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Changes in Nutrient Concentrations and Limitations of Poyang Lake Associated with Socioeconomic Development in the Watershed from 1978 to 2021

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Abstract: Socioeconomic development often leads to environmental pollution and degradation initially while, beyond a certain point, there is the potential for improvements in environmental quality. In this study, we conducted a comprehensive review of published literature and national data to investigate changes in nutrient concentrations and limitations in Poyang Lake from 1978 to 2021. Our objective was to examine the relationships between these changes and the process of socioeconomic development in the watershed. The findings revealed a rapid socioeconomic development of the Poyang Lake Watershed, showing significant changes in various indexes. For example, population, Gross Domestic Product (GDP), urbanization, grain and meat productions, sewage amount and treatment rate, and forest coverage in the watershed showed increasing trends with different fitting curves, each following distinct fitting curves such as exponential, binary, and linear models. Concurrently, the concentrations of total nitrogen (TN) and total phosphorus (TP) in Poyang Lake exhibited a linear increase over the years, surpassing eutrophication thresholds since the early 1980s. However, TN and TP have shown a decreasing trend in recent years. Notably, the lake displayed co-limitation by N and P, with TN primarily driving the N:P ratio. TN and TP showed a significant "∩" shape with the increase in GDP and urbanization, while they increased with the population. TN:TP showed an increasing pattern with GDP and urbanization but a "U" shape with the population. This research contributes significant insights into the long-term changes in nutrient concentrations, shifts in nutrient limitations, and their associations with socioeconomic development. The findings highlight the need for a balanced and strategic approach to appropriately manage both nutrients for effective eutrophication mitigation.

Keywords: eutrophication; gross domestic product; nutrient stoichiometry; urbanization

1. Introduction

The major biogeochemical cycles on the earth have been altered by the rapid development of human society, such as population expansion and industrialization [1–3]. In particular, the total amount of circulating nitrogen (N) in the biosphere has doubled [4,5], and the total amount of phosphorus (P) has quadrupled [6] compared to preindustrial times. These changes have resulted in large quantities of nutrients being delivered into aquatic ecosystems, leading to the stimulation of primary production and the acceleration of the eutrophication process [7,8]. Eutrophication, characterized by excessive nutrient enrichment, has been identified as one of the greatest threats to aquatic ecosystems worldwide [9–11], causing water quality degradation, biodiversity loss, and the disruption of ecosystem functions [12,13]. The Environmental Kuznets Curve (EKC) theory provides additional insights into the relationship between environmental degradation and socioeconomic development, suggesting that as societies undergo economic development, they initially experience an increase in environmental degradation [14,15]. However, beyond a certain level of economic growth and technological advancement, societies may start to witness a decline in environmental degradation and an improvement in environmental quality [16–18]. This theory is relevant to understanding the relationship between socioeconomic development and the long-term nutrient variations in lake ecosystems.

Nitrogen and phosphorus are essential nutrients that support primary production in both aquatic and terrestrial ecosystems, playing important roles in protein synthesis, energy transfer, and nucleic acid structure [19,20]. In lake ecosystems, excess nutrient inputs can lead to eutrophication [21,22]. The dynamics of nutrient enrichment are important for ecosystem health, and researchers have examined the concept of nutrient limitation [19,23,24]. Traditionally, phosphorus has been recognized as the primary limiting nutrient for lake primary production. Unlike certain other essential nutrients that have gaseous atmospheric cycles, phosphorus lacks a significant gaseous atmospheric cycle and relies primarily on geological processes for its availability. This characteristic emphasizes its significance as a critical nutrient for various organisms [25–27]. In marine systems, nitrogen is typically the limiting nutrient due to the inhibition of nitrogen fixers by high salinity [20,28,29]. However, several studies have suggested that lakes can experience frequent nitrogen limitation alongside phosphorus limitation, indicating a dual nutrient limitation [30–32]. A useful indicator for inferring nutrient limitation in lakes is the N:P ratio in the water column, which can provide insights into whether a lake is primarily limited by nitrogen, phosphorus, or both [33,34]. Shifts in lake N:P stoichiometry indicate changes in phytoplankton nutrient limitation patterns [35]. Generally, a TN:TP molar ratio greater than 50:1 is indicative of possible phosphorus limitation, a ratio less than 20:1 suggests possible nitrogen limitation, and ratios between 20:1 and 50:1 indicate a possible co-limitation by N and P [36,37]. Changes in nutrient stoichiometry can lead to alterations in the composition and structure of the primary producer community [35,38–40], favoring species with strong competitive abilities for using phosphorus under enhanced phosphorus limitation [38,41] and nitrogen-fixing cyanobacterial species under nitrogen limitation [36]. Different nutrient management strategies, such as phosphorus-only control, nitrogen control, and dual nutrient control, have been suggested to mitigate and halt lake eutrophication based on the nutrient limitation of phytoplankton [27,42–44].

