

NUTRIENT ASSESSMENT OF SEDIMENTS OF CARP FISH PONDS

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PROCENA NUTRIJENATA U SEDIMENTU ŠARANSKOG RIBNJAKA

Abstract

The aim of this study is related with the characterization of chemical parameters of organic nitrogen and biogenic elements in sediments of carp ponds, permitting an assessment of their nutritional value.

A vertical differentiation was established in the levels of the surveyed chemical indicators of the sediments. In the 0 cm - 15 cm horizon the content of organic nitrogen is on average 47.95% higher, and that of ammonium and nitrate ions is on average of 34% - 37.85% higher compared to that registered in the 15 cm - 30 cm horizon. The content of phosphate ions is 13.1% higher in 15 cm - 30 cm horizon in comparison with the 0 cm - 15 cm horizon.

Based on the reported levels of organic nitrogen, soluble inorganic forms of nitrogen and phosphorus, the reserve of bottom sediments is determined as average to good. This characterizes them as a natural source of nutrients with the possibility of their integration in agriculture.

Key words: fish ponds, sediments, organic nitrogen, soluble inorganic forms of nitrogen, soluble inorganic forms of phosphorus

INTRODUCTION

In fish ponds, the bottom sediments are a natural biological product, formed during their long term exploitation. As a result of allochthonous and autochthonous organic

matter mineralization and technology used in fish farming, they form different in chemical composition and quantity slime layer.

Bottom sediments are rich in organic matter, nitrogen, phosphorus, potassium and other macro and micro biogenic elements accumulated in fish ponds during the vegetation period (Briggs and Funge-Smith, 1994; Hopkins et al., 1994; Krom et al., 1985; Smith, 1996; Jamu and Piedrahita, 2001; Boyd et al., 2002). In China, Thailand and Vietnam, the pond sediments are used in agriculture as fertilizer for the field crops, whereas higher yields have been recorded (Little and Muir, 1987; Prein, 2002).

The integration of aquaculture with agriculture is not widespread yet, due to the lack of scientific researches in this field (Hopkins and Bowman, 1993; Lin and Yi, 2003). In most cases the fish is taken as the only product of fish ponds and the role of fish pond water and bottom sediments is neglected (Brankeret, 1979; Little and Muir, 1987; Pillay, 1994).

In this context, the aim of this study is related with the characterization of chemical parameters of organic nitrogen and biogenic elements in sediments of carp ponds, permitting an assessment of their nutritional value.

MATERIAL AND METHODS

The study was conducted in carp ponds, situated in the Experimental Base of the Institute for Fisheries and Aquaculture, Plovdiv, which have different characteristics in terms of the area size. A traditional technology for growing warm-water fish species in polyculture is applied. The scheme is shown in Table 1.

Taking of samples was carried out during 2009 vegetation season, whereas the sediment samples are taken once per month by applying the modified version of the Kachinski probe from 2 horizons at a depth of 0-15 cm and 15-30 cm. The analysis of the sediments include the determination of organic nitrogen (%) by the Kijeldahl method after selenium mineralization by using VELP - Scientifica semiautomatic analysis system type DK-6 for decomposition and UDK - 132 for distillation; of nitrogen's mobile forms, determined spectrophotometrically during their preliminary extraction from the soil solution of KCl; of phosphorus' inorganic forms, determined according to double-lactate method of Egner-Reem (Tomov et al, 1999). The data were statistically analyzed using the Microsoft Office 2007.

Table 1. Scheme of study

Pond No	Area, ha	Type of farmed fish
8	0.38	Common Carp, Silver Carp
28	2.4	Common Carp, Silver Carp, Grass Carp
29	7.0	Common Carp, Grass Carp, Silver Carp, Northern Pike, Wels

RESULTS AND DISCUSSION

Data obtained by surveys of the organic nitrogen (**ON**) content in bottom sediments of the examined fish ponds in 0 cm - 15 cm and 15 cm - 30 cm horizons are shown in **Table 2**. In the period 31.03.- 06.10.2009, the variation in the values of the ON in 0 cm - 15 cm horizon is 0.2198 % to 0.4252 % with average seasonal value of 0.3264 %, while

in 15 cm - 30 cm horizon - respectively 0.0979 % to 0.2759 % with average seasonal value of 0.1699 %. In the surveyed ponds is reported trend of higher values of the organic nitrogen content in the bottom sediments in 0 cm -15 cm horizon - average 47.95 percent, compared with those reported for 15 cm - 30 cm horizon. In seasonal aspect is determined gradual increase in the organic nitrogen level up to August, with pronounced peaks in pond 8 and pond 29.

The research results on nitrogen soluble inorganic forms in the bottom sediments of the surveyed fish ponds are shown in **Table 3**.

