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COMPLEX INVESTIGATIONS ON THE RIVER VARDAR. II. THE MOST POLLUTED SITES IN THE FIRST THREE MONTHS

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ABSTRACT

Krstić, S., Melovski, Lj., Levkov, Z. and Stojanovski, P. (1994). Complex investigations on the river Vardar. II. The most polluted sites in the first three months. Ekol. Zašt. Život. Sred., Vol. 2, No 2, Skopje.

Presented article refers to complex physic-chemical and floristic investigations on river Vardar, Macedonia. The study has been started in February 1993 and the most polluted sampling sites along the river flow, amid the first one in high mountain region, in the first three months are presented. In addition to 25 controlled physic-chemical parameters diatom flora communities were investigated through app. 1600 permanent slides. Diatom flora composition and floristic statistical indices in relation to determined pollution are discussed.

Key words: diatoms, rivers, pollution, statistical indices.

ИЗВОД

Крстиќ, С., Меловски, Љ., Левков, З. и Стојановски, П. (1994). Комплексни истражувања на реката Вардар. II. Најзагадените точки во првите три месеци. Екол. Зашт. Живот. Сред., Том 2, Бр. 2, Скопје.

Трудот се однесува на комплексните екосистемски и флористички истражувања на реката Вардар, Македонија. Од истражувањата започнати во февруари 1993 година се прикажани најзагрозените испитувани точки, покрај првата во извориштен дел, за првите 3 месеци. Вкупно беа следени 25 физичко-хемиски параметри и составот на дијатомејските заедници со околу 1600 трајни препарати. Дискутирани се составот на дијатомејската флора и статистичките флорни индекси во однос на утврдената полуција.

Клучни зборови: дијатомеи, реки, загадување, статистички индекси.

INTRODUCTION

As a central water ecosystem river Vardar's basin represents the most important and humanly influenced water resource in Macedonia. Recently proposed projects for its turnover to a serial of dams and subsequently few stagnant water bodies have actualized the need for obtaining the ecological study and starting the pollution monitoring system. Although permanent the up-to-date mostly chemical investigations on river Vardar have pointed several critical sites as severely polluted, but have done nothing in relation to complex impact of polluters on hydrobionts. Round (1991) states that both chemical and biological analyses are essential for monitoring the river conditions. But, as the chemical features have unpredictable fluctuations due to breakage of chemical compounds, absorption and interactions and are diluted or changed in various degrees (water flow, concentration of nutrients, nutrient imput, etc.) under the complex climate influence, the interpretation of those results becomes rather difficult except in broad terms. On the other hand, biology phytocenosys and zoocenosys assessment at specified sampling sites or along the river is crucial for revealing the forced changes in the biocenosys compositions and estimation of living world's response to overall chemical influence. In addition, the choosing of living organism for pollution monitoring is quite doubtful as well. Numerous attemptions for using animal biocenosys have pointed to various disadvantages due to complex reproductive cycles, sampling difficulties and uneven distribution of groups along the river. Keithan et al. (1988) stated that in respect of rivers longitudinal changes in physic-chemical parameters qualitative differences in algal populations should be expected. Lange-Bertalot (1978) has an opinion that: "... diatoms (Bacillariophyta) represent outstanding bioindicators for different degrees of pollution...".

Except the realized project by Šapkarev et al. (1990) and serial of papers (Krstić et al. 1990; Kungulovski et al. 1990; Stojanovski & Krstić 1991; Krstić et al. 1992; Kungulovski et al. 1992; Krstić & Stojanovski 1993), which were mostly based on evaluation of microflora population diversity in relation to Sladeček (1973) system of saprobity indicators and unfortunately not supported by sufficient number of chemical parameters, only the article by Krstić & Melovski (1994) represents the first attempt for autecology estimation of diatom populations in relation to complex physic-chemical parameters in Macedonia.

The presented paper, postulated as the first one in a serial about the complex investigations on river Vardar, has an aim to represent the investigated area, methods and preliminary conclusions about the most polluted river parts in the beginning of the project that had been started in February 1993.

STUDY AREA

Fig. 1 represents river waternet in Macedonia and investigated sampling sites along the central river Vardar water ecosystem. River Vardar has a source on the South slopes of mountain Šar-planina, near the village Vrutok, at 683 m a.s.l. (Gaševski 1978). The total length till the Mediterranean estuary in Greece is 388 km with 301 km belonging to Macedonia. It has the dominant 20535 km^2 drainage area in Macedonia as well. The total inclination of river bed is 640 m while the average relative one is 2,1%.

