

Study on Water Purification of Freshwater Aquaculture Pond based on Correlation Analysis

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Abstract: Nowadays, pond culture is the main form of freshwater culture in China. However, with the aggravation of water pollution and eutrophication of freshwater ecosystem, it is easy to cause pond water bloom. Water bloom will not only reduce the biodiversity of ponds, but also consume dissolved oxygen and produce toxic and harmful substances, which is of great harm to pond aquaculture. By studying the relationship between the main physical and chemical factors in freshwater aquaculture ponds, this paper studies the causes of water bloom, so as to improve the yield of pond culture and enhance everyone's awareness of environmental protection.

Keywords: Pond Aquaculture; Water Bloom; Physical and Chemical Factors; Pearson Correlation Coefficient.

1. Background

Freshwater aquaculture technology refers to the production of aquatic economic animals (fish, shrimp, crab, shellfish, etc.) and aquatic economic plants by using ponds, reservoirs, lakes, rivers and other inland waters (including brackish water), which is an important part of inland aquatic industry [1]. Freshwater aquaculture has a long history in China, which has played an important role in changing the rural economic structure, promoting the development of national economy and improving people's living standards. Judging from the composition of aquaculture area, at present, the freshwater aquaculture area in China far exceeds that of marine aquaculture. By 2020, the freshwater aquaculture area in China will be 5040.56 thousand hectares, accounting for 71.6% of the total area, and its significance is self-evident [2]. Especially after China's reform and opening up, freshwater aquaculture has entered a new era. Breeding varieties increased, breeding area expanded, and breeding mode was constantly innovated. The progress of science and technology and the development of fishery production have made China's freshwater aquaculture industry develop unprecedentedly [3]. The total output of aquatic products and freshwater fish has

always ranked first in the world. China's freshwater aquaculture is developing towards pollution-free aquaculture and healthy aquaculture [4].

2. Bloom Phenomenon in Freshwater Aquaculture Ponds

Water bloom, also known as algal bloom, is a natural phenomenon of sudden excessive proliferation of algae due to excessive nitrogen and phosphorus content in water, and the water surface often appears blue, red, brown, milky white and so on [5]. The main reason is that after the wastewater containing a lot of nitrogen and phosphorus in life and industrial and agricultural production enters the water body, algae multiply in large numbers and become the dominant population in the water body, which eventually leads to the phenomenon of water bloom [6]. "Water bloom" mainly occurs in static water bodies, especially in fish ponds and stagnant internal rivers. The appearance of water bloom phenomenon will not only reduce the biodiversity of water body, consume dissolved oxygen in water body, but also produce toxic substances and odor, which will have a bad impact on aquaculture and human drinking water safety [7].

Table 1. Physical and Chemical Factor Data of Monitoring Point A in Pond 1

Pool number	Number of weeks	Total phosphorus			Phosphate phosphorus			total nitrogen		
		pond water	interstitial water	bottom mud	pond water	interstitial water	bottom mud	pond water	interstitial water	bottom mud
Pond 1A monitoring point	1	4.9588	5.1649	0.0404	0.0138	0.0164	0.0383	1.2726	6.6161	0.0876
	2	2.1237	7.3299	0.0285	0	0.0052	0.0201	1.1688	6.5437	0.1042
	3	1.9691	8.8763	0.0385	0.0048	0.0358	0.0367	0.497	6.6253	0.12
	4	1.7629	10.1134	0.0386	0.0024	0.0361	0.0372	1.2726	5.8749	0.0987
	5	1.7113	7.0206	0.0401	0.003	0.0409	0.0324	1.0882	5.9647	0.1147
	6	1.9691	6.5567	0.0403	0.0042	0.0284	0.0409	0.7917	4.8684	0.1109
	7	1.5052	5.5258	0.0233	0.0028	0.0332	0.0449	0.4489	3.8953	0.0731
	8	3.7216	4.0309	0.0403	0.0103	0.0333	0.0474	1.3015	4.9892	0.0821
	9	6.0928	4.5979	0.0404	0.027	0.0214	0.0408	2.1992	4.5096	0.084
	10	3.2577	8.4124	0.0319	0.0098	0.0254	0.051	1.1472	4.6899	0.0831
	11	3.5155	8.7732	0.0393	0.0065	0.2089	0.0516	1.739	4.6726	0.1313
	12	5.3196	3.2577	0.0394	0.0178	0.0171	0.0419	1.0701	4.6334	0.1317
	13	6.4536	7.0206	0.0431	0.03	0.017	0.0431	1.696	6.6643	0.1531
	14	7.0722	6.9691	0.0422	0.034	0.2058	0.0503	2.0101	6.9525	0.162
	15	7.7938	6.4021	0.0482	0.0463	0.2149	0.0507	1.4823	6.1152	0.1571

