Summer | 24.69 | 31.491 | 28.798 | 2.92 | 28.475 | 1.953 | 0.273 | 0.549 | | 2015 | Autumn | 16.102 | 28.22 | 26.413 | 5.503 | 23.534 | 4.587 | 1.272 | 2.772 | | 2015 | Winter | 7.861 | 8.981 | 8.092 | 0.554 | 8.278 | 0.447 | 0.182 | 0.469 |   Table S5 Descriptive statistics of water temperature in QCS Reservoir (unit: °C) |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Year | Season | Min | Max | Median | IQR | Mean | SD | SE | CI | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 2013 | Spring | 0.815 | 1.879 | 1.273 | 0.410 | 1.322 | 0.314 | 0.064 | 0.133 | | 2013 | Summer | 0.901 | 2.261 | 1.638 | 0.810 | 1.621 | 0.416 | 0.054 | 0.107 | | 2013 | Autumn | 0.701 | 1.468 | 1.152 | 0.409 | 1.110 | 0.247 | 0.041 | 0.084 | | 2013 | Winter | 0.483 | 1.311 | 0.798 | 0.139 | 0.873 | 0.298 | 0.099 | 0.229 | | 2014 | Spring | 0.854 | 1.977 | 1.552 | 0.395 | 1.528 | 0.284 | 0.041 | 0.083 | | 2014 | Summer | 0.666 | 1.840 | 1.226 | 0.453 | 1.235 | 0.316 | 0.036 | 0.073 | | 2014 | Autumn | 0.643 | 1.487 | 0.957 | 0.368 | 0.999 | 0.254 | 0.046 | 0.093 | | 2014 | Winter | 0.461 | 1.254 | 0.938 | 0.241 | 0.857 | 0.248 | 0.052 | 0.107 | | 2015 | Spring | 0.870 | 2.033 | 1.462 | 0.572 | 1.418 | 0.355 | 0.064 | 0.130 | | 2015 | Summer | 0.734 | 2.138 | 1.235 | 0.482 | 1.293 | 0.352 | 0.049 | 0.099 | | 2015 | Autumn | 0.638 | 1.460 | 1.253 | 0.185 | 1.195 | 0.329 | 0.091 | 0.199 | | 2015 | Winter | 0.415 | 0.994 | 0.598 | 0.297 | 0.700 | 0.239 | 0.097 | 0.251 |   Table S6 Descriptive statistics of pre-week PAR in QCS Reservoir (unit: mol m-2 d-1) |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Term | EDF | Ref.DF | Statistic | P.Value | | --- | --- | --- | --- | --- | | s(nweek) | 5.293509 | 8.000000 | 21.395662 | 0.000000 | | s(ndate) | 1.757591 | 1.757591 | 3.755324 | 0.091522 |   Table S7 Summary of time series analysis for *Planktothrix*; s(nweek) denotes the seasonal pattern, and s(ndate) denotes the long-term pattern |

|  |
| --- |
| Fig. S6 Time series analysis of *Planktothrix* based on seasonal and long-term trend smooth functions |

Seasonal and long-term trends of *Planktothrix* and *Pseudanabaena* were evaluated using time series analysis, as illustrated in [Table S7](#stb-platimegam), [Fig. S6](#sfg-plagamcheck), [Table S8](#stb-psetimegam) and [Fig. S7](#sfg-psegamcheck).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Term | EDF | Ref.DF | Statistic | P.Value | | --- | --- | --- | --- | --- | | s(nweek) | 6.246786 | 8.000000 | 11.302972 | 0.000000 | | s(ndate) | 1.943873 | 1.943873 | 82.456653 | 0.000000 |   Table S8 Summary of time series analysis for *Pseudanabaena*; s(nweek) denotes the seasonal pattern, and s(ndate) denotes the long-term pattern |

|  |
| --- |
| Fig. S7 Time series analysis for *Pseudanabaena* based on seasonal and long-term trend smooth functions |

We select water temperature (temp), pre-week photosynthetically active radiation (weekPAR), total nitrogen (TN), nitrate (NO3), total phosphate (TP), ammonia (NH4), wind speed (wind) and maximum daily air temperature (maxtemp) as the potential predictors for abundances of *Planktothrix* ([Table S9](#stb-planklm)) and *Pseudanabaena* ([Table S10](#stb-pseudlm)). Linear model (, ) between these predictors (, i = 1, 2, …) and logarithm transformed abundances ().

