Distribution of benthic macroinvertebrates in Mantovo Reservoir (South-East part of the R. Macedonia)

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Abstract:

Composition and community structure as well as functional feeding organization of the macroinvertebrates from Mantovo Reservoir (South-East part of the R. Macedonia) in relation to lake depth were carried out during the period from May 2003 to April 2004. Bottom fauna samples were collected at four stations situated on the depth profile across the reservoir.
Forty nine taxa belonging to 14 animal groups were recorded. With exception on the lower profundal, the results of this study show that Limnodrilus hoffmeisteri was the most abundant species in the benthic community. The latter presents taxon highly tolerant to organic pollution, as well as collector (deposit - feeders), witch features indicate presence of abundant fine particulate organic matter (FPOM) in Mantovo Reservoir. Only, zooplankton predator, Chaoborus crystallinus (97.21%) was presented in considerable quantities in the bottom fauna from the deepest part of the lake (20.3 m).
Distribution of the macrozoobenthos was determined by depth gradient, both in quantitative and qualitative terms. The station with the highest richness (d = 3.22), diversity (H' = 1.68), evenness ($J_{(e)}$ = 0.50) and community density (5,939.05 ind·m^2) belongs to the littoral region and additionally is located near the main river input, which very likely act as colonizing source. Heterogeneous bottom habitat contributes to species richness of macroinvertebrates in the littoral region. In relation to other depth profiles, low species richness (d = 0.99), diversity (H' = 0.17) and evenness ($J_{(e)}$ = 0.08) as well as significant decrease in abundance of zoobenthos community (3,313.39 ind·m^2) were noticed in lower profundal, near the dam. These results point up different environmental conditions in the deepest part of the lake.

KEY WORDS: Mantovo reservoir, macrozoobenthos, distribution, community indices

Introduction

Reservoirs are artificial water bodies whose dynamics and structures present a pattern of organization midway between those of rivers and lakes (Callisto *et al*., 2005). They are more like streams at the head where major tributaries enter and are more like lakes near the dam (Thornton *et al*., 1990). Within the aquatic communities, benthic macroinvertebrates represent one of the groups most affected by reservoir construction (Krzyżanek, 1991; Krzyżanek and Kasza, 1995). These organisms form an important link between primary producers, detrital deposits and higher trophic levels in aquatic food webs (Stoffels *et al*., 2005). In addition, benthic macrofauna provide information on the trophic level and the evolution of an ecosystem, which, in turn, exert a direct effect on the benthic community downstream from the dam (Ward and Voelz, 1988).

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Food availability and quantity, sediment type (organic, sandy, clay), substrate (rock, wood, aquatic macrophytes), water quality (temperature, oxygen, and dissolved substances (Callisto, 2005) as well as lake morphometry affect community structure of macroinvertebrates (Rasmussen, 1988). The major community which Klugh (1923) referred to as the lake bottom association has commonly been divided by limnologists into the littoral, sublittoral and profundal zones. These zones are defined as follows: littoral, from the lake margin to a depth at which aquatic vegetation, through lack of light, can no longer grow; sublittoral, extends from the lower edge of the rooted macrophyte zone to about the level of the upper boundary of the hypolimnion; and profundal, roughly, the area of the bottom in contact with the hypolimnion, which consists of exposed fine sediment free of vegetation (Williams and Feltmate, 1992).
Apart natural lakes, the littoral zones in typical reservoirs is subject of high water level fluctuation. Only the shores near the inflow(s) often exhibit more gentle slopes, which may allow the growth of higher vegetation (Black *et al.,* 2003). Also, when a hypolimnion is present it varies in depth from season to season. Are the profundal zone limits then to change with the fluctuations of the hypolimnion? Many writers, in order to avoid such poorly defined categories, have instead used the categories mentioned (littoral, sublittoral and prafundal) but have defined them by stating the exact depth limits of each zone (Sublette, 1957). A more logical system would be to designate the zones on the basis of sediment substratum as has been pointed out by Pearse (1939) for marine communities.
In this paper we report the results of an analysis of composition and community structure as well as functional feeding organization on the benthic macroinvertebrates from Mantovo Reservoir (South-East part of the R. Macedonia). The main objective is to see whether distribution of bottom fauna was related to depth, both in quantitative and qualitative terms. An additional aim is to provide contribution to the knowledge of the diversity of benthic macroinvertebrates from Macedonian artificial lakes.

