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INFLUENCE OF THE DATE OF AUTUMN HARVESTING ON THE QUALITY OF DISCHARGED WATERS

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ABSTRACT

The rearing of carp K_{2-3} in polyculture with a grass- carp, silver carp and European catfish was carried out within 1995- 1997, in six (1995-1996) or in seven (in 1997) variants of ponds differed in stocking densities as well as in kind of feed fed. The objective of the present paper was to verify if the change of harvest date from September into November can affect the quality of discharged waters. Estimation of discharged water quality was made on the basis of following chemical factors: dissolved oxygen, water pH, total suspended matter, chemical oxygen demand COD_{Mn}, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen and phosphates. The change of harvest date for 40 days improved markedly the quality of discharged water. In November 1997 values of the hydrochemical parameters of water decreased twice on average, e.g. suspended matter from 600 to 200 mg dm $^{-3,}$ ammonium from 10.0 to 5.0 mg dm $^{-3}$, while in November 1995 third or even five times when compared to results obtained in September, e.g. chemical oxygen demand COD_{Mn} from 200 to 30 mg dm^{-3} whereas phosphates from 4.5 to 2.0 mg dm^{-3}.

Key words: carp pond, hydrochemical parameters of water, water quality.

INTRODUCTION

The fish culture in ponds with bigger stocking densitities when compared to natural conditions where the fish growth is based on natural food, in conditions of low intensive culture with fish fed extra with the grain feed, in case of lack of proper pond culture, may result in waters eutrophication. The intensive culture however with high stocking densities of fish fed with pellets may result in the contamination of surface waters [9]. The response of the pressure of international bodies on ecological management of water is to maintain or to restore the high quality in water ecosystems [7].

Since Poland has an accession to European Union in prospect soon, it has to be introduced, similarly like in other European countries, more rigorous methods of estimation and severe criteria of the water classification. Juridical regulations concerned the post-production waters will oblige the fish farmers to use both rules and technology of fish rearing as well as levels of intensification of fish production determined by ecological requirements of the environment [4]. It will be necessary both for the intake and discharged waters to meet well defined requirements for the physical and chemical parameters. Due to discharge of water in the autumn when procedures of fertilization and feeding of fish have already been over, most of the metabolites accumulated during the season are deposited in the bottom of fish ponds. As can be observed, the period determined by the termination of fish feeding to fish harvest is extremely important. Thus the delay in the fish harvest seems to be one of the method to improve the quality of water discharged. Nowadays the pro-ecological policy of our State focused on the protection of environment, including as well the water protection, has forced to use its resoures more sensible. Therefore the possibility of estimation of influence of the post-production waters discharged from the carp ponds on purity of the surface reservoirs seems to be very essential.

The objective of the present paper was to check out if and how the delay of date of fsh harvest in ponds (from September into November) can influence the quality of water discharged.

MATERIALS AND METHODS

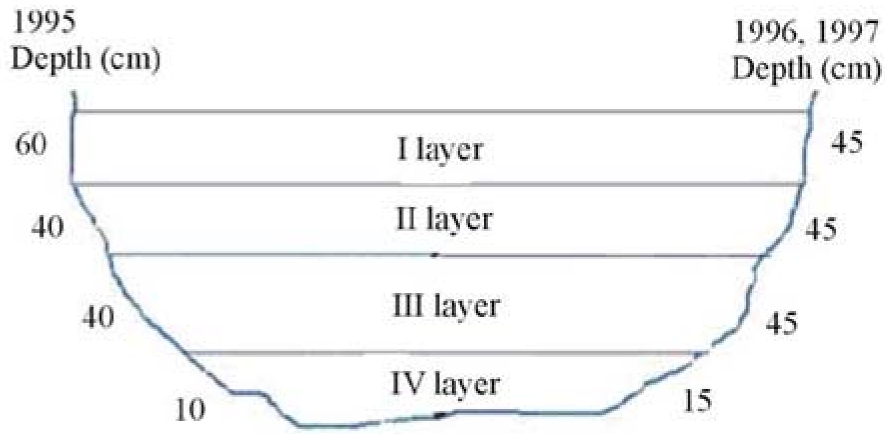
Investigations were carried out in the complex of experimental ponds of the equal area of 0.15 ha and depth of 1.5 m. The rearing of carp *Cyprinus carpio* (L.) in polyculture with a grass- carp *Ctenopharyngodon idella* (Val.), silver carp *Hypophtalmichthys molitrix* (Val.) and European catfish *Silurus glanis* L. was carried out in six (1995-1996) and in seven (in 1997) variants of ponds differed in stocking densities as well as in kind of feed fed, according to scheme given in Table 1. Estimation of discharged water quality was made on the basis of following chemical factors: oxygen dissolved, water pH, total suspended matter, chemical oxygen demand COD_{Mn} in acid medium, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and phosphates [5]. Water in each of ponds examined was divided into four horizontal layers of known depth (determined along the outlet monk) (Fig.1). One dm^3 of water was taken out of each water layer with a bathometer for chemical analyses from one location in pond (platform of outlet monk). The first sample of water was taken from the upper layer of pond. After discharge a quantity of water equal in volume to the first layer, next sample had been taken and then the discharge of next layer was begun. The last sample from each pond was taken from 10- or 15 cm layer of water.