N-NH₄. The variation in the values of N-NH₄ in pond 8 at 0 cm - 15 cm horizon is 42.5 mg.kg⁻¹ to 76.25 mg.kg⁻¹, with average seasonal value of 61.67 mg.kg⁻¹, and at 15 cm - 30 cm horizon - respectively 11.25 mg.kg⁻¹ to 68.75 mg.kg⁻¹, with average seasonal value of 38.33 mg.kg⁻¹. In the surveyed ponds is recorded a trend of higher values of the content of ammonium ions in the bottom sediments of 0 cm - 15 cm horizon on average 37.85 %, compared with those reported for 15 cm - 30 cm horizon. In pond 28 and pond 29 the average seasonal levels of ammonium ions are lower than those recorded in pond 8 with 43.4 % - 66.73 % for 0 cm - 15 cm horizon and by 64.57% - 72.65% for the 15 cm - 30 cm horizon. Their absolute values vary from 6.25 mg.kg⁻¹ to 58.75 mg.kg⁻¹ for 0 cm -15 cm horizon and 3.75 mg.kg⁻¹ to 33.75 mg.kg⁻¹ for the 15 cm - 30 cm horizon. In the seasonal aspect is established a gradual increase in the level of ammonium nitrogen from June to August, whereas they are very specific for the different ponds.

Table 2. Average values of organic nitrogen (%) in sediments of the fish ponds in 0 cm - 15 cm and 15 cm - 30 cm horizons

2009	n=3	Pond 8		Pond 28		Pond 29	
months	horizons	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
April	X	0,304	0,1399	0,4019	0,1775	0,3926	0,21
	Sx	0,0031	0,0001	0	0	0,0001	0,0034
	Cv	1,46	0,11	0	0,03	0,04	2,29
June	X	0,2663	0,1493	0,317	0,1354	0,3145	0,1743
	Sx	0,0035	0	0,0004	0,0029	0,0036	0,0042
	Cv	1,88	0	0,19	2,99	1,63	3,38
July	X	0,2991	0,1801	0,3223	0,0981	0,3691	0,2148
	Sx	0	0,0004	0,0032	0,0033	0,0033	0
	Cv	0,02	0,33	1,4	4,79	1,26	0,03
August	X	0,3691	0,2148	0,2997	0,1307	0,4252	0,2293
	Sx	0,0033	0	0,0252	0,0001	0,0034	0,0034
	Cv	1,26	0,03	11,89	0,13	1,14	2,07
September	X	0,285	0,182	0,2198	0,1166	0,383	0,2759
	Sx	0,0034	0,0035	0,0033	0,0034	0,0001	0,0033
	Cv	1,68	2,72	2,12	4,12	0,05	1,7
October	X	0,3269	0,1635	0,229	0,0979	0,3503	0,1678
	Sx	0,0068	0,0034	0,0033	0,0032	0,0033	0,0001
	Cv	2,92	2,91	2,03	4,65	1,34	0,09

N-NO₃. The variation in the values of N-NO₃ in pond 8 at 0 cm - 15 cm horizon is 5.14 mg.kg⁻¹ to 17.56 mg.kg⁻¹, with average seasonal value of 10.35 mg.kg⁻¹, and at 15 cm - 30 cm horizon - respectively 1.22 mg.kg⁻¹ to 16.37 mg.kg⁻¹, with average seasonal value of 6.83 mg.kg⁻¹. In the surveyed ponds is recorded a trend of higher values of the content of nitrate ions in the bottom sediments of 0 cm - 15 cm horizon on average by 34% compared with those reported for 15 cm - 30 cm horizon. Similar trend of nitrates reduction in depth is reported in Bharmal and Laurent (2004) research. For pond 28 and pond 29 the absolute values vary from 1.49 mg.kg⁻¹ to 8.19 mg.kg⁻¹ for 0 cm - 15 cm horizon and by 1.08 mg.kg⁻¹ to 5.06 mg.kg⁻¹ for the horizon 15 cm - 30 cm. In the seasonal aspect is established a gradual increase in the level of nitrogen nitrate in June (pond 8) and July-August (ponds 28 and 29), whereas they are very specific for the different ponds.

The research results on soluble inorganic forms of phosphorus (**P-PO₄**) in bottom sediments of the surveyed fish ponds are shown in **Table 3**. The variation in the values of phosphate phosphorus in the 0 cm - 15 cm horizon is from 15.0 mg.100g⁻¹ to 105.5 mg.100g⁻¹ sediment with average seasonal value of 50.31 mg.100g⁻¹ and at 15 cm - 30 cm horizon - respectively 20.13 mg.100g⁻¹ to 115.0 mg.100g⁻¹, with average seasonal value of 57.91 mg.100g⁻¹. A trend of higher values of the content of phosphate ions in bottom sediments is recorded for 15 cm - 30 cm horizon on average by 13.1% compared to the 0 cm - 15 cm horizon. This pattern is probably a consequence of the higher level of organic matter in this layer, the mineralization of which releases phosphates.

In a seasonal aspect is monitored natural increase of phosphate phosphorus with registered characteristic peaks in August at 15 cm - 30 cm horizon for pond 8 and in the entire analyzed horizon for the other two ponds. There are specific relations between the horizons in the sediments of the surveyed ponds in the period from July to August for pond 8, August to September for pond 28 and pond 29.