Material and Methods

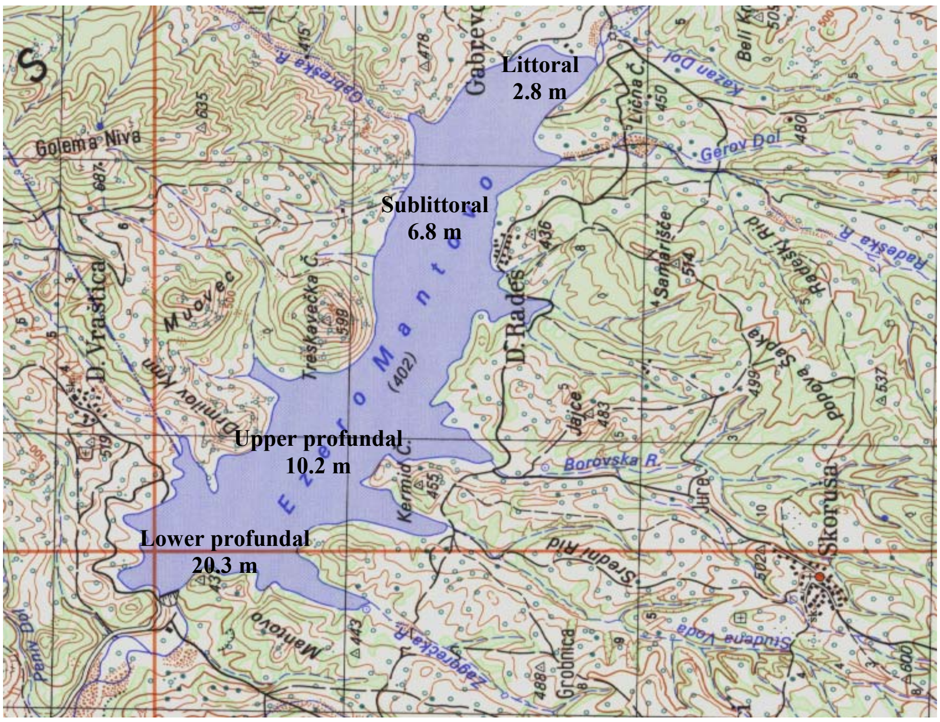

Figure 1. Map of Mantovo Reservoir, including sampling stations.

Mantovo Reservoir presents dimictic lake located in the South-East part of the Republic of Macedonia at an altitude 402.5 m (Slavevska-Stamenković *etal.,* 2008). Detailed description of Mantovo Reservoir was given in earlier paper (Smiljkov and Slavevska-Stamenković, 2006).
Biological examinations were carried out according to standard methodology for sampling (Lind, 1979; Rosenberg *et al*., 1997). Monthly sampling was done during the period from May 2003 to April 2004. Bottom fauna samples were collected with an Ekman's grab at four stations situated on the depth profile across the reservoir (Fig. 1): in the littoral (depth of 2.8 m), in the subllitoral (depth of 6.8 m), and in profundal (depths of 10.2 - upper profundal and 20.3 m - lower profundal). Because of steep shores, littoral area is located only near the mouth of River Kriva Lakavica The bed is muddy with non-decomposed fragments of water plants, sand and gravel. Additionally, light penetrate almost to the bottom. The character and structure of the littoral sediments influence the formation of sublittoral habitats. Thus, the bed contains a high percentage of sand and decomposing vegetation. Upper profundal is situated in the centre of the lake in a zone thought to be less subject to environmental variation caused by mass water movement. The bed is composed of mud. Lower profundal is located about 50 m from the dam. The bed composed of black fine sediment with unpleasant odor. Two benthic samples were taken at each sampling stations and fixed with 4% formaldehyde. To complete species list, qualitative samples were taken with hand net near lake shore. In the lab, animals were sieved trough a 0.28 mm mesh net and identified (to species or other taxonomic level). Identification was done using the following taxonomic key: Pavlovskii and Lepneva (1948); Lepneva (1964 and 1966); Pankratova (1970, 1977 and 1983); Galewski and Tranda (1978); Kerovec (1986); Elliot *et al.* (1988); Hynes (1997). Calculated densities are finally referred to as number of individuals per square metre of sediment surface (ind·m^2). In order to determined community structure, two diversity indices and one evenness index were applied, namely:

(1) Species diversity (Shannon and Weaver, 1949): $H' = - \Sigma \, pi \ln pi$

(2) Species richness (Margalef, 1958): $d = (S - 1) / \ln N$

(3) Evenness (Pielou, 1966): $J_{(e)} = H' / \ln S$

where,

$pi = n_i / N$,
n_i = number of individuals of species i,
N = the total number of individuals in a sample,
S = total species number.

Functional feeding groups were identified following Merritt and Cummins (1984) to evidence relationships between macroinvertebrates assemblages and trophic substrates.

Results

During investigation of the bottom fauna from Mantovo Resrervoir, 49 taxa belonging to 14 animal groups were recorded (Tab.2). Chironomidae (21 taxa) was the most diverse group. Less diverse were Oligochaeta (6 taxa), Gastropoda (5 taxa), Ephemeroptera (4 taxa) and Odonata, Coleoptera, Hemiptera (2 taxa), while the most uniform groups, represented by only one species were found to be Nematoda, Bivalvia, Amphipoda, Ceratopogonidae, Chaoboridae, Tabanidae and Trichoptera. Of the total number of species, 14 taxa from 7 groups (*Baetis rhodani*, *Cloeon dipterum*, *Ephemerella ignita*, *Caenis macrura* - Ephemeroptera, *Calopteryx splendens*, *Ischnura elegans* - Odonata, *Platambus maculatus*, *Agabus sp.* - Coleoptera, *Micronecta scholtzi, Ilyocoris cimicoides* - Hemiptera, *Anadonta cygnea* - Bivalvia, *Gammarus balcanicus* - Amphipoda, *Tabanus sp.* - Tabanidae and *Planorbis planorbis* - Gastropoda) were founded only in qualitative samples taken near lake shore.

Table 1. Benthic macrofauna of Mantovo Reservoir: abundance (ind·m^{-2}); relative contribution (%); feeding groups (c-g: collector-gatherer; c-f: collector-filterer; prd: predator; scr: scraper; shr: shredder); taxa founded only in qualitative samples from littoral region (+).

Taxa	abundance (ind·m^{-2})	relative contribution (%)	feeding groups
Nematoda			
Nematoda sp.	18.17	0.40	prd
Gastropoda			
Limnea auricularia L.	1.06	0.02	c-g
Galba(Limnea) tronculata Müll.	0.27	0.01	c-g
Limnea peregra Müll.	19.05	0.42	c-g
Physa acuta L.	1.06	0.02	c-g
Planorbis planorbis L.	+	+	scr
Bivalvia			
Anadonta cygnea	+	+	c-f
Oligochaeta			
Nais communis Piquet.	92	2.01	c-g
Enchytraeus albidus Henle.	13.23	0.29	c-g
Tubifex tubifex Müll.	69.59	1.52	c-g
Limnodrilus hoffmeisteri Clap.	2288.03	50.09	c-g
Limnodrilus udekemianus Clap.	32.81	0.72	c-g
Aulodrilus pluriseta Piquet.	6.70	0.15	c-g
Amphipoda			
Gammarus balcanicus Sch.	+	+	c-g
Ceratopogonidae			
Stilobezzia sp.	34.49	0.76	prd
Chaoboridae			
Chaoborus crystallinus De Geer.	710.06	15.55	prd
Tabanidae			
Tabanus sp.	+	+	prd
Chironomidae			
Chironomus gr.plumosus L.	334.79	7.33	c-g
Dicropendipes nervozsus Staeg.	19.14	0.42	c-g
Cladotanitarsus gr. mancus Wal.	340.35	7.45	c-f
Tanitarsus gregarius Kieff.	3.44	0.08	c-f
Polypedilum bicrenatum Kieff.	12.17	0.27	shr
Polypedilum nubeculosm Meig.	3.44	0.08	shr
Polypedilum tetracrenatum Hirv.	5.03	0.11	shr
Leptochironomus tener Kieff.	6.62	0.15	c-g
Criptocladopelma viridula Fabr.	31.22	0.68	c-g
Parachironomus varus Goetgh.	1.50	0.03	prd
Cryptochironomus gr. defectus Kieff.	54.33	1.19	prd
Endochironomus albipennis Meig	2.12	0.05	shr
Procladius choreus Meig.	438.51	9.60	prd
Tanypus punctipennis Meig.	15.17	0.33	prd
Ablabesmya monilis L.	0.27	0.01	prd