Table 1. Experiment design carried out within 1995-1997

Year	Pond variants	Stock density (ind. ha^{-1}) and age-group of fish				Feeding
		carp	grass-carp	silver carp	European catfish	
1995		K_{2-3}	Ab_{1-2}	Tb_{2-3}	Se_{2-3}	
	O	0	0	0	0	none
	PN	500	100	200	67	natural
	T	1 500	333	600	67	grain feed
	G1	1 500	333	600	867	pellets
	G2	4 000	800	1 600	867	pellets
	G3	4 000	800	1 600	867	pellets
1996		K_{2-3}	Ab_{2-3}	Tb_{3-4}	Se_{1-2}	
	O	0	0	0	0	none
	PN	500	100	200	67	natural
	T	1 500	333	600	67	grain feed
	G1	1 500	333	600	633	pellets
	G2	4 000	800	1 600	633	pellets
	G3	4 000	800	1 600	633	pellets
1997		K_{2-3}	Ab_{2-3}	Tb_{2-3}	Se_{2-3}	
	O	0	0	0	0	none
	PN	500	100	153	100	natural
	T	1 500	300	453	0	grain feed
	G1	1 500	300	453	0	pellets
	G2	4 000	800	1 200	0	pellets
	G3	4 000	800	1 200	220	pellets
	G4	4 000	800	1 200	220	extruded feed

Explanations:
O- non-stocked pond;
PN- low stocking density on the natural food;
T - intensive culture of fish on grain feed;
G1- intensive culture of fish on stabilized feed adjusted to fish nutrient requirement (32.5% of protein, 13% of lipids);
G2- high- intensive culture on feed adjusted to fish nutrient requirement (32.5% of protein, 13% of lipids);
G3- high- intensive culture on feed adjusted to fish nutrient requirement (32.5% of protein, 13% of lipids); with water aeration in the high season;
G4- high- intensive culture on extruded feed (36%of protein, 22%of lipids).

Fig. 1. Distribution of pond layers in dependence of year of study



The examinations were conducted on water discharged from 12 ponds, from six ones (each of peculiar variant of density) being discharged within 25-29 September, while from remaining ponds within 5-9 November 1995. In 1996 the examinations were conducted on water discharged from 12 ponds, from six ones (each of peculiar variant of density) being discharged within 23-27 September, while from remaining ponds within 3-7 November. In 1997 the examinations were conducted on water discharged from 21 ponds, from 14 ones (in twos of peculiar variant of density) being discharged within 22-27 September, while from 7 ponds (each of peculiar variant of density) within 3-7 November.

In order to find out significant differences in values of suspended matter, dissolved oxygen, ammonia nitrogen and phosphates between two dates of fish harvest, the results obtained were treated with statistical test of the least significant differences NIR.