Human population growth, urbanization, and economic development are key drivers of global environmental change, especially water pollution [45–49]. As the global population continues to surge, so does the demand for resources and land, leading to increased agricultural activities, industrialization, and urban expansion. Urbanization, characterized by the proliferation of impervious surfaces and concentrated human activity, generates substantial volumes of wastewater and stormwater runoff. When inadequately managed, these runoff sources can transport pollutants into rivers, lakes, and oceans [50,51]. Concurrently, economic development fosters industrial growth and infrastructure expansion, often resulting in the release of chemicals, heavy metals, and nutrients into aquatic ecosystems [52–57]. For example, in the study by Hall et al. [52], the impacts of socioeconomic indices, such as cropland area, livestock biomass, and nitrogen in sewage, on water quality were compared with climate factors including temperature, evaporation, and river discharge. The findings indicate that the former (socioeconomic) factors were stronger determinants influencing algal communities than the latter (climate) factors. Yuan et al. [58] reported statistically significant higher nutrient levels and increased concentrations of total and thermotolerant coliforms (or fecal coliforms) in highly urbanized locations when compared to medium- and low-urbanization sites. This complex interplay among these driving forces underscores the critical importance of conducting comprehensive analyses to unravel the multifaceted challenges posed by population growth, urbanization, and economic development, all of which are pivotal in safeguarding the long-term health of these vital aquatic ecosystems and preserving our invaluable water resources.

Since China's Opening Up and Reform Process began in 1978, the country has experienced remarkable social and economic development [53,59]. From 1978 to 2021, China's population increased from 963 million to 1412 million, the proportion of urban areas in the watershed increased from 17.9% to 64.7%, and GDP increased 313-fold from CNY 367 billion to CNY 114,924 billion [60]. Concurrently, lake eutrophication has become a significant environmental problem in China since the 1980s, particularly in shallow lakes in the middle and lower reaches of the Yangtze River basin [61–63]. As the largest freshwater lake in China and an important river-connected lake in the Yangtze River region, Poyang Lake has experienced rapid economic and population growth within its watershed. The increased anthropogenic inputs resulting from industrialization, urbanization, and population expansion have elevated both nitrogen and phosphorus concentrations in Poyang Lake [64–66]. Comprehensive pollution-source identification revealed that nutrient pollution in Poyang Lake originates from non-point sources related to agricultural activities and atmospheric deposition, as well as point sources such as municipal effluents and fertilizer plant wastewater [67].

These nutrient inputs have led to persistent harmful algal blooms, significantly degrading the water quality and ecological integrity of Poyang Lake. However, the long-term variations in nutrient concentrations and their relationships with socioeconomic development in the region remain unclear. A thorough understanding of these relationships can provide valuable insights into the increasing environmental impacts of economic growth, helping policymakers to make informed decisions in order to promote sustainable development and mitigate potential ecological threats. Additionally, this research can aid in the development of targeted strategies for nutrient management and environmental conservation in the area.

Therefore, the specific objectives of this study were: (1) to evaluate trends in nutrient concentrations and nutrient limitation status in Poyang Lake from 1978 to 2021 by reviewing published literature and national monitoring data, and (2) to assess the EKC theory by investigating the relationships between lake nutrient changes and socioeconomic development indexes. By achieving these objectives, this research aims to provide important insights into the long-term changes in nutrient concentrations, shifts in nutrient limitation, and their associations with socioeconomic development. These findings will contribute to the effective management of eutrophication in Poyang Lake and inform future decision-making processes.

2. Materials and Methods

2.1. Study Area

Poyang Lake, located in the northern Jiangxi Province and lower reach of Yangtze River, has a surface area over 4000 km^2 in the summer, an average depth of 8.4 m, and a watershed area spanning 162,200 km^2 [68,69]. The lake region falls within the East Asian Monsoon Region and experiences a subtropical warm and humid climate, characterized by an average temperature of 17 °C and an average annual precipitation ranging from 1200 to 1700 mm. The lake is fed by five rivers, namely the Ganjiang, Fuhe, Xinjiang, Raohe, and Xiushui rivers, and it has one outlet connecting to the Yangtze River (Figure 1). The annual runoff of Poyang Lake is 152.5 billion m^3, accounting for 16.3% of the annual runoff of the Yangtze River. Generally, the flood season begins at the end of March and lasts until October [69]. During the summer, Poyang Lake acts as a flood buffer, receiving excess water from the Yangtze River and mitigating flood risks downstream. The water level of Poyang Lake fluctuates significantly due to variations in inflows from the five tributaries and water exchange with the Yangtze River, resulting in large seasonal variations in the water surface area [70,71]. Poyang Lake is known as "the kidney of the Yangtze River" as its water quality directly affects the ecological security of the middle and lower reaches of the Yangtze River.