Given that the bulk of nitrogen in the soil (98% - 99% of its total volume) is represented by organic compounds, it is essential to help their mineralization for the purpose of release the accessible forms of the nitrogen. Thus they are included in the natural food chain in the ponds (Tomov et al, 1999). In fresh deposits, for as such could be considered bottom sediments of fish ponds, a large part of organic nitrogen gets mineralized in depositions through nitrification and denitrification (Bharmal and Laurent, 2004).

Summarizing the results of the concentration of soluble inorganic forms of nitrogen and phosphorus indicated that the content of ammonium and nitrate ions in bottom sediments of operational fish farming ponds at the 0 cm - 15 cm horizon is on average 34% - 37.85% higher compared with that recorded in 15 cm - 30 cm horizon. The dynamics of the nitrate nitrogen content follows that of the ammonium nitrogen, especially regarding the 0 cm - 15 cm horizon, whereas the concentration of the ammonium forms is higher than nitrate forms.

The content of phosphate ions in the 15 cm - 30 cm horizon is on average 13.1% higher - than that recorded in 0 cm - 15 cm horizon. Overall the reserve of the ponds in the analyzed 0 cm - 30 cm horizon is determined as good (Tomov et al, 1999).

Table 3. Average values of soluble inorganic forms of nitrogen ($\text{mg}\cdot\text{kg}^{-1}$) and phosphorus ($\text{mg}\cdot 100\text{ g}^{-1}$) in sediments of the fish ponds in 0 cm - 15 cm and 15 cm - 30 cm horizons

2009		Pond 8		N-NH ₄ , mg.kg ⁻¹		N-NO ₃ , mg.kg ⁻¹		P-PO ₄ , mg/100 g	
months	horizons	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
April		53,75	36,25	12,8	8,63	22,50	32,50		
June		42,5	18,75	10,12	4,47	21,25	37,63		
July		73,75	68,75	17,56	16,37	105,50	52,00		
August		76,25	51,25	8,25	5,55	15,00	93,75		
September		76,25	11,25	8,25	1,22	26,25	32,63		
October		47,5	43,75	5,14	4,74	42,63	52,63		
Average of season	X	61,67	38,33	10,35	6,83	38,85	51,19		
	Sx	6,93	9,47	1,9391	2,3435	15,18	10,37		
	Cv	25,14	55,25	41,88	76,72	33,94	23,18		
		Pond 28		N-NH ₄ , mg.kg ⁻¹		N-NO ₃ , mg.kg ⁻¹		P-PO ₄ , mg/100 g	
months	horizons	0 - 15 cm	15 - 30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
April		11,25	8,75	2,68	2,08	33,75	39,50		
June		23,75	21,25	5,66	5,06	45,00	77,50		
July		32,5	10,63	7,74	2,53	37,00	58,75		
August		33,12	6,25	7,88	1,49	87,00	115,00		
September		6,25	5,63	1,49	1,34	62,50	41,25		
October		16,25	11,25	1,67	1,22	65,00	40,20		
Average of season	X	20,52	10,63	4,52	2,29	55,04	62,03		
	Sx	4,98	2,5368	1,3213	0,6469	9,07	13,37		
	Cv	54,29	53,38	63,36	63,26	20,28	29,91		
		Pond 29		N-NH ₄ , mg.kg ⁻¹		N-NO ₃ ,* mg.kg ⁻¹		P-PO ₄ , mg/100 g	
months	horizons	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
April		34,38	14	8,19	3,33	48,00	70,00		
June		20	8,75	4,76	2,08	56,25	38,75		
July		52,5	33,75	5,68	3,66	40,25	59,00		
August		58,75	3,75	6,36	1,41	70,00	96,25		
September		21,88	11,25	2,36	1,22	87,68	20,13		
October		21,88	10	2,36	1,08	40,20	85,00		
Average of season	X	34,9	13,58	4,95	2,13	57,06	61,52		
	Sx	7,5892	4,6699	1,029	0,4993	8,38	12,76		
	Cv	48,63	76,86	46,47	52,16	18,73	28,52		

CONCLUSION

A vertical differentiation was established in the levels of the surveyed chemical indicators of the sediments. In the 0 cm - 15 cm horizon the content of organic nitrogen is on average 47.95% higher, and that of ammonium and nitrate ions is on average of 34% - 37.85% higher compared to that registered in the 15 cm - 30 cm horizon. The content of phosphate ions is 13.1% higher in 15 cm - 30 cm horizon in comparison with the 0 cm - 15 cm horizon.

A trend of higher levels of organic nitrogen in ponds with a larger area (2.4-7.0 ha) is recorded during the period from July to September in the surveyed horizons up to 30 cm depth of the bottom layer, compared to ones with area of max 0.5 ha. More pronounced dynamics in the quantities of mineral forms of nitrogen are recorded for ammonium compared to nitrate ions.

Based on the reported levels of organic nitrogen, soluble inorganic forms of nitrogen and phosphorus, the reserve of bottom sediments is determined as average to good. This characterizes them as a natural source of nutrients with the possibility of their integration in agriculture.

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