Degradation of water quality in Lough Neagh, Northern Ireland, by diffuse nitrogen flux from a phosphorus-rich catchment

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ABSTRACT: Annually resolved fossil records of nitrogen (N) inputs (as sedimentary $\delta^{15}N$, N content), aquatic production ($\delta^{13}C$, C content), and algal abundance and gross community composition (pigments, nonsiliceous microfossils) from Lough Neagh, Northern Ireland (NI), were compared with annual records of climatic variability, atmospheric and urban nutrient loading, whole-catchment nutrient budgets, and limnological monitoring data to identify the unique effects of N on the eutrophication of a phosphorus (P)-rich lake during ca. 1933-1995. Cluster analysis revealed two major biostratigraphic zones. Zone I (ca. 1933-1955) was characterized by moderate lake production, as inferred from low concentrations of most fossil pigments and reduced $\delta^{15}N$ signatures but elevated $\delta^{13}C$ values and chlorophyte microfossil concentrations. In contrast, Zone II (ca. 1955-1995) exhibited greatly increased contents of ^{15}N, N, C, and algal pigments, combined with strongly reduced $\delta^{13}C$ ratios and chlorophyte fossil abundance, a pattern consistent with recent severe eutrophication. Overall, microfossils of diazotrophic cyanobacteria were most abundant during the transition period between zones (ca. 1955-1964). Regression analysis revealed that past N influx to the lake (as $\delta^{15}N$; $r^2 = 0.916$, $p < 0.0001$), colonial cyanobacterial abundance(as myxoxanthophyll; $r^2 = 0.837$, $p < 0.0001$), and total algal standing crops (as b-carotene; $r^2 = 0.388$, $p < 0.0001$) were all strongly correlated to agricultural inputs of N to NI farmland, weakly correlated to P inputs to NI farmland (r^2 $\delta^{15}N = 0.503$, $p < 0.0001$; $r^2_{cyanobacteria} = 0.296$, $p < 0.0001$; $r^2_{total\ algae} = 0.046$, $p < 0.05$), and uncorrelated to most measures of climatic variability and atmospheric or urban nutrient inputs. Thus, degradation of water quality during the 20th century resulted from excessive loading of diffuse N to the lake from P-rich agricultural lands.

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