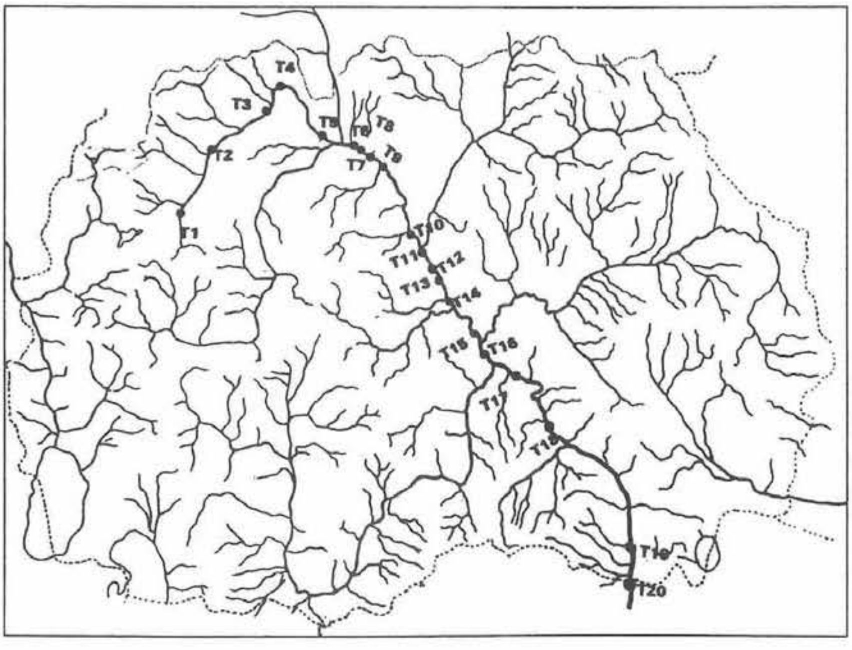

Fig. 1. Map of river waternet in Macedonia and sampling sites on river Vardar
Сл. 1. Мапа на речниот систем во Македонија и испитуваните точки на реката Вардар

Presented 20 sampling sites, carefully chosen for estimation of human influence on river Vardar, are always located infront and after probable major polluters (human settlements, industries, tributaries, etc.) and slightly more frequent around two major cities, the capitol Skopje and industry center Veles. Existing wastewater treatment plants, amid few exceptions, are either out of order or have not been working at all thus resulting with input of completely untreated industrial and communal wastewaters into the river flow.

Description of sampling sites

In order the first monitoring system on river Vardar to be established, the following sampling sites were chosen although some additional points have become important during the investigations and will probably be included in future:

T1 - Village Vrutok (670 m a.s.l.); T2 - after city Gostivar (550 m a.s.l.); T3 - Village Želino (495 m a.s.l.); T4 - Village Jegunovce (425 m a.s.l.); T5 - in front the capitol Skopje (350 m a.s.l.); T6 - after river Lepenec mouth in river Vardar (320 m a.s.l.); T7 - the center of Skopje (310 m a.s.l.); T8 - the main Skopje city communal input (310 m a.s.l.); T9 - the main meat industry waste input in Skopje (300 m a. s. l.); T10 - after river Pčinja mouth in river Vardar (290 m a.s.l.); T11 - in front industrial city Veles (290 m a.s.l.); T12 - the main outflow of food and heavy metal industry in the town center (280 m a.s.l.); T13 - the center of the city Veles (280 m a.s.l.); T14 - after main leather industry outflow in Veles (270 m a.s.l.); T15 - after the chemical industry outflow in Veles area (250 m a.s.l.); T16 - after river Bregalnica mouth in river Vardar (230 m a.s.l.); T17 - after river Crna Reka mouth in river Vardar (220 m a.s.l.); T18 - the Demir Kapija canyon (200 m a.s.l.); T19 - in front city Gevgelija (180 m a.s.l.); T20 - after city Gevgelija - the border (180 m a.s.l.).

The complete description of the sampling sites was published in previous number of this volume.

MATERIALS AND METHODS

The material for microflora analysis and water for physic-chemical ones were sampled in monthly intervals from February 1993 to February 1994. A total of 25 physic- chemical parameters have been measured for each sampling site according to methods recommended in APHA (1985). Diatom populations were collected from stones, pebbles and as epiphytic growth on submerged water plants by scraping or treating the whole collected material.

Method proposed by Hustedt (1930) was applied for boiling and cleaning of the diatom frustules which were than mounted in kanadabalsam (i. r. 1, 53) and observed under light microscope. An average of 200 frustules have been counted in each sample due to obtaining the percentage abudance composition that was later used for calculating the following statistical indices: index of species richness, Margaleff (1958); equitability index, Pielou (1975); index of diversity, Shannon & Weaver (1940); index of domination degree, Karr (1971) and index of similarity, Marczewski & Steinhaus (1959).

RESULTS

Tab. 1 represents the physic-chemical parameters determined in February 1993 for presented eight sampling sites. From T1 sampling site (as a reference point for clean mountain waters) downstream there is an obvious tendency for increasing of all parameters especially the biology important ones. The correlation between O_2 and BOD_5 as well as total nitrogen quantity, nitrogen forms (NH_4, NO_2, NO_3) and total sulfates is very indicative emphasizing T8, T9 and T16 sites for organic pollution and T15 as extraordinary inorganic polluted one. The data for metal ions are characteristic for Na, K and Ca when considering the organic pollution and for P on T15 as very high value for inorganic one. The concentration of heavy metals also increases downstream but without exceptionally high values.

Tab. 1 Physic-chemical parameters determined in February 1993 for 8 presented sampling sites.
Таб. 1 Физичко-хемиски карактеристики на 8-те презентирани точки утврдени во февруари 1993 год.