In order to study the relationship between the main physical and chemical factors (total phosphorus, phosphate phosphorus, total nitrogen, nitrate nitrogen, nitrous nitrogen and ammonium nitrogen) in freshwater aquaculture ponds, we chose to monitor the contents of six physical and chemical factors in pond water, interstitial water and sediment for 15 weeks, and set up two monitoring points in each pond to avoid accidental data. Table 1 shows the contents of total

phosphorus, phosphate phosphorus and total nitrogen in pond water, interstitial water and sediment at monitoring point A in pond 1 for 15 weeks.

Table 2 shows the contents of nitrate nitrogen, nitrous nitrogen and ammonium nitrogen in pond water, interstitial water and sediment at monitoring point B in pond 2 for 15 weeks.

Table 2. Physical and Chemical Factor Data of Monitoring Point B in Pond 2

Pool number	Number of weeks	nitrate nitrogen			Nitrous nitrogen			ammonium nitrogen		
		pond water	interstitial water	bottom mud	pond water	interstitial water	bottom mud	pond water	interstitial water	bottom mud
Monitoring point of pond 2B	1	0.08	0.1856	0.9142	0.005	0.0244	1.1553	0.5841	6.0239	17.2733
	2	0.0112	0.142	1.4125	0.0285	0.0265	2.7278	0.2408	7.9521	25.6943
	3	0.041	0.0298	0.6041	0.0497	0.0234	12.2989	0.0957	5.7882	11.6788
	4	0.0234	0.0196	0.4783	0.0216	0.0414	13.7867	0.1731	4.1683	22.3728
	5	0.2874	0.0075	0.5293	0.0377	0.0115	0.1162	0.6784	9.4125	28.7188
	6	0.3641	0.2704	0.145	0.1548	0.0184	0.0712	1.3361	13.0996	29.0591
	7	0.0701	1.6064	3.3623	0.073	0.4337	3.6167	0.6736	2.5907	10.1387
	8	0.0967	0.6188	0.8172	0.044	0.3651	3.8704	0.7558	3.1951	13.4509
	9	0.0662	0.0067	2.1765	0.1212	0.0165	2.9758	1.5174	2.7357	9.4078
	10	0.0527	0.0224	1.8182	0.0647	0.0101	7.6679	1.2418	2.4094	9.41
	11	0.0892	0.0534	0.4228	0.1728	0.0105	1.7838	0.6712	7.4142	14.2891
	12	0.653	0.0151	1.2493	0.4443	0.0096	2.2796	0.3837	2.6269	24.4452
	13	0.5733	0.0242	0.4448	0.7696	0.0198	0.9384	0.5745	3.6545	22.9404
	14	0.303	0.0142	0.7427	0.0689	0.0119	1.0619	0.485	8.883	24.3476
	15	0.2973	0.0234	1.0439	0.2641	0.0092	1.064	0.4487	5.0085	14.2944

In this paper, the data unit of pool water and interstitial water is mg L⁻¹, and the data unit of sediment nutrients is mg kg⁻¹ except for total phosphorus and total nitrogen.