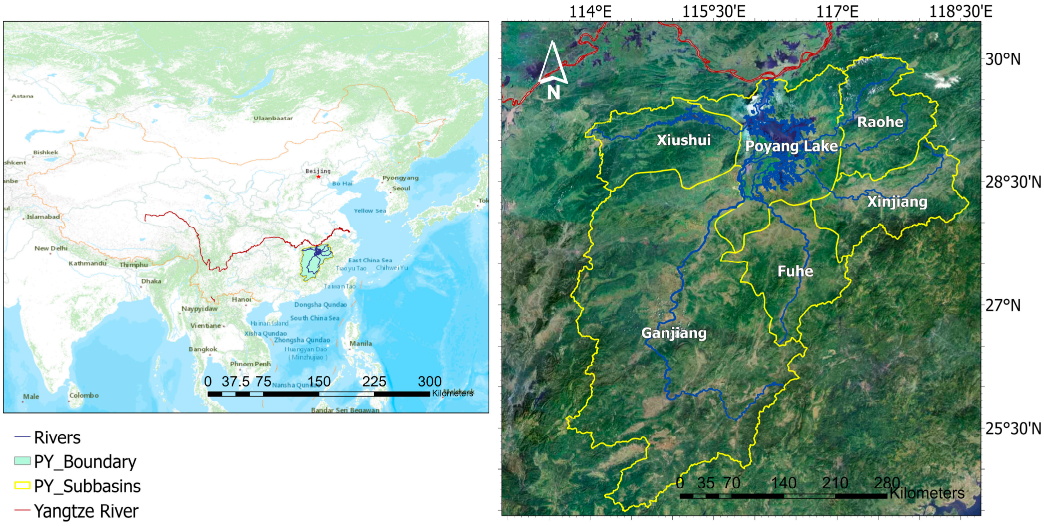

Figure 1. The map of the Poyang Lake Watershed. Poyang Lake is the largest freshwater lake in China.

Poyang Lake is not only significant in terms of its hydrology but also serves as a critical wintering refuge for 310 species of migratory birds [72,73], including 16 threatened species on the International Union for the Conservation of Nature Red List (IUCN, www.iucnredlist.org, accessed on 27 April 2022, version 2022-2). The lake hosts approximately 99% of the global population of the critically endangered Siberian Cranes and about 95% of the global population of the endangered Oriental White Storks during the winter [72,73]. Moreover, Poyang Lake supports a remarkable array of fish species, including the only freshwater porpoise in the world, diverse aquatic vegetation, and a few dozen species of mammals that reside in the lake at various times. Due to its exceptional ecological diversity, Poyang Lake was designated as a Wetland of International Importance by the Ramsar Convention in 1992.

2.2. Data Collection and Statistics

The nutrient concentration (TN and TP) data from 1978 to 2021 were collected from 28 sources documented in scientific papers and the nation's monitoring data (Table S1). When multiple yearly TN and TP values were available for the same years, we used the averaged values. Additionally, we calculated yearly averages from the monthly monitoring data. All of the data were carefully checked and cross-referenced with reference datasets spanning a 10-year duration. The N:P molar ratio was calculated with the average values of TN and TP. The watershed area of Poyang Lake accounts for 97% of the area of Jiangxi Province; thus, we used the sociometric data of Jiangxi Province to represent the data of the Poyang Lake Watershed. The sociometric indexes from 1978 to 2021 were collected from Jiangxi Statistical Yearbooks (http://tjj.jiangxi.gov.cn, accessed on 6 December 2022), including GDP, population, proportion of urban area (urbanization), domestic sewage amount, sewage treatment rate, forest coverage, grain yield, meat yield, agriculture land area, total amount of N-fertilizer and P-fertilizer, and the molar ratio of N-fertilizer:P-fertilizer. The change trend in these indexes was assessed using the ggtrendline package (https://cran.r-project.org/web/packages/ggtrendline, accessed on 27 April 2022) in R 3.6.3 (R Core Team. 2020. R: A language and environment for statistical computing, R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org, accessed on 29 February 2020). The relationships among TN, TP, and TN:TP, as well as the relationships between the nutrient indexes (TN, TP, and TN:TP) and sociometric indexes (GDP, population, and urbanization) were assessed using the ggtrendline package in R.

3. Results

3.1. Socioeconomic Indexes

The Poyang Lake Watershed has experienced rapid societal development as evidenced by significant changes in various socioeconomic indexes since 1978 (Figure 2). GDP increased exponentially from CNY 8.7 billion to CNY 2962 billion (Figure 2). Population shows a quadratic relationship, increasing from 31.8 million to 45.2 million and plateauing since 2010 (Figure 2). Urbanization has also increased quadratically from 16.8% to 61.5%. During these 43 years, GDP increased 340-fold, population increased 1.4-fold, and urbanization increased 3.7-fold. Moreover, from 2003, the total volume of domestic sewage increased linearly, while the treatment rate of sewage also increased simultaneously in a parabolic pattern and reached 98.1% in 2021 (Figure 2). The forest coverage of the watershed increased parabolically and has stayed at around 63% since 2010. The meat production and grain production increased linearly, while the agriculture area showed a "U" shape. The N-fertilizer showed an "∩" shape, while the P-fertilizer first increased and has then decreased since 2014. The fertilizer N:P ratio is the ratio of the nutrients being applied to the land. In the watershed, the ratio showed a significant decreasing trend from 13 to 8 (Figure 2).