Table 1. Continued.

Glyptotendipes glaucus Meig.	3.44	0.08	shr
Cricotopus bicinctus Meig.	0.53	0.01	scr
Ortocladinae rod ? L.molesta	0.27	0.01	c-g
Cricotopus algarum Kieff.	0.27	0.01	shr
Cricotopus gr.silvestris Fabr.	0.53	0.01	scr
Glyptotendipes sp.	0.27	0.01	shr
Hemiptera			
Micronecta scholtzi (ad.) Fieber,	+	+	prd
Ilyocoris cimicoides (lar.) L,	+	+	prd
Odonata			
Calopteryx splendens Harris,	+	+	prd
Ischnura elegans V.d.Lind,	+	+	prd
Trichoptera			
Ecnomus tenelus	7.94	0.17	c-f
Ephemeroptera			
Baetis rhodani Pict.	+	+	c-g
Cloeon dipterum L	+	+	c-g
Ephemerella ignita Pod,	+	+	c-g
Caenis macrura Steph.	+	+	c-g
Coleoptera			
Platambus maculatus (ad.) L,	+	+	prd
Agabus sp.(lar.)	+	+	prd

The results of these additional samples are not presented in detail, whatever, to present diversity of bottom fauna, species are included in the species list (Tab. a).

Oligochaeta (54.80%), Chironomidae (27.84%) and Chaoboridae - *Chaoborus crystallinus* (15.55%) play dominant quantitative role in zoocenosis of the reservoir (Fig. 2). *Limnodrilus hoffmeisteri* was the dominant species in the benthic community and comprised 50.09% of the total invertebrate community during the study period (Tab. 1). Among chironomids, *Procladius choreus*, *Cladotanytarsus gr. mancus* and *Chironomus gr. plumous* were the most abundant species, with 9.60%, 7.45% and 7.33% contribution of the total benthic community, respectively (Tab. 1). Collectors (gatherers and filterers) were by far the most abundant trophic functional group (63.84% and 7.7%). Predators were the second most numerous group (27.87%), while shredders and scrapers were nearly absent (0.61% and 0.02%). Dominant species present: collector-gatherers (*L. hoffmeisteri* and *C. gr. plumous*), collector-filterers (*C. gr. mancus*) and zooplankton and zoobenthos predators (*C. crystallinus* and *P. choreus*, respectively) (Tab. 1). In certain stations, less significant for benthocoenotic characterisation accidental groups (Gastropoda, Trichoptera, Nematoda and Ceratopogonidae), were sporadically found.

Bathymetrically, both the benthos abundance (5,939.05 ind·m^2) and the number of benthic species (29 + 14 in qualitative samples = 43) were the highest in the littoral region (Fig. 3). The most dominant taxa in the littoral were *L. hoffmeisteri* (57.72%), *C. gr. mancus* (9.57%) and *C. gr. plumosus* (7.87%) (Tab. 2). The other oligochaetes, as *Nais communis* (4.68%) and *Tubifex tubifex* (6.21%) were also found in considerable numbers. *P. choreus* show lower contribution in the benthic community from the shallowest part of the lake (2.46%).