3. The Relationship between the Main Physical and Chemical Factors in the Pond

3.1. Pearson Correlation Coefficient (PCC) Method

Pearson Correlation Coefficient is a statistical method that can quantitatively measure the correlation between variables [8]. Pearson correlation coefficient is essentially a linear correlation coefficient, which describes the linear correlation between variables. The greater the absolute value of Pearson correlation coefficient, the stronger the linear correlation between variables, that is, the closer Pearson correlation coefficient is to 1 or -1, the stronger the linear correlation between variables. On the contrary, if Pearson correlation coefficient is closer to 0, the weaker the linear correlation between variables [9].

Pearson correlation coefficient is calculated as follows:

$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{N})(\sum Y^2 - \frac{(\sum Y)^2}{N})}} \quad (1)$$

Where the variable X is the set of X coordinates of all points, the variable Y is the set of Y coordinates of all points, and n represents the total number of all points. According to formula (1), this is the ratio of covariance to the product of standard deviation of two variables, which is dimensionless and standardized covariance.

3.2. Data Scatter Plot

In this paper, all the data of two monitoring points in each pond are averaged to avoid the influence of accidental data on

the research. Interstitial water, also known as free water, is water that can move without being absorbed by soil particles in the interstitial space of soil or water body. Considering that the material exchange between adjacent layers in water is more intensive, this paper only studies the relationship between physical and chemical factors between adjacent layers of water.