RESULTS

In order to compare the quality of water discharged from ponds in two different dates (September, November), values of suspended matter, chemical oxygen demand COD_{Mn}, forms of nitrogen (ammonium, nitrate, nitrite)and phosphates from particular layers were added up, what allowed to obtain values relating to the whole water column in each pond, in accordance with schedule of studies given in methods. Water pH and dissolved oxygen were shown as average values of four layers of water. Values of pH and dissolved oxygen recorded in September and in November were close and in some variants of ponds in November slightly lower (Table 2a). The dissolved oxygen of water discharged in November was higher compared to September (Table 2b). Differences in the oxygen quantity between September and November of 1995 and 1997 increased along with the increasing value of the stocking density in the pond (from 3% for pond without fish to 32% for pond with the highest density). In 1996 the dissolved oxygen in November was both smaller and bigger than in September, but the differences were of little importance. In the most variants quantities of nitrite nitrogen were lower by 0.2 mg $N\text{-}NO_2$ dm^{-3} in November, whereas the biggest difference recorded in the pond of variant T (Table 2c). The situation was similar for nitrate nitrogen (Table 2d). In November quantities of this form of nitrogen were lower by 0.4 to 3.8 mg $N\text{-}NO_3$ dm^{-3}, while this latter value was pertinent (similarly like in $N\text{-}NO_2$) to the pond with the density of 1500 individuals per hectare.

Table 2. Comparison of selected chemical parameters of water discharged from ponds in September and November within 1995-1997
a - pH- average and range of four layers.

Pond variant	1995		1996		1997	
	Sept	Nov	Sept	Nov	Sept	Nov
O	8.00	7.60	8.00	7.85	7.90	7.40
Range	7.60-8.40	6.90-8.00	7.30-8.75	7.60-8.10	7.70-8.00	7.35-7.50
PN	8.00	7.60	8.10	7.80	8.60	7.65
Range	7.50-8.30	7.50-7.80	7.55-8.80	7.75-8.15	8.10-9.15	7.60-7.65
T	7.75	7.50	7.80	7.70	7.75	7.60
Range	7.30-8.10	7.20-7.70	7.55-8.25	7.35-8.00	7.50-8.55	7.45-7.70
G1	7.70	7.75	7.90	8.35	7.45	7.55
Range	7.60-8.00	7.30-8.00	7.50-8.25	7.90-8.75	7.30-7.65	7.45-7.65
G2	7.50	7.85	7.80	7.70	7.85	8.10
Range	7.10-7.80	7.60-8.10	7.30-8.25	7.50-8.00	7.45-9.15	7.50-8.35
G3	7.90	7.70	7.90	7.60	8.25	7.55
Range	7.20-8.40	7.30-8.00	7.55-8.25	7.40-7.90	7.85-9.25	7.50-7.60
G4					8.10	8.15
Range					7.40-9.10	7.65-8.35

b - Dissolved oxygen (%) - average and range of four layers

Pond variant	1995		1996		1997	
	Sept	Nov	Sept	Nov	Sept	Nov
O	88	91	95	106	62	64
range	83-96	83-96	82-106	96-115	46-77	60-68
PN	87	91	96	94	75	71
range	70-97	75-102	87-107	92-98	62-90	66-75
T	76	94	77	59	41	65
range	61-91	73-110	30-99	4-109	35-55	62-72
G1	64	81	68	97	38	57
range	56-74	58-102	10-97	75-110	23-48	52-63
G2	52	84	68	84	45	78
range	36-66	52-101	10-107	61-105	24-89	73-85
G3	87	82	70	52	60	65
range	49-113	54-98	36-94	3-110	37-98	60-75
G4					57	82
range					32-97	74-89

c - N-NO_2 (mg dm^{-3}) - total of four layers

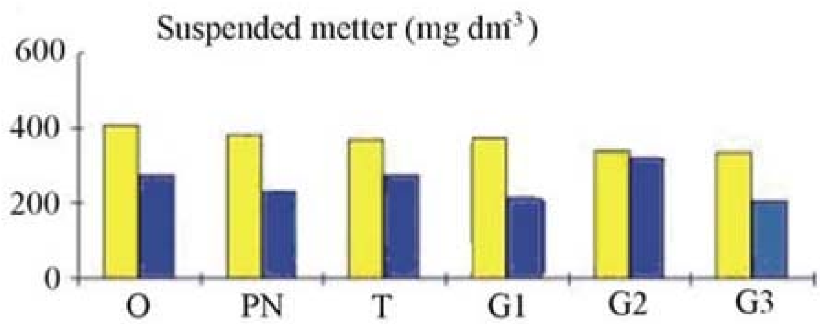
Pond variant	1995		1996	
	Sept	Nov	Sept	Nov
O	0.24	0.32	0.27	0.13
PN	0.60	0.41	0.54	0.79
T	1.25	0.44	0.93	0.50
G1	0.82	0.68	0.48	0.58
G2	1.30	1.04	1.06	1.02
G3	0.90	1.00	1.16	0.57