	T1	T8	T9	T10	T11	T12	T15	T16
Water T. (0C) (Т. на вода)	8,5	3,5	3,8	5,0	5,0	5,0	6,0	4,5
Air T. (0C) (Т. на воздух)	-3,5	3,0	2,0	2,8	5,0	6,0	10,5	11,0
Water flow (m/s) (Проток)	1,0	1,2	0,9	0,8	0,8	0,8	1,0	0,9
pH	7,7	7,9	8,0	8,2	8,2	8,2	7,2	7,7
CO_2 (mg/l)	0,2	0,0	0,0	0,0	1,9	1,7	3,8	2,9
O_2 (mg/l)	19,54	15,5	17,1	7,8	9,5	5,9	9,2	15,6
BOD_5 (mg/l) ($БПК_5$)	5,5	11,5	15,0	0,8	5,1	10,7	1,6	10,4
Dry matter (mg/l) (Сува материја)	130	283	230	261	286	413	200	302
Org. matter (mg/l) (Орг. материја)	61	120	88	91	143	91	71	78
Inorg. matter (mg/l) (Неорг. мат.)	69	164	142	170	143	323	129	224
Total N (mg/l) (Вкупен N)	0,92	7,28	2,55	2,86	1,48	2,05	33,48	3,14
NH_4 (mg/l)	0,82	5,23	2,53	0,76	0,87	0,31	33,1	1,36
NO_2 (mg/l)	0,020	0,292	0,164	0,206	0,234	0,254	0,185	0,203
NO_3 (mg/l)	1,103	5,386	14,030	8,745	5,625	4,085	2,393	4,910
SO_4 (mg/l)	3,91	21,53	17,16	19,78	26,0	15,87	104,4	28,59
P (mg/l)	0,005	1,071	0,137	0,206	0,335	0,419	16,670	1,365
Cl (mg/l)	5,2	16,8	17,6	15,0	15,5	17	29,5	17,5
Na (mg/l)	3,96	36	56,6	28,5	18,6	13,5	17,6	15,1
K (mg/l)	1,91	2,49	2,43	3,11	4,01	4,41	3,84	3,03
Mg (mg/l)	5,33	13,20	11,40	18,30	18,30	15,70	16,40	17,70
Ca (mg/l)	28,0	42,0	34,0	103,7	98,4	82,2	92,1	102,6
Pb (mg/l)	0,038	0,058	0,068	0,102	0,100	0,090	0,096	0,096
Fe (mg/l)	0,229	0,806	0,590	0,706	0,750	0,972	0,992	0,646
Cu (mg/l)	0,016	0,022	0,009	0,039	0,032	0,028	0,043	0,041
Mn (mg/l)	0,004	0,023	0,015	0,044	0,044	0,051	0,070	0,051

The same pattern can be observed in March 1993 with very similar data values except for Fe ion which are much higher. Technology processes of CIV (Chemical Industry in Veles) in that period were based on acid and phosphate components what is confirmed with decreased pH value as well.

Tab. 2 Physic-chemical parameters determined in March 1993 for 8 presented sampling sites.
Таб. 2 **Физичко-хемиски карактеристики на 8-те презентирани точки утврдени во март 1993 год.**

	T1	T8	T9	T10	T11	T12	T15	T16
Water T. (0C) (Т. на вода)	8,5	9	9	9	9,5	11	12	9
Air T. (0C) (Т. на воздух)	4	18	17	12,5	14	12	10	13
Water flow (m/s) (Проток)	0,8	0,9	0,8	7,5	1	1,2	0,9	1
pH	7,2	7,6	8	7,9	7,7	7,5	6,9	7,5
CO_2 (mg/l)	3,1	2,6	3,3	6,2	8,1	12,4	10	10
O_2 (mg/l)	10,5	10,3	9,97	8,72	8,5	8,72	8,56	7,84
BOD_5 (mg/l) ($БПК_5$)	1,49	3,89	9,62	7,1	7,37	5,42	8	6,09
Dry matter (mg/l) (Сува материја)	168	395	432	497	395	430	914	602
Org. matter (mg/l) (Орг. материја)	127	116	144	86	153	142	136	174
Inorg. matter (mg/l) (Неорг. мат.)	41	279	288	411	242	288	778	428
Total N (mg/l) (Вкупен N)	1,06	3,88	2,37	1,52	2,09	2,45	6,88	2,34
NH_4 (mg/l)	0,28	3,74	1,55	0,69	0,33	1,07	6,83	1,02
NO_2 (mg/l)	~0.0	0,15	0,26	0,29	0,4	0,51	0,34	0,44
NO_3 (mg/l)	1,43	1,08	4,91	4,22	3,32	2,68	5,2	3,92
SO_4 (mg/l)	5,27	20,8	21,9	22,2	22,8	29	86,5	56,6
P (mg/l)	0,19	1,17	0,31	1,03	0,79	0,57	42,6	1,53
Cl (mg/l)	2,5	24	11	13	13	21	21	17
Na (mg/l)	2,43	20,8	13,9	13,2	20,1	21,1	20,3	22,6
K (mg/l)	2,03	5,32	6,19	7,46	5,21	5,5	8,01	5,49
Mg (mg/l)	4,55	16,8	14,2	14,5	16,5	15,9	24,1	15,1
Ca (mg/l)	56,5	70,5	44,5	73,5	66	63,5	111	75
Pb (mg/l)	0,18	0,1	0,06	0,11	0,09	0,31	0,28	0,1
Fe (mg/l)	0,4	7,7	1,55	9,35	9,6	11,4	22,5	11,7
Cu (mg/l)	0,02	0,04	0,02	0,04	0,03	0,03	0,03	0,03
Mn (mg/l)	0,01	0,12	0,03	0,16	0,15	0,13	0,15	0,15

The values for April 1993 are generally much lower compared to previous months most probably due to increased water flow related to spring rains in mountain areas. Nevertheless, the values for BOD_5 are on the same levels indicating high rate input of organic matters amid increased dillution rate.

Tab. 3 Physic-chemical parameters determined in April 1993 for 8 presented sampling sites.
Таб. 3 Физичко-хемиски карактеристики на 8-те презентирани точки утврдени во април 1993 год.