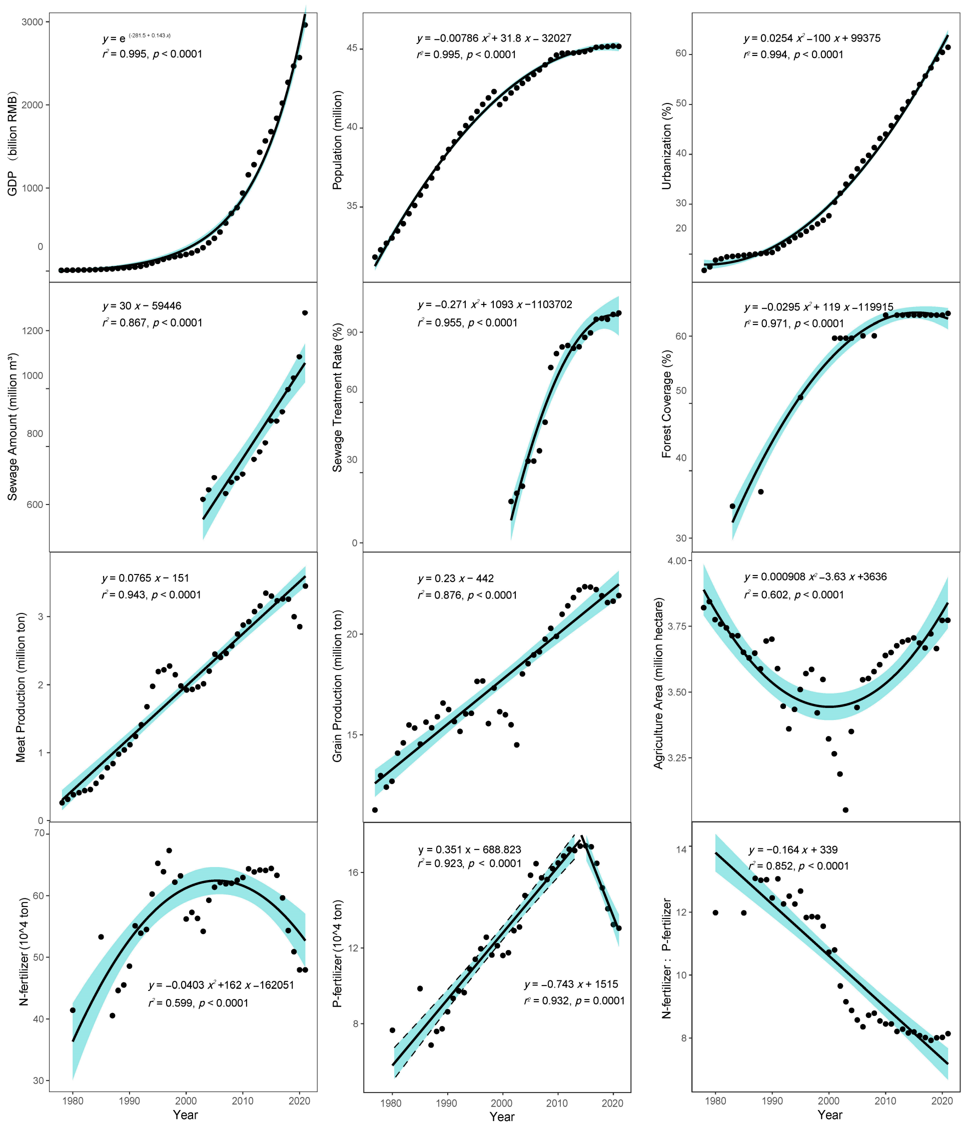

Figure 2. The socioeconomic indexes of Poyang Lake Watershed from 1978 to 2021. The blue shading shows 95% confidence intervals.

3.2. Nutrient Concentration and Nutrient Limitation

From 1978 to 2021, the annual average TN of Poyang Lake showed a significant ($p < 0.001$) linear increase with an increasing rate of 0.037 mg/L per year, while this rate decreased from 2019 (Figure 3). Meanwhile, TP increased significantly with an increasing rate of 0.003 mg/L per year until 2014 and then decreased significantly at a rate of 0.013 mg/L per year (Figure 3). TN:TP ratio showed an "U" shape trend with the lowest value observed around 2000 (Figure 3).