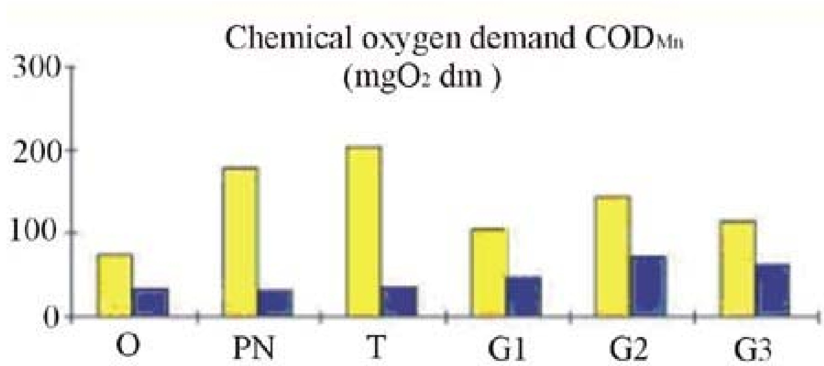
d - $N\text{-}NO_3$ (mg dm^{-3}) - total of four layers

Pond variant	1995		1996		1997	
	Sept	Nov	Sept	Nov	Sept	Nov
O	1.21	1.36	1.02	2.08	1.71	0.49
PN	1.93	1.52	2.21	2.36	1.56	0.47
T	5.20	1.38	2.48	1.57	1.99	1.09
G1	2.60	1.86	1.70	2.80	1.95	0.46
G2	3.68	2.04	3.11	2.76	2.17	0.75
G3	3.82	1.64	1.87	1.57	2.46	1.23
G4					2.28	0.80

Markedly lower values of suspended matter, dissolved oxygen, ammonium and phosphates were recorded in November during 3 years of examination. Particularly big differences in the values (twice or even four times) were noted in 1995 (Fig. 2) and 1997 (Fig. 3). Lower contents of ammonia nitrogen and phosphates recorded in November were observed in particular in ponds where fish production was at the intensive and high-intensive level of culture. In 1995 and 1997 values of the suspended matter and chemical oxygen demand COD_{Mn} were markedly lower compared to September. The twice or even four times as large increase of the organic matter load was observed.

Fig. 2. Comparison of chemical parametres of water discharged in September and November 1995