	T1	T8	T9	T10	T11	T12	T15	T16
Water T. (0C) (Т. на вода)	8,5	14,0	14,0	15,0	15,0	16,0	15,0	14,0
Air T. (0C) (Т. на воздух)	17	25	20	21	19	19	14	16
Water flow (m/s) (Проток)	1,1	1,0	1,2	1,1	1,1	1,2	1,0	1,1
CO_2 (mg/l)	5,50	4,10	2,15	3,80	14,50	4,80	4,50	6,50
O_2 (mg/l)	9,59	9,32	9,27	9,51	10,00	9,30	9,40	7,10
BOD_5 (mg/l) ($БПК_5$)	1,03	9,18	8,22	5,62	5,36	7,45	4,85	5,70
Dry matter (mg/l) (Сува материја)	127	266	221	281	251	243	138	230
Org. matter (mg/l) (Орг. материја)	86	66	78	105	64	91	35	59
Inorg. matter (mg/l) (Неорг. мат.)	41	200	143	176	187	152	103	171
Total N (mg/l) (Вкупен N)	1,56	4,57	2,27	1,70	5,64	7,25	7,38	5,47
NH_4 (mg/l)	0,49	2,92	0,31	0,62	0,82	0,82	2,76	1,16
NO_2 (mg/l)	0,004	0,130	0,042	0,242	0,280	0,310	0,310	0,410
NO_3 (mg/l)	1,65	2,29	4,09	3,81	3,66	4,32	4,13	3,64
SO_4 (mg/l)	17,38	15,59	14,93	15,59	15,10	16,10	39,90	14,40
P (mg/l)	~ 0,0	0,17	~ 0,0	~ 0,0	0,03	~ 0,0	0,595	0,24
Cl (mg/l)	5,5	12	16	11	10	18	13	12
Na (mg/l)	2,21	77,30	40,70	28,10	36,30	55,90	123,70	34,00
K (mg/l)	1,220	2,170	2,290	2,580	3,520	2,630	3,470	3,100
Mg (mg/l)	1,695	5,790	9,570	3,800	3,000	2,400	7,100	7,700
Ca (mg/l)	6,740	4,125	19,930	25,780	9,700	10,500	5,700	9,500
Pb (mg/l)	0,090	0,090	0,084	0,083	0,084	0,085	0,091	0,142
Fe (mg/l)	0,52	1.65	0,44	1,82	5,35	1,03	6,90	6,50
Cu (mg/l)	0,010	0,013	0,010	0,012	0,014	0,011	0,016	0,019
Mn (mg/l)	0,012	0,050	0,028	0,042	0,081	0,035	0,100	0,101

Although there is an interesting observed tendency for developing very similar diatom flora assemblages in investigated area, only few taxa (*Diatoma vulgaris, Synedra ulna var. oxyrchynchus, Synedra vaucheriae, Rhoicosphenia abbreviata, Navicula lanceolata, Navicula tripunctata, Cymbella helvetica, Cymbella minuta, Nitzschia dissipata*) were determined in all sampling sites generally increasing their abudance towards higher pollution levels. However, taxa belonging to genera *Navicula, Gomphonema* and *Nitzschia* increase their abudance and diversity gradually towards most polluted sites with assemblages dominated by *Nitzschia palea, Nitzschia dissipata, Gomphonema parvulum, Gomphonema olivaceum, Navicullla phyllepta* and by not so dominant but marked presence of *Nitzschia umbonata* and *Nitzschia amphibia*. *Pinnularia microstauron var. brebissonii* can only be determined on T15 sampling site as a form characteristic for low pH reaction.

Tab. 4 List of diatom taxa and their relative abudance for 8 presented sampling sites in February 1993.
Таб. 4 Листа на дијатомејски таксони и нивна релативна застапеност за 8-те презентирани точки за февруари 1993 год.