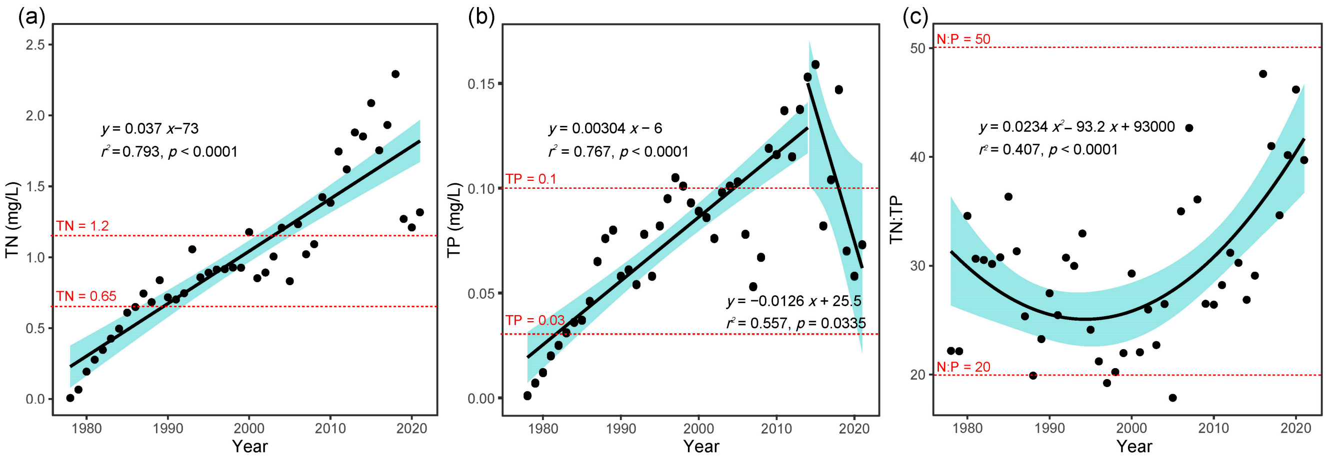

Figure 3. The change in nutrient concentrations and the shifts of nutrient limitation in Poyang Lake from 1978 to 2021. (**a**) The red dash lines represent the TN concentration threshold for eutrophication TN = 0.65 mg/L and hypereutrophication TN = 1.2 mg/L. (**b**) The red dash lines represent the TP concentration threshold for eutrophication TP = 0.03 mg/L and hypereutrophication TP = 0.1 mg/L. (**c**) The red dash lines represent the nutrient limitation in terms of the N:P molar ratio, less than 20:1 indicates nitrogen limitation, greater than 20:1 and less than 50:1 indicate nitrogen and phosphorus co-limitation, and greater than 50:1 indicates phosphorus limitation. The blue shading shows 95% confidence intervals.

During the past 43 years from 1978 to 2021, Poyang Lake had a higher TN and TP than the eutrophication thresholds in most years. Only the first 9 years had a TN lower than 0.65 mg/L, and only the first 5 years had a TP lower than 0.03 mg/L. For the N:P ratio, almost all of the years (40 out of 43) had a value less than 50:1 and greater than 20:1. There was a significant ($p < 0.001$) linear relationship between TN and TP (Figure 4). The TN:TP ratio showed a significant but weak relationship with TN, while it did not with TP (Figure 4).

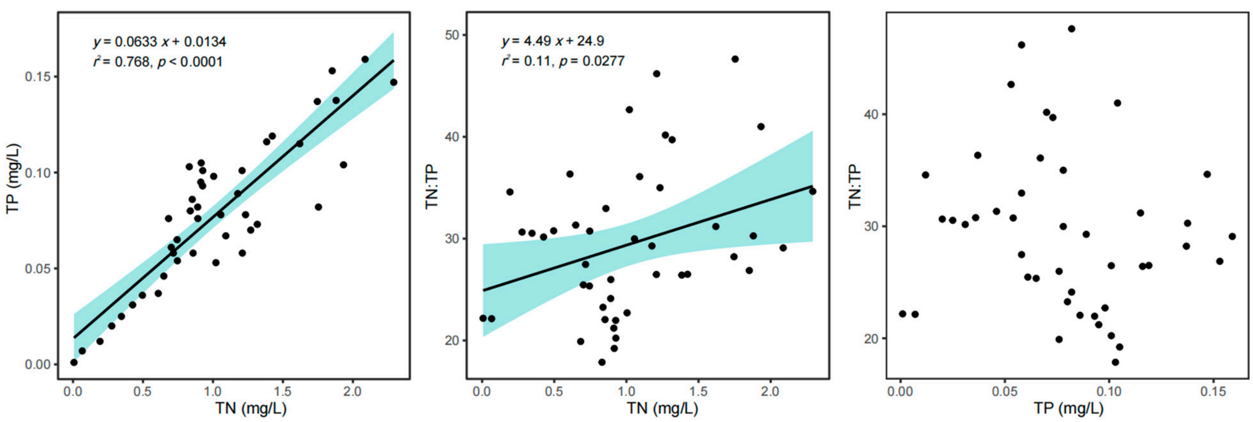

Figure 4. The relationships among TN, TP, and TN:TP ratio. The blue shading shows 95% confidence intervals.