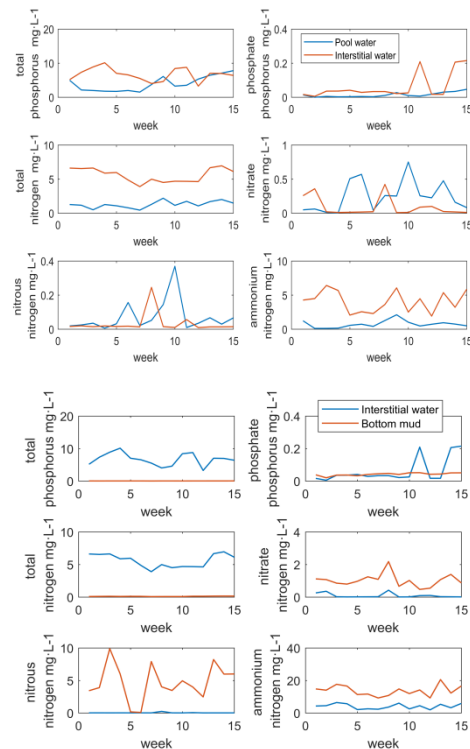


Fig 1. Relationship Diagram of Physical and Chemical Factors of No.1 Pool

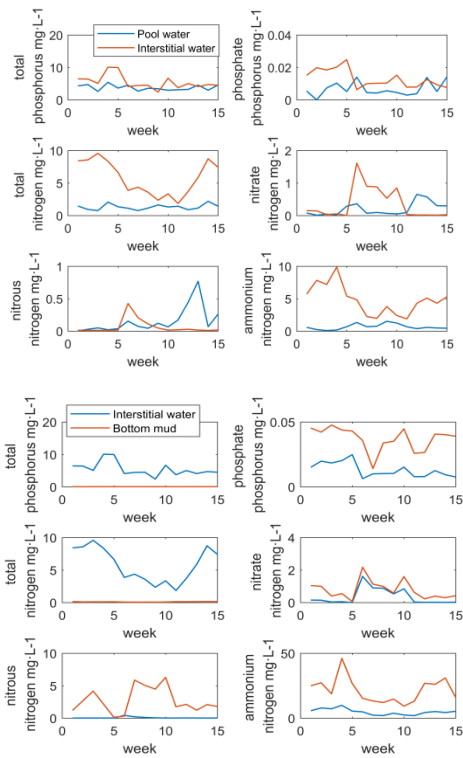


Fig 2. Relationship Diagram of Physical and Chemical Factors of No.2 Pool

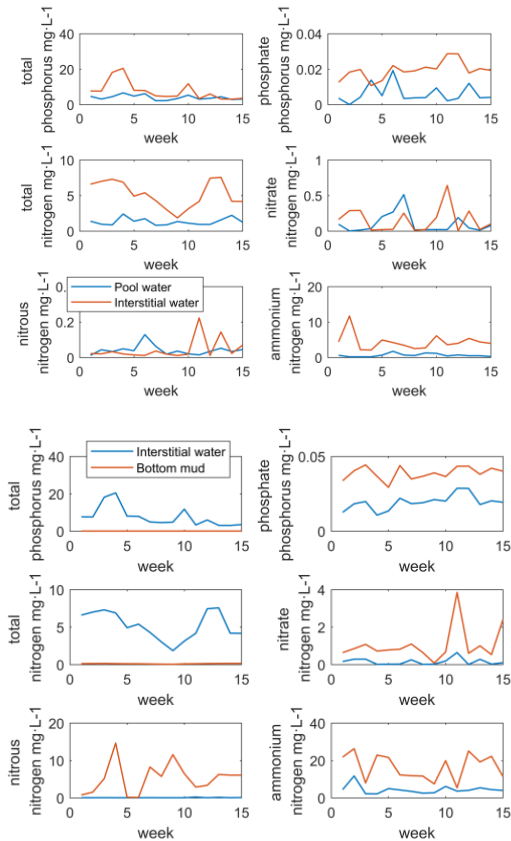


Fig 3. Relationship Diagram of Physical and Chemical Factors of No.3 Pool

By observing scatter charts 1, 2, 3 and 4, it can be seen that there is no obvious correlation between the physical and chemical factors of most ponds in pool water and interstitial water, but the physical and chemical factors of total nitrogen

in pool 1 and nitrous nitrogen in pool 4 have similar changing trends. There is no obvious correlation between total phosphorus and nitrous nitrogen in interstitial water and sediment, but the four physical and chemical factors of phosphate phosphorus, total nitrogen, nitrate nitrogen and ammonium nitrogen have similar changing trends.