TAKSONI	T1	T8	T9	T10	T11	T12	T15	T16
Cyclotella comta (Ehr.)Kutz.			+					
Cyclotella iris Braun et Heriband			1			+		
Cyclotella meneghiniana Kutz.			1				+	
Cyclotella ocelata Pantocsek			1		+		+	
Diatoma elongatum Ag.		2			7			
Diatoma mesodon	4						6	7
Diatoma vulgaris Bory	+	37	45	5	6	4	2	3
Meridion circulare Ag.	+							
Meridion circulare var.constricta (Ralfs)V.H.		+						
Ceratoneis arcus Kutz.		+	+	+	+	3	+	
Asterionella formosa Hasall		1	2	+	+	10		5
Fragilaria capucina Desmazieres					2	+		
Fragilaria capucina var.capitellata (Grun.)L.B.	12		0.52				+	+
Fragilaria intermedia Grun.						+		
Fragilaria parasitica					6			
Synedra acus Kutz.								+
Synedra acus var.angustissima Grun.							+	
Synedra ulna (Nitzsch)Ehr.	1		+		+		+	+
Synedra ulna var.oxyrinchus		1	+	2	+	+	+	+
Synedra vaucheriae Kutz.				+			+	3
Cocconeis disculus (Sch.)Cl.	4		1.03					
Coconeis pediculus Ehr.			+	+			+	
Coconeis placentula Ehr.	10							
Coconeis placentula var.euglypta Ehr.	24	+	6	+	+	2		+
Achnanthes lanceolata Breb.	6		0.52				+	
Achnanthes lanceolata var.rostrata (Ostup)L.B.	3					+		
Achnanthes minutisima Kutz.							+	
Rhoicosphaenia abbreviata Kutz.	4	2	4	3	+	5	5	5
Gyrosigma acuminatum (Kutz.)Rabh.	4		+			+		
Gyrosigma scalproides (Rabh.)Cl.			1					
Frustulia vulgaris (Thw.)De Toni	1				+	+		
Diploneis ovalis Kutz.					+			
Navicula capitatoradiata Germain		1	8	15	6	6	4	5
Navicula cryptocephala Kutz.				+		+		
Navicula cryptotenela L.B.			2	+		6	5	5
Navicula cuspidata Kutz.	9						+	
Navicula goeppertiana (Bleisch)H.L.Sm.						3	+	+
Navicula lanceolata (Ag.)Ehr.	+	14	6	10	7	6	7	6
Navicula menisculus Schumann				7				
Navicula phyllepta Kutz.	3	4	2	3	10	4	7	5
Navicula pupula Kutz.							+	+
Navicula pygmaea Kutz.						+		
Navicula radiosa Kutz.	1							
Navicula tripunctata (O.Mull)Bory	6	7	5	4	+	3	+	2
Navicula viridula var.rostelata (Kutz.)Cl.			+				+	
Caloneis bacillum (Grun.)Cl.	2							
Cymbella affinis Kutz.		2	1	+	2	5	+	+
Cymbella helvetica Kutz.	+	7	2	3	+	3	+	+
Cymbella minuta Hilse ex Rabh.	+	4	3	1	3	3	2	8
Cymbella prostrata (Berk.)Cl.	+		1					
Cymbella sinuata Kutz.							+	3
Cymbella solea						+	+	
Cymbella silesiaca Bleish in Rabh.			+					
Cymbella tumida (Breb.)V.H.							+	
Amphora libica Ehr.			1					
Amphora ovalis Kutz.							+	
Amphora pediculus Kutz.			1					
Gomphonema olivaceum (Horn.)Breb.		10	1	7	17	5	31	12
Gomphonema parvulum Kutz.		+		7	8	4	7	10
Rhopalodia gibba (Ehr.)O.Mull							+	
Nitzschia amphibia Grunow							5	+
Nitzschia apiculata					+			
Nitzschia constricta (Kutz.)Ralfs			+	+		+	+	
Nitzschia dissipata Kutz.	2	4	3	10	12	5	2	5
Nitzschia heufleriana	+	+	+	+	+			3
Nitzschia intermadia Hantzsch	2				+			
Nitzschia linearis (Ag.)W.Smith			1	+	+	8	+	+
Nitzschia palea (Kutz.)W.smith			2	8	6	5	11	3
Nitzschia recta Hantzsch				+	+		+	3
Nitzschia sigmoidea (Nitzsch.)				+	+	8		+
Nitzschia umbonata (Ehr.)L.B.			+				+	
Cymatopleura solea (Breb)W.Smith			+					
Surirella brebisonii var.kuetzingii		5	4	10	7	+	6	3
Surirella minuta Breb.		+	+	+		+		+

Tab. 5 List of diatom taxa and their relative abudance for 8 presented sampling sites in March 1993.
Таб. 5 Листа на дијатомејски таксони и нивна релативна застапеност за 8-те презентирани точки за март 1993 год.

TAXA - MARCH '93	T1	T8	T9	T10	T11	T12	T15	T16
Aulacoseira granulata (Ehr.)Simonsen						+		
Cyclotella meneghiniana Kutz.				4		+		1
Cyclotella ocellata Pantocsek		+				+	2	
Cyclotella stelligera Cleve & Grunov				+				
Diatoma hyemalis (Lyngb.)Heib.			5	15				
Diatoma mesodon (Ehr.)Kutz.	10							
Diatoma vulgaris Bory		33	38	7	23,5	14	3	2,5
Meridion circulare Ag.	15							
Ceratoneis arcus Kutz.		+	4	2	9,5	2,5	1	
Asterionella formosa Hasall				5	2,5	2	+	2,5
Fragilaria intermedia Grun.				+				
Fragilaria pinnata Ehr.	+				+			
Synedra acus var.angustissima Grun.						+		
Synedra ulna (Nitzsch)Ehr.		+		+	2,5			+
Synedra ulna var.oxyrhynchus (Kutz.)V.H.		2	2	3	2	2	3	3
Synedra vaucheriae Kutz.		+	+	+	4	2	1	2,5
Synedra vaucheriae var.capitellata Grun.		+						
Cocconeis pediculus Ehr.	5					+	3	+
Cocconeis placentula Ehr.				+				
Cocconeis placentula var.euglypta Ehr.	10	3	2	1	3	3	3	2
Achnanthes lanceolata Breb.			+				+	
Achnanthes minutissima Kutz.	5							
Rhoicosphaenia abbreviata Kutz.		4		4	4	3	6	+
Gyrosigma acuminatum (Kutz.)Rabh.				+	2			
Gyrosigma scalproides (Rabh.)Cl.			+					
Frustulia vulgaris (Thw.)De Toni		+		+	+			
Caloneis bacillum (Grun.)Cl.	+							
Navicula accomoda Hustedt			+			+		
Navicula capitatoradiata Germain		+	2	1	2	3,5	4	+
Navicula cryptotenella L.B.	20	+	+			+	+	+
Navicula cuspidata Kutz.					+		1	
Navicula goeppertiana (Bleisch)H.L.Sm.					2		3	9
Navicula lanceolata (Ag.)Ehr.		5	6	10	5	10	15	8
Navicula phyllepta Kutz.		+	+	+		9	10	+
Navicula tripunctata (O.Mull)Bory	2	+	2	1,5	3	2,5	3	
Navicula trivialis L.B.							+	
Pinullaria microstauron (Ehr.)Cl.								+
Cymbella affinis Kutz.				+				+
Cymbella helvetica Kutz.		3		1,5	2,5	+	+	
Cymbella minuta Hilse ex Rabh.	+	15	7	10	2	4	2	9
Cymbella prostrata (Berk.)Cl.					2	+		1
Cymbella silesiaca Bleish in Rabh.		+						
Cymbella sinuata Kutz.		+				+	1	
Amphora ovalis Kutz.				+	2,5		2	
Amphora pediculus Kutz.	5				+		+	
Gomphonema olivaceum (Horn.)Breb.		4	15	10	1	6	7	19
Gomphonema parvulum Kutz.		+		5		8	1	5
Epithemia sorex Kutz.				+				
Rhopalodia gibba (Ehr.)O.Mull				+				
Hantzschia amphyoxis (Ehr.)Grun.							+	
Nitzschia amphibia Grunow							5	+
Nitzschia constricta (Kutz.)Ralfs				+				+
Nitzschia dissipata Kutz.		12	3	3	7	2	7	14
Nitzschia fonticola Cholnoky	28		+		2			
Nitzschia heufleriana Grun.		+	+					+
Nitzschia intermedia Hantzsch		7	5	1,5	2	4		+
Nitzschia linearis (Ag.)W.Smith		+	5		2,5	+		+
Nitzschia palea (Kutz.)W.smith		+		10		15	3	2,5
Nitzschia recta Hantzsch							+	
Nitzschia sigmoidea (Nitzsch.)Ehr.				1	2,5			
Nitzschia umbonata (Ehr.)L.B.						+		
Cymatopleura elliptica (Breb)W.Smith					+			
Cymatopleura solea (Breb)W.Smith			+	2	2		+	
Surirella ovata Kutz.		10	4		5	2,5	10	19
Surirella ovata var.apiculata W.Smith							2	
Surirella ovata var.pinnata W.Smith		2		2	2	5	+	