3.3. Lake Nutrients and Society Development

Combining the water nutrients and the major socioeconomic development indexes, we found interesting relationships. The socioeconomic development indexes exhibited the most significant influences on TN compared to the other two nutrient indexes, as evidenced by the highest regression coefficients. High residual values (high SSE in Figure 5) were observed when assessing the societal development impacts on TN:TP. Specifically, both TN and TP showed a significant "∩" shape ($p < 0.001$) with the increase in GDP per capital and urbanization (Figure 5). Meanwhile, TN showed an exponential relationship and TP showed a linear relationship with the increasing population (Figure 5). In addition, TN:TP showed an increasing pattern with increasing GDP and urbanization, while a "U" shape was observed with the increasing population (Figure 5).

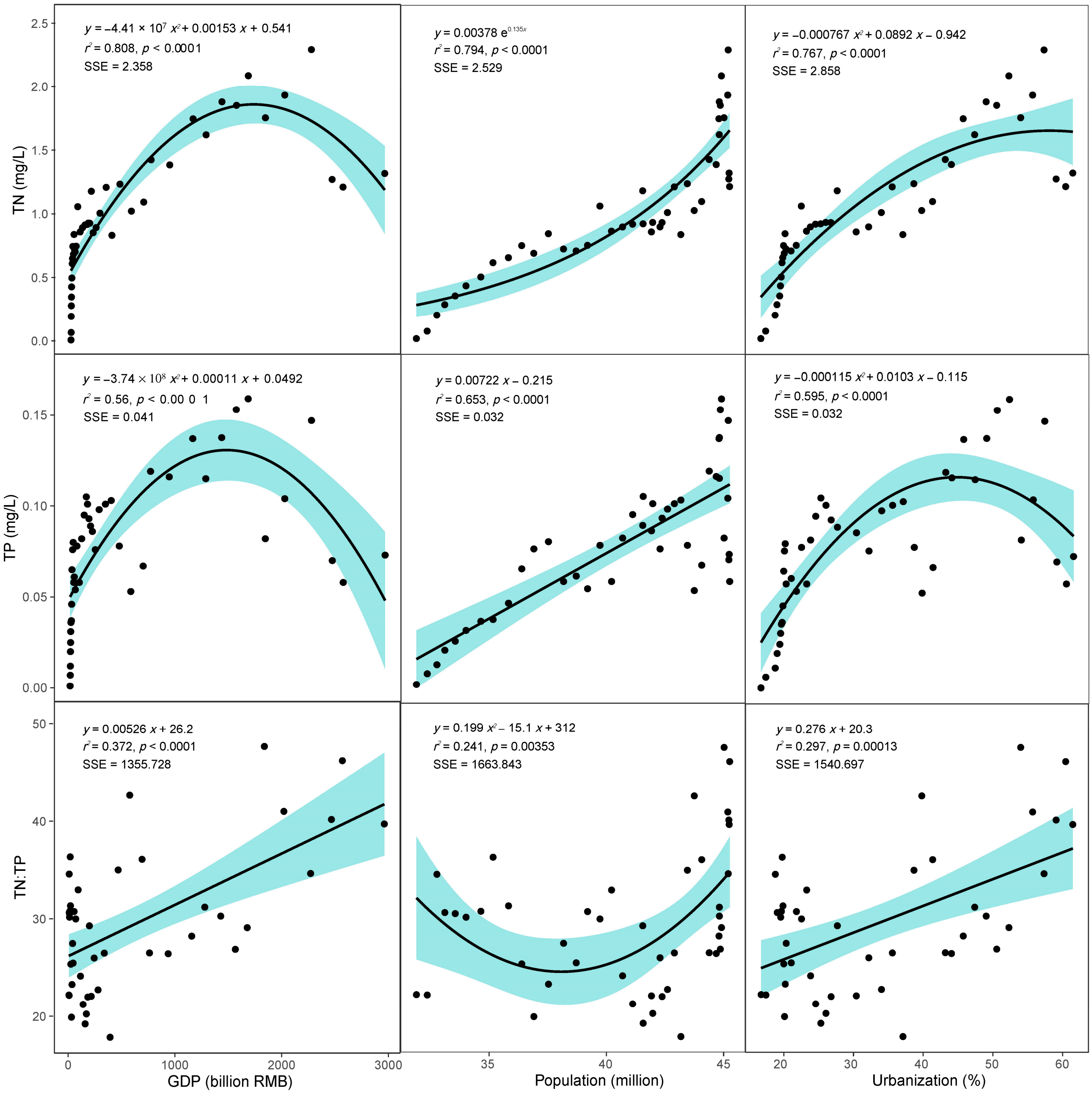

Figure 5. The relationships between socioeconomic development (population, grain yield, GDP, and urbanization) and lake nutrients. The blue shading shows 95% confidence intervals.