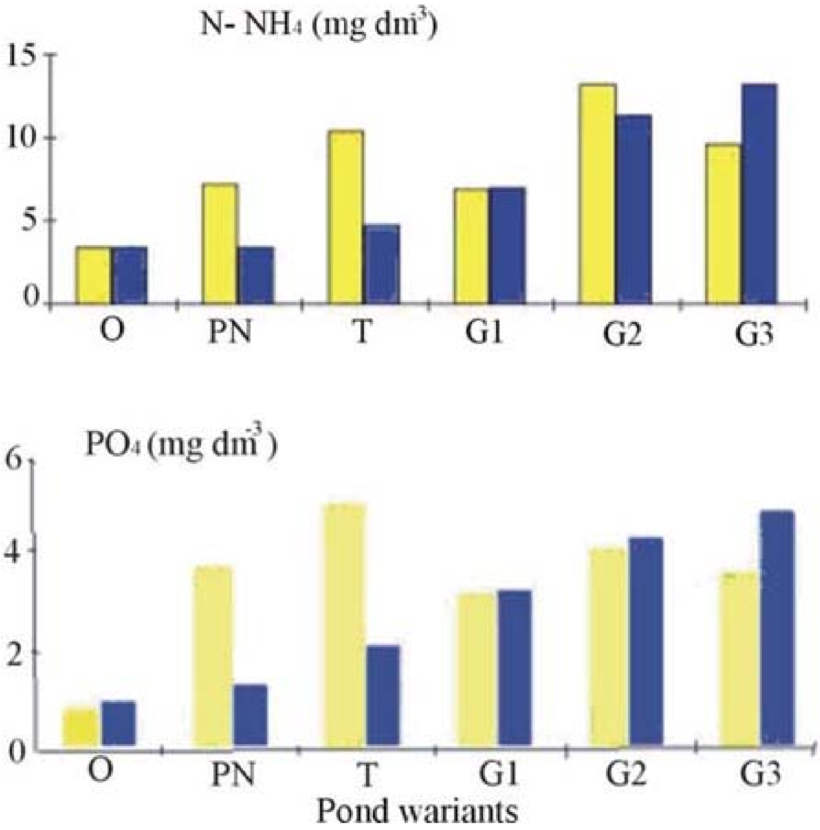
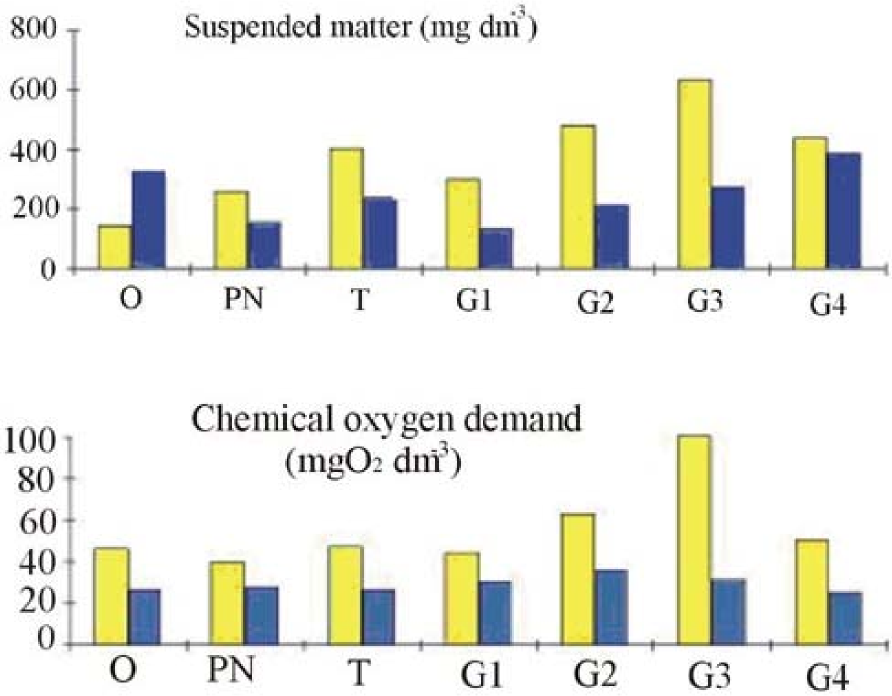
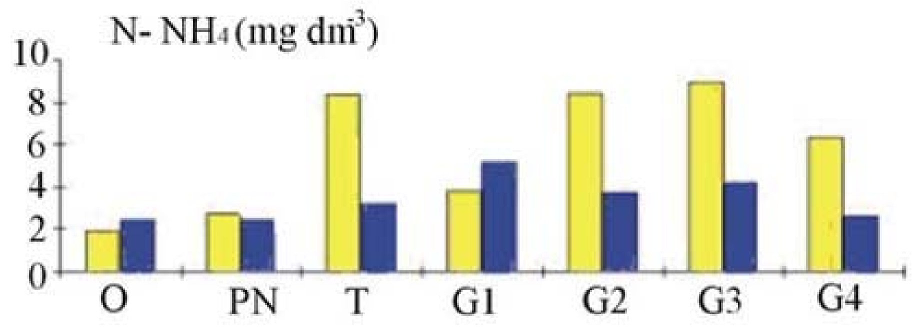
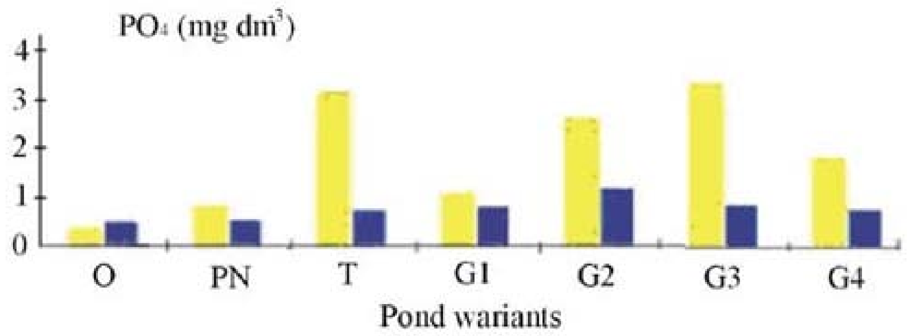