Community density (4,651.23 ind·m^2) slightly decreased in the sublittoral region. A qualitatively more varied macrozoobenthos (31 species) has also been recorded in this part of the lake. Some representatives of both littoral (*C. gr. mancus*) and profundal (*C. crystallinus*) fauna as well as euritopic species (*L. hoffmeisteri, C. gr. plumosus* and *P. choreus*) were present in significant quantities. As previous station, *L. hoffmeisteri* was the dominant species (54.32%) in sublittoral, too (Tab. 2).

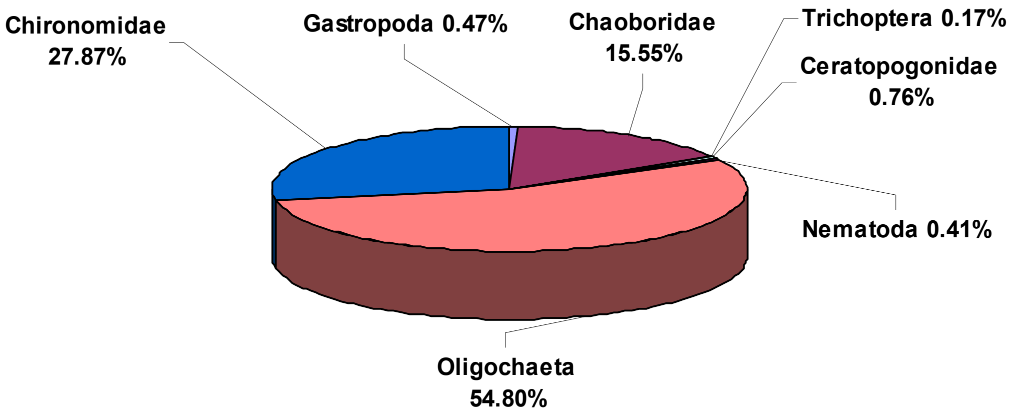

Figure 2. Relative contribution (% of total mean density) of the groups in Mantovo Reservoir.

Results of this study show significant differences in the structure of the bottom fauna from the central and the deepest part (near the dam), which belong to the upper and lower profundal region, respectively. Moderate number of species (17) and high community density (4,120.9 nd·m^2) were registered in the upper profundal. *L. hoffmeisteri* (58.92%), *C. crystallinus* (19.42%) and *C. gr. plumosus* (13.53%) were the most abundant species at the central part of the reservoir. As in littoral area, *P. choreus*, show lower contribution in the benthic community from the depest part of the lake (3.87%).
In relation to other depth profiles, the least number of species (9) as well as significant decrease in abundance of zoobenthos community (3,313.39 ind·m^2) were noticed in lower profundal. *L. hoffmeisteri* (0.95%) and *C. gr. plumosus* (0.84%) were almost absent in the bottom near the dam. Only, *C. crystallinus* (97.21%) was presented in considerable quantities in the bottom fauna from the deepest part of the lake (Tab. 2).

