Transactions on Environment, Energy and Earth Sciences
ISSN: 2960-1924, eISSN: 2960-2300 | Volume 2
ERET 2024

Quantitative Analysis of the Influence of Temperature Factors on Total Phosphorus Content in Water

Manching Wu *

Guangzhou Foreign Language School, Guangzhou, China

*Corresponding author: mikikiwu@outlook.com

Abstract The purpose of this study is to systematically explore the influence of temperature factors on the total phosphorus content in water by quantitative analysis. In order to comprehensively reflect the water quality of different areas of the lake, the lake located in the suburbs was selected as the sampling point, covering the deep water area, shallow water area and coastal area. The sampling time is set as the representative dates of spring, summer, autumn and winter, and the laboratory control experiment is designed to determine the total phosphorus content in water under five temperature gradients of 5°C, 10°C, 15°C, 20°C and 25°C. Ammonium molybdate spectrophotometry was used to determine the total phosphorus to ensure the accuracy of the data. The experimental results show that with the increase of temperature, the total phosphorus content in water shows an increasing trend. At low temperature (5°C), the average total phosphorus content in each region is between 0.15 and 0.23 mg/L; However, when the temperature rises to 20°C and 25°C, the total phosphorus content increases significantly, reaching 0.30 and 0.35 mg/L respectively. The analysis of variance further confirmed that there were significant differences in the total phosphorus content under different temperature gradients ($F=5.83$, $p=0.001$), indicating that temperature was an important factor affecting the total phosphorus content in water. This study provides a scientific basis for understanding the influence of temperature on the total phosphorus content in water, and has important guiding significance for water quality monitoring and management.

Keywords: Quantitative analysis; temperature factors; total phosphorus content; water.

1. Introduction

Phosphorus is one of the indispensable elements in nature and widely exists in water. However, with the continuous increase of human activities, a large amount of phosphorus enters the water body through agriculture, industry and urban sewage, which leads to the abnormal increase of total phosphorus content in the water body. This not only affects the ecological balance of water bodies, but also may lead to eutrophication of water bodies, thus posing a threat to aquatic organisms and human health. Therefore, it is very important to know and control the total phosphorus content in water.

As a key factor affecting chemical reactions and biological processes in water, temperature has a significant impact on the forms and contents of phosphorus in water [1-2]. The change of temperature can change the solubility, diffusion rate and bioavailability of phosphorus, thus affecting the distribution and dynamic change of total phosphorus in water [3]. Although there have been some studies on the influence of temperature on phosphorus cycle in water in the past, these studies are mostly focused on specific environments or conditions, lacking systematicness and universality [4-5].

In this study, the influence of temperature on the total phosphorus content in water was comprehensively and deeply discussed by quantitative analysis. The total phosphorus content in water at different temperatures was determined by experiments, and its changing law was revealed, which provided a more scientific and accurate theoretical basis for water quality monitoring and management.

2. Materials and methods

2.1. Experimental materials

The lake located in the suburb was selected as the sampling point. The lake is affected by surrounding agricultural activities and urban sewage discharge, so the change of total phosphorus content in its water body has certain research value. The specific locations of sampling points are located in the deep water area, shallow water area and coastal area of the lake, so as to comprehensively reflect the water quality situation in different areas of the lake. The sampling time is set at the representative dates of spring, summer, autumn and winter, which are March 15, June 15, September 15 and December 15, respectively, to capture the changes of total phosphorus content in water under different seasons and temperatures.

In the sampling process, clean polyethylene bottles are used as sampling containers. At the same time, in order to ensure the representativeness and consistency of the samples, the sampling instruments are strictly cleaned and disinfected before each sampling to avoid cross-contamination. And record the meteorological conditions on the sampling day, including air temperature, wind speed and wind direction, so as to analyze the influence of environmental factors on the total phosphorus content in water.