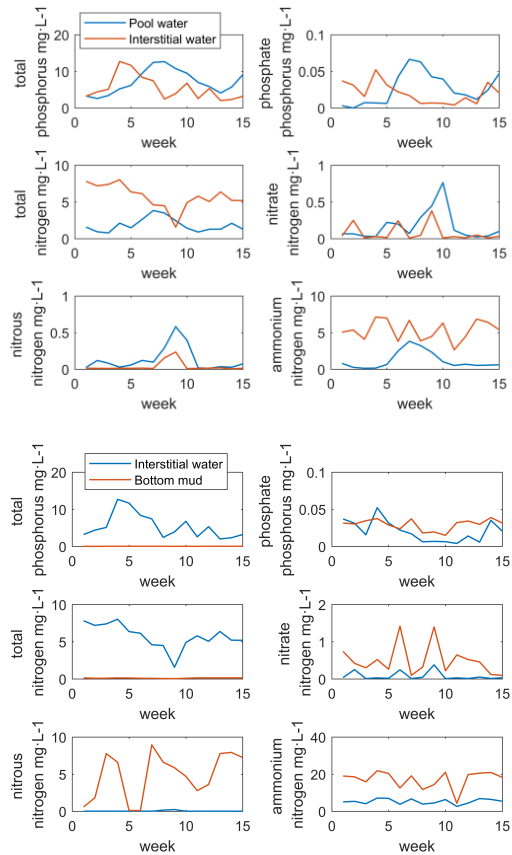


Fig 4. Relationship Diagram of Physical and Chemical Factors of No.4 Pool

4. Correlation Research

4.1. Study on the Correlation between Physical and Chemical Factors in Pool Water and Interstitial Water

As shown in Table 3, after calculating the Pearson correlation coefficient of six physical and chemical factors in pool water and interstitial water, it is found that the physical and chemical factors of phosphate and phosphorus in interstitial water are highly correlated, and the physical and chemical factors of total phosphorus in interstitial water are also highly correlated, while the physical and chemical factors of phosphate and phosphorus in interstitial water and total phosphorus in pool water have only a certain correlation. In addition, the physical and chemical factors of ammonium and nitrate in interstitial water are also highly correlated. In a word, there is no obvious correlation between the six physical and chemical factors in pool water and interstitial water. It is mainly because there are many factors that interfere with the content of physical and chemical factors in pond water during pond culture. Fertilizer, rainfall and the number of cultivated plants will all affect the content of physical and chemical factors in pond water.

Table 3. Pearson correlation coefficient of six physical and chemical factors in pond water and interstitial water

R value /P value	Total phosphorus in pond water	Phosphate phosphorus in pool water	Total nitrogen in pond water	Nitrate nitrogen in pool water	Nitrous nitrogen in pool water	Ammonium nitrogen in pond water
Total phosphorus in interstitial water	-0.3815/0.1606	-0.2919/0.2912	-0.0807/0.7748	0.0223/0.9371	0.0709/0.8017	-0.5886/0.0210**
Phosphorus phosphate in interstitial water	0.4689/0.0779*	0.5186/0.0476**	0.4357/0.1045	-0.1742/0.5348	-0.2005/0.4737	-0.1870/0.5046
Total nitrogen in interstitial water	0.2581/0.3531	0.2668/0.3364	0.1728/0.5379	-0.2761/0.3192	-0.3457/0.2069	-0.2830/0.3068
Nitrate nitrogen in interstitial water	-0.0955/0.7349	-0.2543/0.3603	-0.0253/0.9288	-0.2456/0.3775	-0.2533/0.3624	0.0853/0.7624
Nitrous nitrogen in interstitial water	-0.0583/0.8365	-0.1216/0.6660	0.0562/0.8423	0.0003/0.9992	-0.1065/0.7055	0.2358/0.3976
Ammonium nitrogen in interstitial water	0.2683/0.3335	0.3081/0.2638	0.3316/0.2273	-0.4650/0.0807*	-0.2019/0.4706	0.0145/0.9590

(Note: ***p<0.01, **p<0.5, *p<0.1)

4.2. Correlation between Interstitial Water and Physical and Chemical Factors in Sediment

Table 4. Pearson correlation coefficient between interstitial water and six physical and chemical factors in sediment

R value /P value	Total phosphorus in interstitial water	Phosphorus phosphate in interstitial water	Total nitrogen in interstitial water	Nitrate nitrogen in interstitial water	Nitrous nitrogen in interstitial water	Ammonium nitrogen in interstitial water
Total phosphorus in sediment	-0.0783/0.7816	0.4305/0.1092	0.3949/0.1452	-0.1654/0.5557	0.0970/0.7308	0.3658/0.1800
Sediment phosphate phosphorus	-0.0825/0.7701	0.5833/0.0225**	-0.3470/0.2051	-0.3263/0.2353	0.2106/0.4511	-0.1044/0.7113
Total nitrogen in sediment	0.1612/0.5660	0.6387/0.0104**	0.5228/0.0456**	-0.3238/0.2391	-0.2674/0.3354	0.1774/0.5269
Nitrate nitrogen in sediment	-0.2804/0.3114	-0.1279/0.6498	0.1319/0.6394	0.5555/0.0316**	0.7218/0.0024***	-0.2246/0.4210
Nitrous nitrogen in sediment	0.3356/0.2214	0.1256/0.6556	0.2688/0.3326	-0.1917/0.4938	-0.0890/0.7523	0.5228/0.0456**
Ammonium nitrogen in sediment	0.4800/0.0702**	0.0869/0.7582	0.6063/0.0166**	-0.1841/0.5112	-0.2315/0.4065	0.8629/0.0000***