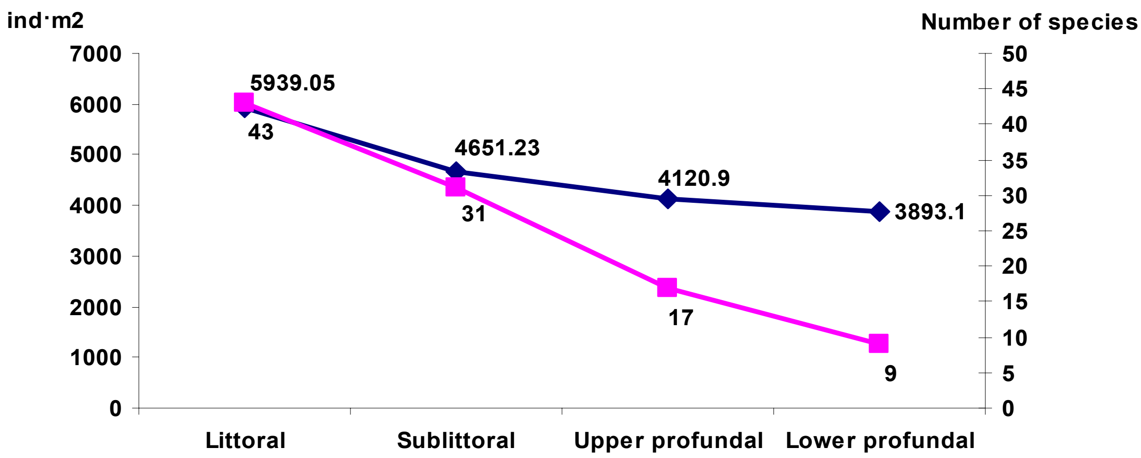

Figure 3. Mean density and number of species related to depth gradient in Mantovo Reservoir.

Table 2. Benthic macrofauna of Mantovo Reservoir related to depth gradient: abundance (ind·m^{-2}) and relative contribution (%).

Taxa	Littoral (2.8 m)		Sublittoral (6.8 m)		Upper profundal (10.2 m)		Lower profundal (20.3 m)	
	ind·m^{-2}	%	ind·m^{-2}	%	ind·m^{-2}	%	ind·m^{-2}	%
Nematoda	38.30	0.64	13.89	0.31	29.64	0.72	3.71	0.11
Limnea auricularia			1.39	0.03	1.85	0.04		
Galba(Limnea) tronculata	185	0.03						
Limnea peregra	4259	0.72	18.06	0.46	18.53	0.45		
Physa acuta			1.39	0.03			1.85	0.06
Nais communis	277.82	4.68	88.75	1.93	11.11	0,27		
Enchytraeus albidus	85.2	1.43	1.85	0.04				
Tubifex tubifex	368.57	6.21	18.98	0.40	42.6	1.03		
Limnodrilus hoffmeisteri	3428.2	57.72	2532.1	54.32	2428.1	58.92	31.49	0.95
Limnodrilus udekemianus	166.69	2.81	15.75	0.36				
Aulodrilus pluriseta	7.41	0,.2	9.88	0.21				
Stilobezzia sp.	67.29	1.13	35.19	0.76	33.34	0.81		
Chaoborus crystallinus	29.64	0.50	229.97	4.70	800.1	19.42	3220.8	97.21
Chironomus gr.plumosus	467.35	7.87	322.73	7.08	557.,47	13.53	27.78	0.84
Dicropendipes nervosus	24.08	0.41	27.47	0.56				
Cladotanitarsus gr. mancus	568.59	9.57	451.60	9.79	7.41	0.18		
Tanitarsus gregarius	1.85	0.03	5.09	0.10	1.85	0.04		
Polypedilum bicrenatum	9.26	0.16	18.99	0.41				
Polypedilum nubeculosm			6.02	0.13				
Polypedilum tetracrenatum	7.41	012	6.95	0.15				
Leptochironomus tener	5.56	0.09	9.73	0.22	1.85	0.04		
Criptocladopelma viridula	5.,71	0.90	41.21	0.88				
Parachironomus varus	3.71	0.06	1.69	0.04				
Cryptochironomus gr. defectus	96.93	1.63	68.06	1.49	7.41	0.18	3.70	0.11
Endochironomus albipennis	9.26	0.16	0.93	0.02			1.85	0.06
Procladius choreus	146.32	2.46	685.89	14.78	159.28	3.87	20.37	0.61
Tanypus punctipennis	12.97	0.22	19.14	0.40	16.67	0.40		
Ablabesmya monilis			0.46	0.01				
Glyptotendipes glaucus	9.26	0.16	3.24	0.07			1.85	0.06
Cricotopus bicinctus	1.85	0.03	0.46	0.01				
Ortocladinae rod ? L.molesta			0.46	0.01				
Cricotopus algarum					1.85	0.04		
Cricotopus gr.silvestris	1.85	0.03			1.85	0.04		
Glyptotendipes sp.	1.85	0.03						
Ecnomus tenelus	3.70	0.06	12.97	0.29				

The highest richness (d = 3.22) and diversity (H' = 1.68) were measured in the littoral region (Fig. 4). Species richness and diversity slightly decreased in sublittoral, declining to a low values in the zone of upper profundal and a minimum in lower profundal (d = 0.99; H' = 0.17). The evenness index - $J_{(e)}$, however, remained relatively steady to upper profundal (0.50 - 0.44), and severe droped (0.08) at 20.3 m depth.