4. Discussion

4.1. Nutrient Changes and Eutrophication

Reactive N is a crucial element supplied to the biosphere through natural processes such as N-fixation, as well as human activities including industrial N-fixation and fossil fuel combustion [42,74,75]. In contrast, phosphorus (P) enters the biosphere through the natural weathering of rocks, as well as mining, fertilization, and the use of P-containing products [76,77]. However, the excessive influx of N and P into rivers and lakes poses a significant threat to aquatic ecosystems, leading to eutrophication and the disruption of vital ecosystem functions [8,78]. From 1978 to 2021, the escalating levels of total nitrogen (TN) and total phosphorus (TP) in Poyang Lake indicate a concerning trend. TN has been higher than the eutrophication threshold (TN = 0.65 mg/L) since 1986. TP has been higher than the eutrophication threshold (TP = 0.03 mg/L) for even longer, since 1983. These alarming findings clearly demonstrate the severity of eutrophication in Poyang Lake. Moreover, this pattern of eutrophication is not unique to Poyang Lake, as many lakes in the middle and lower reaches of the Yangtze River experienced a significant turning point towards eutrophication during the 1980s [61]. However, there has been some positive news in recent years regarding the mitigation of nitrogen and phosphorus pollution in Poyang Lake. Since 2014, there has been a notable decline in TP levels, indicating a substantial reduction in phosphorus pollution. This positive trend suggests that efforts to control and manage nutrient inputs have shown some effectiveness in curbing the eutrophication of Poyang Lake in the processes of ecological civilization [63,79]. Further investigation is needed to identify the specific factors contributing to this decline and to evaluate the long-term sustainability of these improvements.

The N:P ratio in the water column has been widely used as an indicator of nutrient limitation for phytoplankton growth [33,34,80,81]. Among the essential elements, phosphorus (P) is generally considered the most limiting nutrient for phytoplankton growth [27,82]. In the case of Poyang Lake, the TN:TP ratios varied from 17.86 to 47.63, with an average value of 29.47. This suggests that phytoplankton growth in the lake was co-limited by both nitrogen (N) and phosphorus (P) for the majority of the time. Notably, in the context of Poyang Lake, there was a significant linear relationship observed between TN and TP concentrations. However, the TN:TP ratio exhibited a significant relationship only with TN, implying that nutrient limitation in the lake was primarily influenced by N inputs. This finding suggests that the availability of nitrogen played a more substantial role in regulating phytoplankton growth and nutrient limitation dynamics in Poyang Lake. Recent studies have provided additional insights into nutrient dynamics and limitation in freshwater systems. Variations in the N:P ratio strongly influence the dominance of different phytoplankton species, emphasizing the importance of considering the N:P ratio in understanding the complex interactions between nutrient availability and phytoplankton community composition [83–85].

4.2. Lake Nutrients Driven by Socioeconomic Development

China has served as a dynamic laboratory for observing the impacts of rapid urbanization and economic development [86]. The country's population expansion, increased grain yield, economic growth, and urbanization have led to extensive resource exploitation and heightened resource consumption [87–90]. Consequently, there has been a widespread discharge of nutrients from municipal, industrial, and agricultural sources, resulting in the expanding eutrophication of aquatic ecosystems. The Environmental Kuznets Curve (EKC) theory provides insights into the relationship between economic development and environmental degradation [91,92]. With rapid urbanization and economic growth, the urban and rural population experiences lifestyle changes and higher income levels, leading to increased resource consumption [87,93]. In China, this is evident in the significant alteration of food structure, with a shift from plant-based to animal-based diets driven by urban dwellers [89,94]. Meeting the nutrient consumption demands of the urban population necessitates an increase in the supply of food and other products containing N or P, thereby accelerating the cycling of these nutrients [95–97]. Moreover, rapid urbanization in China has also resulted in a severe labor shortage in rural communities, leading to the excessive use of fertilizers and pesticides to maintain or increase grain yields [98,99]. Studies have shown that P cycling in China has been artificially intensified, primarily through fertilization, resulting in a three-fold increase in P losses to rivers and lakes [94,100]. In fact, approximately 80% of mined phosphorus worldwide is used in fertilizers, with 57% directly running off through soil leaching and erosion in farmland [101]. Although Jiangxi Province (representing the whole Poyang Lake Watershed) has a relatively lower economic aggregate and growth rate compared to other regions in China (NBSC, 2022), it has still experienced significant socioeconomic development compared to many countries globally. Over the span of 43 years from 1978 to 2021, the population increased by 1.4-fold, GDP increased by 340-fold, urbanization increased by 3.7-fold, grain production increased by 1.9-fold, and meat production increased 13.1-fold. Regression analyses demonstrate that this socioeconomic development, encompassing population growth, GDP, and urbanization, strongly influenced the eutrophication of Poyang Lake. The "∩" shape relationship between TN and TP against the increase in GDP and urbanization supported the theory of EKC. The reduction in TN and TP when the socioeconomic development reached a certain level might be largely contributed by structural transformations in the economy and improved sewage treatment and pollution management.