As shown in Table 4, after calculating Pearson correlation coefficient between interstitial water and six physical and chemical factors in sediment, it is found that there are significant correlations between interstitial water and physical and chemical factors of nitrate nitrogen and ammonium nitrogen in sediment. However, the physical and chemical factors such as total phosphorus in interstitial water and sediment ammonium nitrogen, phosphate phosphorus in interstitial water and sediment phosphate phosphorus, total nitrogen in interstitial water and sediment nitrogen, total nitrogen in interstitial water and sediment ammonium nitrogen, nitrate nitrogen in interstitial water and sediment nitrate nitrogen, ammonium nitrogen in interstitial water and sediment nitrous nitrogen all have great correlation, while the rest of interstitial water has no obvious correlation with the physical and chemical factors in sediment.

5. Summary and Prospect

In this paper, the relationship between six physical and chemical factors, including total phosphorus, phosphate

phosphorus, total nitrogen, nitrate nitrogen, nitrous nitrogen and ammonium nitrogen, in pond water, interstitial water and sediment was mainly studied. By analyzing the Pearson correlation coefficient of physical and chemical factors between pond water and interstitial water and sediment, it was found that there was basically no correlation between physical and chemical factors between pond water and interstitial water, mainly because there were many factors that interfered with the content of physical and chemical factors in pond water. However, the physical and chemical factors between interstitial water and sediment have certain correlation. In the future, we will study and establish the model of the relationship between the main physical and chemical factors and the damage density of common plankton, and give the range of the main physical and chemical factors when the water bloom occurs, so as to predict the occurrence of water bloom in freshwater aquaculture ponds, so as to achieve the purpose of improving the aquaculture yield in ponds, and also hope to strengthen everyone's awareness of environmental protection.

References

- [1] Song Chao, Meng Shunlong, Fan Limin, et al. Environmental problems and countermeasures of freshwater pond culture in China [J]. *chinese agricultural science bulletin*, 2012, 28(26):4.
- [2] Liu Xianqun, Cheng Huihui. Problems and suggestions for improvement of circulating water culture in ponds [J]. *Guide to Fishery Enrichment*, 2021(4):16-18.
- [3] Hu Gengdong, Song Chao, Chen Jiachang, et al. Construction of pond circulating aquaculture model and its removal effect on nitrogen and phosphorus [J]. *Journal of Ecology and Rural Environment*, 2011,27(3):82-86.
- [4] Song Chao, Chen Jiachang, Ge Xianping, et al. Control of nitrogen and phosphorus in tilapia pond water by floating bed cultivation of water spinach [J]. *chinese agricultural science bulletin*, 2011,27(23):70-75.
- [5] Li Linlin, Lu Shaoyong, Meng Wei, et al. Eutrophication and prevention of key lakes in the Yangtze River basin [J]. *Science and Technology Herald*, 2017, 35(9):10.
- [6] Kong Fanxiang, Gao Guang. Thoughts on the formation mechanism of cyanobacteria bloom in large shallow eutrophic lakes [J]. *Journal of Ecology*, 2005, 25(3):7.
- [7] Fan Xiang, Kong, Ronghua, et al. Theory and practice of prevention, prediction and early warning of cyanobacteria bloom in Taihu Lake [J]. *Lake Science*, 2009(3):15.
- [8] Zhang Jianyong, Gao Ran, Hu Jun, et al. Comparison of the application of grey correlation degree and Pearson correlation coefficient [J]. *Journal of Chifeng University: Natural Science Edition*, 2014, 30(21):2.
- [9] Zhang Yulei, Dang Yan, He Pingan. Quantitative analysis of biological relationship by Pearson correlation coefficient [J]. *Computer Engineering and Application*, 2005, 41(33):5.