Tab. 6 List of diatom taxa and their relative abudance for 8 presented sampling sites in April 1993.
Таб. 6 Листа на дијатомејски таксони и нивна релативна застапеност за 8-те презентирани точки за април 1993 год.

TAXA - APRIL' 93	T1	T8	T9	T10	T11	T12	T15	T16
Aulacoseira granulata (Ehr.)Simonsen						+		
Cyclotella comta (Ehr.)Kutz.						+		+
Cyclotella iris Braun et Heriband								+
Cyclotella meneghiniana Kutz.			+	3		15	+	4
Cyclotella ocelata Pantocsek						+		+
Stephanodiscus neoastraea Hakansson & Hickel								+
Diatoma ehrenbergii Kutz.					3			
Diatoma hyemalis (Lyngb.)Heib.	10				3	+		3
Diatoma mesodon (Ehr.)Kutz.			+					
Diatoma vulgaris Bory		55	16	3,5	1	5	2	5
Meridion circulare Ag.	42		+					1
Ceratoneis arcus Kutz.			2	2,5	1	2	2	5
Ceratoneis arcus var.amphyoxis Rabh.			2		+			3
Fragilaria capucina Desmazieres								3
Fragilaria pinnata Ehr.	+				2			1
Synedra acus Kutz.				+		+		+
Synedra acus var.angustissima Grun.						+		
Synedra parasitica W.Sm.	+							
Synedra parasitica var.subconstricta Grun.						+		
Synedra ulna (Nitzsch)Ehr.	4	+			+	1,8		3
Synedra ulna var.oxyrinchus(Kutz.)V.H.	5	+	3,5	3,5	+	7	3	3
Synedra vaucheriae Kutz.		+	3	2	1	+	6	2,5
Synedra vaucheriae var.capitellata Grun.	+		+					
Eunotia pectinalis var.minor Kutz.	2							
Cocconeis disculus (Sch.)Cl.							+	
Cocconeis pediculus Ehr.			1,5			+	+	+
Cocconeis placentula Ehr.	+					+		
Cocconeis placentula var.euglypta Ehr.	6	22	10	2,5	1	13,5	4	5
Achnanthes lanceolata Breb.			2	2		+		+
Achnanthes lanceolata ssp.rostrata (Ostr.) L.B.					3			
Rhoicosphaenia abbreviata Kutz.	2		5	5	1	7		3
Gyrosigma acuminatum (Kutz.)Rabh.	1							1
Frustulia vulgaris (Thw.)De Toni	+							
Caloneis amphisbaena (Bory)Cl.								1
Caloneis bacillum (Grun.)Cl.	7							
Navicula accomoda Hustedt						+	+	+
Navicula bacillum Ehr.						1		1
Navicula capitatoradiata Germain			1	3,5		6	2	5
Navicula cryptotenella L.B.			+		9	+	10	6
Navicula cuspidata Kutz.				+				
Navicula decussis Ostr.						1		
Navicula goeppertiana (Bleisch)H.L.Sm.						7	+	2,5
Navicula lanceolata (Ag.)Ehr.	5		20	18,5	10	2,3	6	6
Navicula phyllepta Kutz.						2		+
Navicula pupula Kutz.								+
Navicula tripunctata (O.Mull)Bory		+	4	3,5	2	4	4	1
Navicula trivialis L.B.								+
Pinnularia microstauron var. brebisonii (Kutz.)Mayer							+	
Cymbella affinis Kutz.			+	2	+	+	+	
Cymbella helvetica Kutz.		+	1	3	1	+		3
Cymbella minuta Hilse ex Rabh.	2		3,5	4	4	2	5	2,5.
Cymbella prostrata (Berk.)Cl.			+					
Cymbella sinuata Kutz.		23	4	3	+	3	3	3
Amphora lybica Ehr.								+
Amphora ovalis Kutz.						+		
Amphora pediculus Kutz.						+	+	
Gomphonema olivaceum (Horn.)Breb.		+	14,5	15	23	+	11,2	4
Gomphonema parvulum Kutz.			2		15	3,4	20	3,5
Epithemia adnata (Kutz.)Breb.							+	
Hantzschia amphyoxis (Ehr.)Grun.			+					
Nitzschia amphibia Grunow					+	7	6,3	
Nitzschia constricta (Kutz.)Ralfs				1				
Nitzschia dissipata Kutz.			2	3,5	4	6	3,5	2
Nitzschia fonticola Cholnoky	14		3	3,5	15	3	+	3,5
Nitzschia heufleriana Grun.	+							
Nitzschia homburgiensis L.B.								+
Nitzschia intermedia Hantzsch	+			+		+		
Nitzschia linearis (Ag.)W.Smith	+						+	2
Nitzschia palea (Kutz.)W.smith						+	8	5
Nitzschia parvula W.Sm.						+		
Nitzschia sigmoidea (Nitzsch.)Ehr.						1		
Nitzschia umbonata (Ehr.)L.B.						+	+	
Cymatopleura solea (Breb)W.Smith								1
Surirella ovata Kutz.			+	12	1		4	4
Surirella ovata var.pinnata W.Smith				3,5		+		1,5