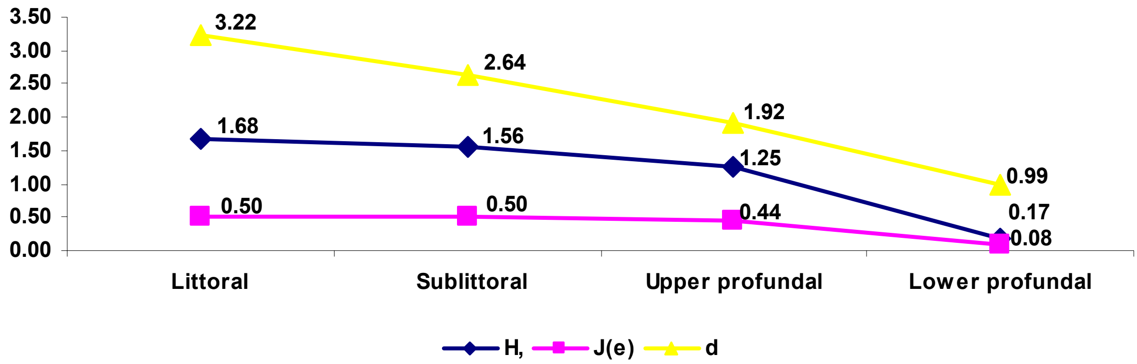

Figure 4. Change of species richness, species diversity and evenness ($J_{(e)}$ = 0.50) related to depth gradient in Mantovo Reservoir.

Discussion

The results of this study showed that Mantovo Reservoir has a moderate density and species richness of macroinvertebrates compared to other European artificial lakes (Rieradevall and Real, 1994; Smiljkov, 1996; Simić and Simić, 1999; Miljanoviċ *et al.,* 2004). It is possible that natural potential of habitat for colonization, presence of different ecological niches as well as food quantity and quality are main factors responsible for diverse (49 taxa) benthic fauna. The development of large numbers of cosmopolitan species in Mantovo Reservoir, such as *L. hoffmeisteri*, *C. crystallinus*, *P. choreus*, *C. gr. mancus* and *C. gr. plumous* is typical of many other artificial lakes (e.g. on the Rivers Volga, Dneiper and Vltava) (Krzyzanek, 1991).
The high abundance of collector–gatherers (*L. hoffmeisteri* and *C. gr. plumous)* and collector-filterers (*C. gr. mancus*), was probably related to high concentrations of organic detritus deposited on the bottom and suspended in water column, as is corroborated by the low average water transparency (1.7 m) (unpublished data) and high average concentration (19.99 mg/l) on dissolved organic matter as consumption on KM_nO_4 (Slavevska-Stamenkovic *et.al.,* 2008). Possible explanation for the origin of organic loading is fact that before filling the reservoir the soil and vegetation weren't removed, as well as by the influence of the River Kriva Lakavica, which carries high content of sediments, silt, nutrients and suspended matter in Mantovo Reservoir (Slavevska-Stamenkovic *et.al.,* 2008). Although, in very eutrophic waters *T. tubifex* may form dense monocultures (Milbrink, 1980), during the examined period low density of the latter species was noticed.
Among dominant species, the predatory chironomid *P. choreus* was presented in considerable quantities, which confirmed long period after construction on Mantovo Reservoir (30 years). Literature data showed that it domination among Chironomidae may be typical for late stages of reservoir succession (Vodopich and Moore, 1984; Krzyzanek, 1991; Krzyźanek and Kasza 1995). The reported high densities of *Chaoborus crystallinus* was not surprising, as it is common species for stratified eutrophic lake with reduced oxygen in the deepest part. Namely, recent review of the seasonally vertical distributions of temperature and dissolved oxygen (Slavevska-Stamenkovic *et al.,* 2008) concluded that from May to October, stable summer stratification was developed in profundal region of Mantovo Reserervoir.
For most lakes and reservoirs, both the abundance and the number of benthic taxa are highest in the littoral zone and decreases as the depth increases (Salmoiraghi *et al.,* 2001). In Mantovo Reservoir too, distribution of the macrozoobenthos was mainly determined by depth gradient. The station with the highest richness (d = 3.22), diversity (H' = 1.68), evenness ($J_{(e)}$ = 0.50) and community density (5939.05 ind·m^2) belong to the littoral region and additionally is located near the main river input, which very likely act as colonizing source. Heterogeneous bottom habitat (muddy bed with non-decomposed fragments of water plants, sand and gravel), accompanied with high concentration of detritus and high average concentration of dissolved oxygen (9.53 mg/l) (unpublished data), probably contributes to species richness and abundance of macroinvertebrates in the littoral region.