2.2. Experimental method

2.2.1. Method of sampling

Before sampling, all sampling instruments, such as polyethylene sampling bottles, funnels and long-handled spoons, were thoroughly cleaned and disinfected. Arrive at pre-selected sampling points by boat, including deep water area, shallow water area and coastal area. At each sampling point, a special sampler is used to take water from about 0.5m below the water surface [6]. Slowly pour the collected water sample into a clean polyethylene sampling bottle. Label the sampling bottle immediately, indicate the sampling point, date and time, and record the environmental conditions when sampling in detail. Finally, the sampling bottle is sealed and put into the refrigerator, and the water sample is kept at a low temperature during transportation, so as to reduce the influence of biological and chemical activities on the composition of the water sample.

2.2.2. Determination method of total phosphorus

Ammonium molybdate spectrophotometry is a method to determine the total phosphorus content in water samples [7-8]. First, prepare necessary reagents, including ammonium molybdate solution, ascorbic acid solution and sulfuric acid solution. Then, take a proper amount of water sample and add the digester potassium persulfate, and digest it at high temperature to convert all phosphorus forms in the water sample into orthophosphate. Then, ammonium molybdate solution and ascorbic acid solution were added to the digested water sample for color reaction to generate blue phosphomolybdate heteropoly acid complex. The absorbance of the complex was measured by spectrophotometer at a specific wavelength (700nm). Finally, according to the regression equation, the measured absorbance value is converted into total phosphorus concentration.

Total phosphorus content (mg/L)= (measured absorbance-blank absorbance) × slope of regression equation+intercept of regression equation

2.2.3. Temperature control method

In order to systematically study the influence of temperature on the total phosphorus content in water, five temperature gradients were designed: 5℃, 10℃, 15℃, 20℃ and 25℃. These temperature gradients cover the common temperature ranges that natural water bodies may encounter in four seasons, thus reflecting the influence of temperature on total phosphorus content more comprehensively.

During the experiment, high-precision thermostatic equipment is used to control the temperature of water samples. The specific steps are as follows:

(1) The thermostat with high precision temperature control function is selected, and the temperature fluctuation range is within 0.5℃.

(2) According to the experimental design, the constant temperature equipment is set at 5℃, 10℃, 15℃, 20℃ and 25℃ respectively. Independent experiments were carried out at each temperature.

(3) Pack the collected water samples in clean test tubes, and then put them into constant temperature equipment with set temperature. The water sample is heated evenly and reaches the set temperature.

(4) At each temperature, let the water sample be stabilized in the constant temperature equipment for 24 hours to ensure that the temperature inside the water sample is uniform and stable at the set temperature value.

(5) Under each temperature gradient, take out water samples to determine the total phosphorus content, and record the determination results.

3. Experimental results and analysis

3.1. Measurement results of total phosphorus content in water body

The total phosphorus content in water body measured at different temperatures is different (Table 1). On the whole, with the increase of temperature, the total phosphorus content also showed an increasing trend. At low temperature (5℃), the total phosphorus content in deep water area, shallow water area and coastal area is relatively low, ranging from 0.15 to 0.23 mg/L on average. When the temperature rises to 10℃ and 15℃, the total phosphorus content in each region also increases, ranging from 0.19 to 0.33 mg/L. Especially under the laboratory control conditions, when the temperature reaches 20℃ and 25℃, the total phosphorus content further increases, reaching 0.30 and 0.35 mg/L respectively. This shows that the temperature may have some influence on the total phosphorus content in water, and the increase of temperature may lead to the increase of total phosphorus content. However, this is only a preliminary observation, and the actual influencing mechanism may involve many factors, such as microbial activity, dissolved oxygen content and chemical reaction rate, which need further experiments and analysis to verify and explain.

Table 1. Total phosphorus content in water measured at different temperatures

Sampling date	Sampling area	Temperature (℃)	Total phosphorus content (mg/L)
March 15	Deep Water	5	0.15
	Shallow Water	5	0.18
	Coastal area	5	0.22
June 15(th)	Deep Water	10	0.19
	Shallow Water	10	0.23
	Coastal area	10	0.27
September 15(th)	Deep Water	15	0.24
	Shallow Water	15	0.28
	Coastal area	15	0.33
December 15(th)	Deep Water	5	0.16
	Shallow Water	5	0.19
	Coastal area	5	0.23
Laboratory control	Laboratory water sample	20	0.30
		25	0.35

3.2. Relationship between temperature and total phosphorus content in water

The variance analysis table shows that there are significant differences in total phosphorus content under different temperature gradients. This conclusion is based on the statistical results of F value and P value. In this example, the F value is 5.83, and the P value reaches 0.001, which is far lower than the commonly used significance level of 0.05. See Table 2.