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Term | Estimate | Std.Error | Statistic | P.Value | | --- | --- | --- | --- | --- | | (Intercept) | 0.055381 | 0.204114 | 0.271325 | 0.786326 | | temp | 0.020686 | 0.006190 | 3.342053 | 0.000936 | | weekPAR | -0.043151 | 0.062931 | -0.685693 | 0.493431 | | TN | -0.125703 | 0.134448 | -0.934960 | 0.350554 | | NO3 | -0.110292 | 0.143055 | -0.770975 | 0.441323 | | TP | 0.915797 | 1.105912 | 0.828092 | 0.408270 | | NH4 | -0.721135 | 0.911296 | -0.791330 | 0.429371 | | wind | 0.085435 | 0.042653 | 2.003032 | 0.046064 | | maxtemp | -0.003568 | 0.005304 | -0.672707 | 0.501646 |   Table S9 Correlation analysis between *Planktothrix* and environmental factors (named as LM1) |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Term | Estimate | Std.Error | Statistic | P.Value | | --- | --- | --- | --- | --- | | (Intercept) | -0.249268 | 0.208706 | -1.194353 | 0.233274 | | temp | 0.041253 | 0.006329 | 6.518053 | 2.97e-10 | | weekPAR | -0.119826 | 0.064347 | -1.862196 | 0.063543 | | TN | 0.189667 | 0.137473 | 1.379667 | 0.168707 | | NO3 | -0.068600 | 0.146274 | -0.468984 | 0.639418 | | TP | 0.202906 | 1.130792 | 0.179437 | 0.857715 | | NH4 | -0.737178 | 0.931798 | -0.791136 | 0.429484 | | wind | -0.034087 | 0.043612 | -0.781579 | 0.435072 | | maxtemp | -0.012824 | 0.005423 | -2.364817 | 0.018669 |   Table S10 Correlation analysis between *Pseudanabaena* and environmental factors (named as LM2) |

We performed Backward Stepwise Regressions to identify the significant variables responsible for the abundances of *Planktothrix* and *Pseudanabaena*. The regression started with a model that contains all variables, and then removing the least significant variables one by one, until a pre-specified stopping rule (here we use AIC rule) is reached.

Below is the Backward Stepwise Regressions of linear model for *Planktothrix*, the water temperature (temp), pre-week PAR (weekPAR), total nitrogen (TN) and wind speed (wind) were considered as effect predictors for *Planktothrix*.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Term | Estimate | Std.Error | Statistic | P.Value | | --- | --- | --- | --- | --- | | (Intercept) | 0.029206 | 0.183201 | 0.159421 | 0.873442 | | temp | 0.018787 | 0.003960 | 4.744185 | 3.21e-06 | | weekPAR | -0.066606 | 0.057760 | -1.153142 | 0.249749 | | TN | -0.194775 | 0.073604 | -2.646272 | 0.008558 | | wind | 0.075903 | 0.040487 | 1.874726 | 0.061780 |   Table S11 Backward Stepwise Regression of linear models for *Planktothrix* |

Below is the Backward Stepwise Regressions of linear model for *Pseudanabaena*, the water temperature (temp), pre-week PAR (weekPAR), total nitrogen (TN), ammonia (NH4) and maximum daily air temperature (maxtemp) were considered as effect predictors for *Pseudanabaena*.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Term | Estimate | Std.Error | Statistic | P.Value | | --- | --- | --- | --- | --- | | (Intercept) | -0.351 | 0.162542 | -2.159404 | 0.031596 | | temp | 0.043007 | 0.005947 | 7.231744 | 3.84e-12 | | weekPAR | -0.118911 | 0.063542 | -1.871372 | 0.062248 | | TN | 0.142841 | 0.078959 | 1.809052 | 0.071424 | | NH4 | -0.888384 | 0.900174 | -0.986903 | 0.324470 | | maxtemp | -0.013610 | 0.005303 | -2.566502 | 0.010749 |   Table S12 Backward Stepwise Regression of linear models for *Pseudanabaena* |

Backward Stepwise Regression approaches were performed for the two linear models to find out the optimum selections of predictors, as summarize in [Table S11](#stb-plankstep) (*Planktothrix*) and [Table S12](#stb-pseudstep) (*Pseudanabaena*), respectively. Water temperature (temp), pre-week PAR (weekPAR), total nitrogen (TN), wind speed (wind) and maximum daily air temperature (maxtemp) were sorted out.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Parameter | VIF | | --- | --- | | temp | 2.025278 | | weekPAR | 1.449414 | | TN | 1.734340 | | TP | 1.148326 | | NH4 | 1.179282 | | wind | 1.119961 |   Table S13 VIF analysis of selected predictors of *Planktothrix* and *Pseudanabaena* models |