High residual values (high SSE in Figure 5) between socioeconomic development indexes and TN:TP also indicate that eutrophication in Poyang Lake can be exacerbated as a result of other unaccounted variables, such as climate change and the Three Gorges Project [69,102]. Li et al. [103] reported that Poyang Lake exhibited a significant warming trend from 1980 to 2018, alongside a marked decrease in wind speed. The rising temperatures create an environment conducive to algal proliferation, and the reduced wind speeds enhance their retention within the lake's waters, elevating the risk of algal blooms. Additionally, impoundment of the Three Gorges Project attenuates the river's force on the lake, resulting in reduced sand mining and nutrient transport, further altering the lake's nutrient dynamics [104]. The complex interplay of climatic factors and the profound influence of large-scale engineering projects may introduce complexities when evaluating the evolving dynamics of eutrophication in Poyang Lake.

4.3. Implications for Eutrophication Control

Eutrophication, which is primarily caused by intensified human activities during the process of socioeconomic development, has become a significant impediment to sustainable development in China [61,105]. Balancing rapid economic growth with minimal environmental impact is a key challenge facing the country [87]. The solution may seem straightforward: reducing inputs of N and P [44,106]. Numerous practices and experiments have been conducted to manage eutrophication, and successful demonstrations of P-only control have been observed. Some argue that N-fixing cyanobacteria can compensate for reductions in nitrogen, rendering N-control efforts futile [43,107]. A noteworthy whole-lake experiment conducted by Schindler and others since 1971 has unequivocally shown that reducing P inputs must be the primary focus of eutrophication management in lakes [106]. Considering the current conditions of Poyang Lake, it is evident that both N and P inputs need to be decreased to mitigate eutrophication in terms of nutrient concentrations. However, when addressing the issue of N and P co-limitation and compensating for N-limitation through N-fixation, controlling N inputs becomes pivotal. Thus, a balanced and strategic approach is necessary to effectively manage both nutrients. Additionally, it is crucial to recognize that the recovery of the ecosystem in Poyang Lake will require several decades, even if external sources of N and P are controlled, due to the high internal loading of P from sediments [69,108]. This highlights the long-term nature of the restoration process, emphasizing the need for sustained efforts and patience [10].

5. Conclusions

This study explores the intricate relationship between socioeconomic development and environmental shifts in the Poyang Lake Watershed. An analysis of data from 1978 to 2021 exposes rapid development through rising population, GDP, urbanization, agricultural output, sewage management, and forest coverage. These changes trigger notable shifts in nutrient concentrations within Poyang Lake. Significantly, total nitrogen (TN) and total phosphorus (TP) concentrations follow a consistent upward trajectory, surpassing eutrophication thresholds since the early 1980s. However, recent years have revealed a promising decline in TN and TP levels. The lake's nutrient dynamics are marked by nitrogen–phosphorus co-limitation, particularly driven by TN influencing the N:P ratio. Interactions between nutrient concentrations and socioeconomic indicators, such as GDP, urbanization, and population, unveil intricate trends. TN and TP exhibit a distinct "∩" shape concerning GDP and urbanization, while correlating positively with population. The TN:TP ratio rises with GDP and urbanization but takes a "U" shape relative to the population.

This study highlights the necessity of adopting a well-balanced approach to nutrient management, ensuring effective eutrophication mitigation. To effectively combat eutrophication, it is essential to address multiple facets of nutrient management and recognize the crucial roles that nitrogen and phosphorus play in ecological dynamics. Evaluating nutrient stoichiometry in conjunction with nitrogen and phosphorus levels is key. Given the co-limitation of nitrogen and phosphorus and the principles of nitrogen compensation in this lake, prioritizing the control of nitrogen inputs is imperative. It is important to note that the challenges faced in the Poyang Lake Watershed are not isolated but representative of a global environmental challenge. Our ability to protect the lake's ecosystem while promoting economic growth serves as a litmus test for our commitment to sustainable development.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/w15183304/s1, Table S1: Features and sources of the data to determine the trend and breakpoints in the Poyang [109–134].

Author Contributions: C.Z. is the primary author who analyzed the datasets, generated results, and wrote the draft. G.S. was mainly responsible for data collection. X.L. was responsible for the overall design of the work and provided constructive suggestions in Section 4. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The data that support the results in this study are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

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