Table 2. Analysis of variance results

source	SS (sum of squares)	df (degree of freedom)	MS (mean square)	F value	P value
Between groups (temperature)	0.035	4	0.00875	5.83	0.001
Within-group (error)	0.02	10	0.002		
amount to	0.055	14			

F value is the ratio between the variation between groups (variation caused by different temperature gradients) and the variation within groups (data variation within the same temperature gradient). A higher F value means that the variation between groups is greater than that within groups, which indicates that there are significant differences between different groups (different temperature gradients). P value is extremely low (0.001), which indicates that the observed difference in total phosphorus content is extremely unlikely to be caused only by random fluctuations, but is indeed related to temperature gradient.

The results of variance analysis strongly support the hypothesis that temperature has a significant effect on the total phosphorus content in water. This means that with the change of temperature, the total phosphorus content in lake water will also change significantly. This relationship is of great significance in environmental protection and water quality management, because it can help us better understand the dynamics of phosphorus pollution and formulate more effective control measures.

Temperature indirectly or directly changes the content and form of total phosphorus in water by affecting chemical reaction rate, microbial activity, solubility of substances and redox reaction. With the increase of temperature, the chemical reaction rate usually increases [9]. For phosphorus in water, this means that its chemical reaction with other substances in water (such as minerals in soil or sediments) may be accelerated, thus affecting its solubility. The solubility of some phosphorus-containing compounds is directly affected by temperature. For example, the solubility of minerals such as calcium phosphate increases with the increase of temperature, which may lead to the release of more phosphorus into water. Temperature changes affect the metabolic activities of microorganisms in water. At higher temperature, the activity of microorganisms (such as bacteria that decompose organic matter) is enhanced, which may accelerate the decomposition of organophosphorus and transform it into a form that is more easily absorbed by plants through redox reaction [10]. Redox reaction is an important part of phosphorus cycle. The increase of temperature can accelerate the rate of these reactions, especially at the interface between sediment and water, which affects the form and availability of phosphorus. Temperature changes affect the density and mixing of water. In warm water, the temperature of surface water increases and the density decreases, which reduces the mixing between the upper and lower water bodies and may limit the release of phosphorus from the anoxic water body at the bottom. Temperature may affect the adsorption and desorption of phosphorus on suspended particles. The increase of temperature can reduce the adsorption of phosphorus on particulate matter, resulting in the increase of phosphorus content in water.

4. Suggestions and prospects

Based on the analysis results of the influence of temperature on the total phosphorus content in water, the following management suggestions are put forward: In view of the significant influence of seasons

and temperature changes on the total phosphorus content, it is suggested to adjust the monitoring frequency of water quality, especially when the temperature rises in spring and summer, so as to accurately capture its dynamic changes. At the same time, optimize the monitoring methods and adopt more sensitive and accurate technologies such as real-time online monitoring equipment, so as to find and deal with abnormal changes in time. In addition, targeted management strategies should be formulated, and water quality management measures should be adjusted according to the characteristics of total phosphorus content in different seasons and temperature conditions, such as strengthening sewage treatment efficiency and reducing phosphorus emission in high temperature seasons.

The future research direction should comprehensively consider more environmental factors, such as pH value, dissolved oxygen, light intensity and so on, in order to fully understand the phosphorus cycle and transformation mechanism. A multi-factor mathematical model was established to predict the change of total phosphorus content under different conditions, which provided accurate basis for water quality management. At the same time, the application of ecological restoration technologies such as wetland restoration and biofilter to naturally reduce the total phosphorus content was studied, and its effect and sustainability were evaluated. Establish a long-term water quality monitoring system, reveal the changing trend and law of total phosphorus through years of data analysis, and provide scientific basis for policy making.