According to the Backward Stepwise Regressions, water temperature (temp), pre-week PAR (weekPAR), total nitrogen (TN), total phosphate (TP), ammonia (NH4) and wind speed (wind) were selected as the valid predictors and used for following general additive models (GAMs). Variance inflation factors (VIF) were calculated and validated the rationality (<5) for these predictors , as summarized in [Table S13](#stb-plankpseudvif).

|  |
| --- |
| Fig. S8 Correlation between environmental factors |

Correlation coefficients among these predictors were computed by Pearson Method, as illustrated in [Fig. S8](#sfg-predictorcorrelation). The results were used for the optimization of non-parameter smooth functions (smoother) in following GAMs for *Planktothrix* and *Pseudanabaena*. Specifically, high correlation coefficient between water temperature (temp) and pre-week PAR (PAR) suggests they are interacting predictors; similarly, total nitrogen (TN) and ammonia (NH4) are interacting predictors.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Term | edf | ref.df | Statistic | p-value | | --- | --- | --- | --- | --- | | t2(temp, weekPAR) | 2.999974 | 2.999974 | 8.441657 | 2.12287e-05 | | t2(TN, NH4) | 2.999898 | 2.999898 | 2.800880 | 0.04014 | | s(TP) | 1.000008 | 1.000008 | 0.759490 | 0.38418 | | s(wind) | 1.000000 | 1.000000 | 3.944025 | 0.04794 |   Table S14 Summary of GAM model with 6 predictors for *Planktothrix* (named as GAM1) |

Iterations between water temperature and pre-week PAR (t2(temp, weekPAR)), and between total nitrogen and ammonia (t2(TN, NH4)) were both evaluated by the tensor products ().

The results of “GAM1” suggest water temperature (temp), pre-week PAR (weekPAR), total nitrogen (TN) and ammonia (NH4) are most important predictors for *Planktothrix* abundance.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Term | edf | ref.df | Statistic | p-value | | --- | --- | --- | --- | --- | | t2(temp, weekPAR) | 5.733091 | 5.733091 | 9.604014 | 0 | | t2(TN, NH4) | 2.999999 | 2.999999 | 0.964346 | 0.41001 | | s(TP) | 2.236544 | 2.236544 | 2.650483 | 0.1095 | | s(wind) | 4.787511 | 4.787511 | 3.886710 | 0.00265 |   Table S15 Summary of GAM model with 6 predictors for *Pseudanabaena* (named as GAM2) |

The results of “GAM2” suggest water temperature (temp), pre-week PAR (weekPAR), total phosphrus (TP) and wind speed (wind) are most important predictors for *Pseudanabaena* abundance.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Term | edf | ref.df | Statistic | p-value | | --- | --- | --- | --- | --- | | t2(temp, weekPAR) | 2.999993 | 2.999993 | 8.439392 | 1.912541e-05 | | t2(TN, NH4) | 2.999870 | 2.999870 | 4.088651 | 0.00689 |   Table S16 Summary of GAM model with 4 predictors for *Planktothrix* (named as GAM3) |

According to “GAM1”, the predictors of *Planktothrix* abundances were further optimized to 4 factors, which are water temperature (temp), pre-week PAR (weekPAR), total nitrogen (TN) and ammonia (NH4). The summary of optimized *Planktothrix* GAM (GAM3) results is shown in [Table S16](#stb-plankfinalgam).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Term | edf | ref.df | Statistic | p-value | | --- | --- | --- | --- | --- | | t2(temp, weekPAR) | 5.870002 | 5.870002 | 9.200651 | 0 | | s(TP) | 2.222784 | 2.222784 | 3.073369 | 0.06404 | | s(wind) | 4.665106 | 4.665106 | 3.782337 | 0.00378 |   Table S17 Summary of GAM model with 4 predictors for *Pseudanabaena* (named as GAM4) |

According to “GAM2”, the predictors of *Pseudanabaena* abundances were further optimized to 4 factors, which are water temperature (temp), pre-week PAR (weekPAR), total phosphorus (TP) and wind speed (wind). The summary of optimized *Pseudanabaena* GAM (GAM4) results is shown in [Table S17](#stb-pseudfinalgam).

## R Language demonstration code

# demo data frame  
require(lubridate)  
require(mgcv)  
modeldf <- data.frame(date = ymd("2020-01-01") + 0:365,  
 y = rnorm(366))  
# seasonal pattern: week number  
modeldf$x1 <- week(modeldf$date)  
# long-term pattern: decimal number  
modeldf$x2 <- year(modeldf$date) + yday(modeldf$date) / 366  
# demo gam model  
m <- gamm(y ~ s(x1, bs = "cc") + s(x2), data = modeldf)

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