Fig. 3. Comparison of chemical parametres of water discharged in September and November 1997







For the total suspended matter, chemical oxygen demand COD_{Mn}, ammonia nitrogen and phosphates during 3 years of study the statistical calculations were performed (Table 4). As the employed NIR test (the least significant differences) displayed for the total suspended matter and chemical oxygen demand COD_{Mn} differences between September and November were statistically significant at the level $\alpha<0.05$.

Table 3. NIR test (least significant differences) for the parameters determined

Parameter Month	Suspended matter	Chemical oxygen demand COD_{Mn},	$N\text{-}NH_4$	PO_4
September	92.8 [a]	18.4 [a]	1.9 [a]	0.65 [a]
November	61.5 [b]	10.3 [b]	1.5 [a]	0.50 [a]

Values of parameters in columns with the same literal index do not differ from each other at $\alpha <$ 0.05.

Table 4. Monthly average water temperature (°C)

Month Year	September	November	Difference
1995	15.4	12.5	2.9
1996	13.2	11.1	2.1
1997	17.3	10.0	7.3

DISCUSSION

When consider a purity of surface waters, efforts are made to improve the water quality discharged from rearing objects. It is possible to gain this goal through the adaptation of rearing technology to requirements of the water environment protection, among others by introducing the post- production waters to the sedimentation ponds [10] or by changes in the harvest techniques [8]. However all methods mentioned need suplementary costs and human work, whereas the change of harvest dates do not result in the increase of costs of fish rearing. The harvests performed too early (end of July, beginning of September) enrich the water with nutrients, suspended matter and organic matter [6]. The harvests carried out in the end of September in the experiment described showed as well the water load particularly with dissolved oxygen and total suspended matter. Not shorter period that 40 days in harvesting delay (from September into November) resulted in considerable improvement of discharged water quality. Only the change of harvest date from the end of September to the beginning of November allowed to twice (on average) decrease in November 1997 of values of the water contamination factors mentioned above when compared to September, in 1995 being even third or four times decreased. The little differentiation of quality of water discharged from ponds resulted from slight differences in water temperature between September and October (the mean temperature of water in October not in November was analysed, because as early as in the beginning of November the water discharge has begun). The monthly average temperature of water noted in September and October 1996 showed as small difference as 2.1°C [1, 2, 3]. Somewhat bigger difference was recorded in 1995 while the biggest one in 1997 (Table 4). The another reason of differences observed was considerable differences in the dates of feeding termination and harvest start (Table 5). The longer periods were conductive to decay of the agglomerated substances as well as to accumulate them in the bottom. The differences in temperatures between dates of pond harvesting in ponds as well as different periods between feeding termination and harvest in ponds influenced smaller or bigger intensity of physical, chemical and biological processes took place in ponds as well as the feeding activity of fish what can be seen in the chemical parameters of water examined.

Table 5. Dates of feeding termination and pond harvesting start

September

Date Year	Feeding termination	Start of pond harvesting	Difference (days)
1995	5.09	25.09	20
1996	6.09	23.09	17
1997	12.09	22.09	10

November

Date Year	Feeding termination	Start of pond harvesting	Difference (days)
1995	5.09	5.11	60
1996	6.09	3.11	57
1997	12.09	3.11	50

CONCLUSIONS

The statistical examinations performed have confirmed, that the delay of harvesting date strongly influenced the decrease of values of chemical oxygen demand COD_{Mn} and total suspended matter, thus two factors which can cause oxygen depletion as well as the silting up of post-production waters.

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