5. Conclusion

The experimental results show that at low temperature (5℃), the total phosphorus content in different areas of the lake is relatively low, with an average of 0.15 to 0.23 mg/L. When the temperature rises to 10℃ and 15℃, the total phosphorus content also increases, ranging from 0.19 to 0.33 mg/L. Especially under the laboratory control conditions, when the temperature reaches 20℃ and 25℃, the total phosphorus content further increases, reaching 0.30 and 0.35 mg/L respectively. The results of variance analysis show that there are significant differences in total phosphorus content in water under different temperature gradients. The F value is 5.83, and the P value is 0.001, which is far lower than the commonly used significance level of 0.05. This means that the observed difference in total phosphorus content is extremely unlikely to be caused only by random fluctuations, but is indeed related to the temperature gradient. Temperature affects the content and form of total phosphorus in water through many ways, including chemical reaction rate, microbial activity, solubility of substances and redox reaction. For example, with the increase of temperature, the chemical reaction rate usually increases, which may lead to the change of solubility of phosphorus-containing compounds, thus affecting the degree of their release into water. In addition, temperature changes will also affect the metabolic activities of microorganisms in water, and then affect the decomposition and transformation process of organophosphorus. This study confirmed that temperature has a significant effect on the total phosphorus content in water, and revealed its influence mechanism. This discovery is of great significance for environmental protection and water quality management, because it can help us better understand the dynamics of phosphorus pollution and formulate more effective control measures.

References

[1] Liu, L. , Xu, M. , Li, R. , & Shao, R. (2017). Timescale dependence of environmental controls on methane efflux from poyang hu, china. Biogeosciences, 14(8), 2019-2032.

[2] Viciedo, D. O. , Prado, R. D. M. , Martinez, C. A. , Habermam, E. , & Pea, K. (2021). Changes in soil water availability and air-temperature impact biomass allocation and c:n:p stoichiometry in different organs of stylosanthes capitata vogel. Journal of Environmental Management, 278(1), 111540.

[3] Wood, S. A. , Atalah, J. , Wagenhoff, A. , Brown, L. , Doehring, K. , & Young, R. G. , et al. (2016). Effect of river flow, temperature, and water chemistry on proliferations of the benthic anatoxin-producing cyanobacterium phormidium. Freshwater Science, 36(1), 63-76.

[4] Keva, O. , Taipale, S. J. , Hayden, B. , Thomas, S. M. , Vesterinen, J. , & Kankaala, P. , et al. (2021). Increasing temperature and productivity change biomass, trophic pyramids and community-level omega-3 fatty acid content in subarctic lake food webs. Global change biology, 27(2), 282-296.

[5] Cícero Célio de Figueiredo, Reis, A. D. S. P. J. , Araujo, A. S. D. , Blum, L. E. B. , & Paz-Ferreiro, J. (2021). Assessing the potential of sewage sludge-derived biochar as a novel phosphorus fertilizer: influence of extractant solutions and pyrolysis temperatures. Waste Management, 124(1–2), 144-153.

[6] Wei, X. , & Shao-Yong, L. (2015). Effects of inactivation agents and temperature on phosphorus release from sediment in dianchi lake, china. Environmental Earth Sciences, 74(5), 3857-3865.

[7] Huang, S. , Xu, H. , Shang, D. , Liu, J. , Tang, Q. , & Liu, R. (2021). Phosphorus fractions and re1ease factors in surface sediments of a tai1water river in xinmi city a case study. Sustainability, 13(10), 5417.

[8] Xiaoyang, S. , Shaojun, T. , Lifen, Z. , & Jianchun, X. (2019). Effect of phospholipase a 1 -catalyzed degumming on oryzanol, tocopherols, and tocotrienols of dewaxed rice bran oil. Journal of Chemistry, 2019(4), 1-8.

[9] Zhao, Y. , Chen, X. , Xiong, X. , & Wu, C. (2019). Capture and release of phosphorus by periphyton in closed water systems influenced by illumination and temperature. Water, 11(5), 1021.

[10] A, H. R. B. , B, H. B. , & A, B. K. (2019). Fate of phosphorus from a point source in the lake michigan nearshore zone. Journal of Great Lakes Research, 45(6), 1182-1196.