Tab. 7 Diatom flora index of similarity for 8 presented sampling sites obtained for all 3 months in 1993.
Таб. 7 Индекс на сличност на дијатомејската флора за 8-те презентирани точки за сите 3 месеци во 1993 год.

FEBRUARY '93								
Sampling sites	T1	T8	T9	T10	T11	T12	T15	T16
T1	\	27,78	30,00	22,73	33,33	26,09	20,37	26,67
T8		\	41,86	61,29	62,50	45,95	31,91	51,43
T9			\	50,00	43,75	46,00	38,89	41,18
T10				\	62,16	63,16	45,83	69,44
T11					\	52,38	38,46	50,00
T12						\	39,62	51,16
T15							\	48,98
T16								\

MARCH '93								
Sampling sites	T1	T8	T9	T10	T11	T12	T15	T16
T1	\	11,11	18,75	6,82	15,00	18,92	14,63	10,81
T8		\	48,57	45,24	42,86	56,41	48,78	52,78
T9			\	33,33	41,46	35,59	37,21	39,47
T10				\	48,89	41,30	41,67	40,91
T11					\	42,22	45,65	45,24
T12						\	54,76	51,28
T15							\	44,19
T16								\

APRIL '93								
Sampling sites	T1	T8	T9	T10	T11	T12	T15	T16
T1	\	26,60	33,30	20,80	28,20	17,20	15,20	18,60
T8		\	35,30	29,70	48,10	28,80	30,30	25,00
T9			\	53,50	56,70	40,70	48,80	47,20
T10				\	50,00	59,20	46,50	48,10
T11					\	45,60	52,70	47,00
T12						\	49,00	47,50
T15							\	41,50
T16								\