Benthic community in sublittoral show transitional character, as (Williams and Feltmate, 1992) stressed, perhaps because of the up and down swing of thermocline, although diversity is reduced compared with the littoral zone. Both, in littoral and sublittoral region, high abundance of *L. hoffmeisteri* and *C. gr. plumosus* was observed, which may be a response to high concentrations of organic detritus. Additionally, considerable contribution of *C. gr. mancus*, characteristic of well oxygenated waters (Van den Berg *et al.,* 1997), indicate favorable oxygen condition in both region.
The central area and the deepest part near the dam manifested the limnological characteristics of a more typically lacustrine aspect. However, results of this study show significant differences in the structure of the bottom fauna from the central and the deepest part near the dam. Taxon highly tolerant of hypoxic condition, *L. hoffmeisteri* (58.92%), *C. crystallinus* (19.42%) and *C. gr. plumosus* (13.53%) (Krzyzanek, 1991; Krzyżanek and Kasza 1995; Real *et al.,* 2000; Malmquist *et al.,* 2002) were the most abundant species at the central part of the reservoir. Opposite, *L. hoffmeisteri* (0.95%) and *C. gr. plumosus* (0.84%) were almost absent in the bottom near the dam. Markedly low evenness value ($J_{(e)} = 0.08$) indicate deterioration on condition in lower profundal, which is the most likely explanation for the decline in their density and for occasional disappearance. Namely, Slavevska-Stamenkovic *et al.* (2008) registered some differences in duration on stratification period between upper and lower profundal which affects the chemistry on the bottom water. Longer presence and permanence of thermal stratification caused more prolonged and pronounced oxygen deficits in the deepest parts of the lake (0.9-3.4 mg/l O_2). Under hypoxic, almost anoxic condition it is possible that large amounts of toxic sulfides were also produced in this region, which according suggestion on Prat (1978) was confirmed with black color on the mud and unpleasant odor (personal observation directly on the field). In addition, under condition of more prolonged and pronounced oxygen deficits in the deepest parts of the lake, toxic concentrations on manganese (2819 µg/l) and copper (147.6 µg/l) were found in the lower profundal (Slavevska-Stamenkovic *et al.,* 2008). In such kind of condition, only, *C. crystallinus* (97.21%) was presented in considerable quantities in the bottom fauna from the deepest part of the lake which wasn't surprisingly because the resent studies by Gosselin and Hare (2003) show that this species could survive anoxic condition accompanied with H_2S in concentration 5 times higher than those known as lethal for other animals. Additionally, this species don't accumulate trace metal from overlaying water, because its exoskeleton is little permeable to dissolved contaminants (Munger and Hare, 1997).
During investigated period diversity index show low values in the upper and lower profundal region, which usually indicate high level of productivity (Petridis and Sinis, 1993). However, significantly lower diversity ($H' = 0.17$), was noticed in the deepest part of the lake, which was primarily the result of a decrease in the number of species (9) and an increase in density of *C. crystallinus* population.
In conclusion, the results of this study showed that depth is the major factor causing changes in the physicochemical parameters of the water and thereby in structure of bentocenosis.

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