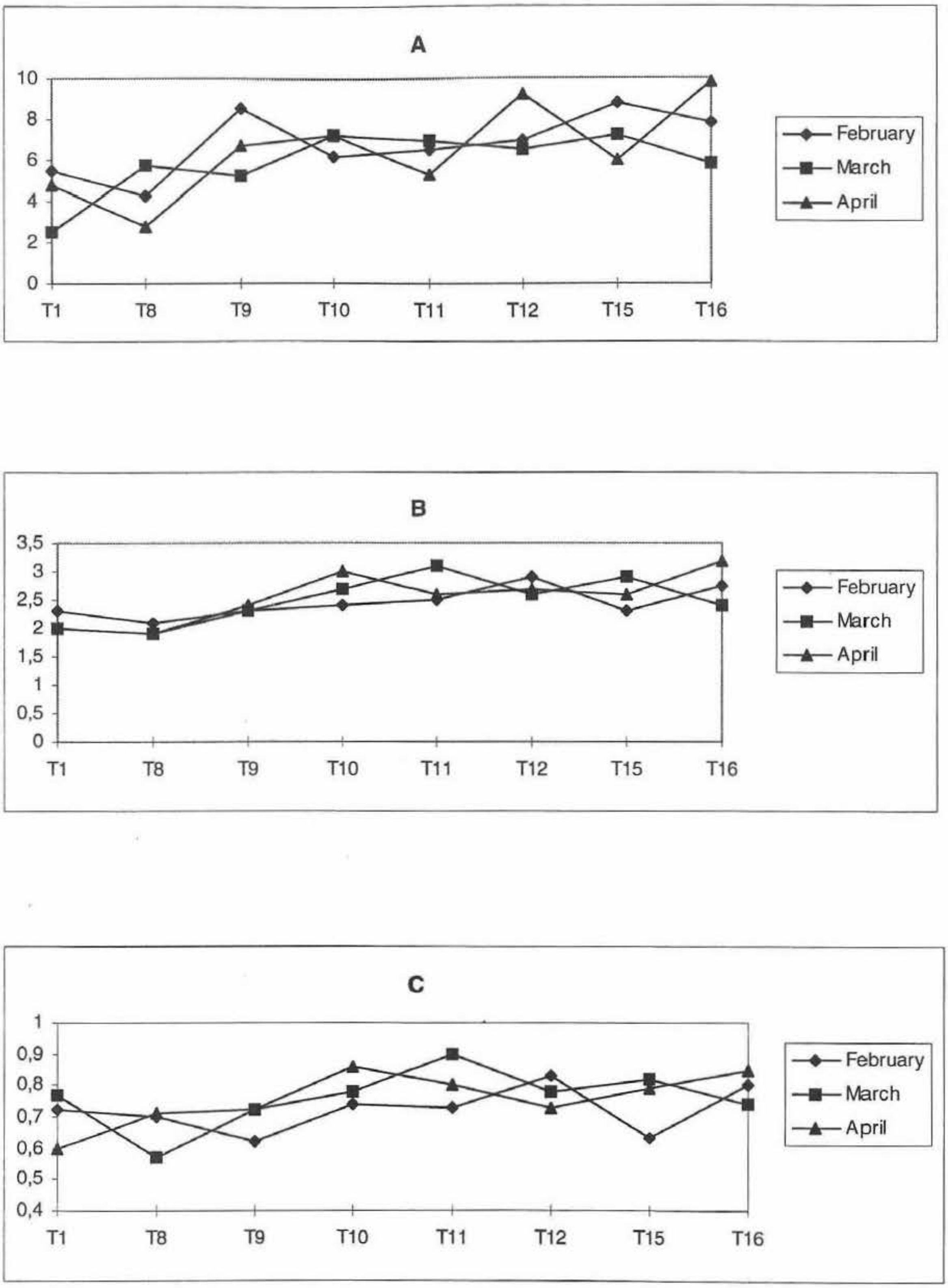

Fig. 2. Plot presentation of various diatom flora indices for 8 sampling sites and for all 3 investigated months in 1993. A - Index of richness; B - Index of diversity; C - Index of equitability; D - Domination degree

Сл. 2 Графички приказ на различни индекси на дијатомејската флора за 8-те испитувани точки за сите 3 месеци во 1993 год. А - Индекс на богатство; Б - Индекс на диверзитет; Ц - Индекс на хомогенитет; Д - Степен на доминација.

DISCUSSION

The first part of physic-chemical data values (Tab. 1, 2, 3) considering the temperatures, water flow, CO_2 and O_2 are quite expectable for winter months in Macedonian continental climate. There is a significant drop of O_2 levels from T1 towards sites with higher pollution due to active microbial decomposition processes even in such low water temperatures what is confirmed with increased BOD_5 values as well.

Total dry matter values, consist of organic and inorganic dry matter data, as an important parameter for artificial input of additional nutrients in river ecosystem, increases quite irregularly downstream closely related to the intensity of human activities on a specific sampling date. The highest value of 914 $mg \cdot l^{-1}$ on T15 supports the high level of observed inorganic pollution mostly related to sulfate and phosphate inorganic compounds. Relatively high dry matter values determined on the other sampling sites are always in connection with organic waste input.

The second group of the physic-chemical parameters is consist of major biologically active nutrient compounds represented by data for total N, ammonia, nitrates, nitrites and values for total phosphates and sulfates. There is again a very obvious tendency for increasing of all towards most polluted sites downstream. The most striking is increasing of total N, sulfates and total P values on T15 sampling site indicating continuous vast inorganic pollution combined with a very low levels of NO_2 and NO_3 ions as intermediate forms of organic decomposition. Decreased levels of this group of data (as well as for all the others) recorded in April 1993 can only be explained with very high water levels (flow). Nevertheless, the tendency of increasing of all measured parameters is rather obvious for April as well.

When comparing these quite high data values for a natural water ecosystems with various waste and natural running waters (according to accessible literature), the values for Jukskei-Crocodile river system (Schoeman 1976), river Nida (Pasternak & Starzecka 1979), pulp and paper effluent (Amblard et al. 1990) and Linggi river basin (Khan 1991) are either far below the stated levels for river Vardar or similar but for heavily polluted wastewaters.

The last group of physic-chemical data represents the values of metal ions concentration as elements of waste degradation or heavy metal ion input. The leading role have Na, Ca and K ions in February and March 1993, while the data for April 1993 are again somehow unexplainable and seem chaotic although obviously increasing downstream. Some unexpected peaks for Fe ion (Tab. 2, 3) are also recorded.

Diatom flora lists of qualitative composition and relative abudance (Tab. 4, 5, 6) show similar patterns stated for numerous lowland rivers worldwide (Lange-Bertalot 1978; Patrick & Palavage 1994). T1 as a control unpolluted site constantly affords development of relatively poor, epilithic on mosses (*Fontinalis pyretica*) diatom community dominated by non-pollution tolerant species (Lange-Bertalot 1979a, 1979b; Descy 1979; Watanabe et al. 1986; Van Dam et al. 1994) such as: *Diatoma mesodon, Meridion circulare, Cocconeis placentula var. euglypta, Navicula cryptotenella, Nitzschia fonticola*. Temporary increase in abudance for *Navicula cuspidata* and *Navicula tripunctata* was recorded in February 1993 and has not been confirmed after.

T8 and T9 sampling sites showed a rapid turnover to a diatom flora dominated mostly by *Diatoma vulgaris, Gomphonema olivacum, Navicula lanceolata* and *Cocconeis placentula var. euglypta* but with marked presence of *Nitzschia dissipata, Rhoicosphenia abbreviata, Synedra vaucheriae,* then *Gomphonema parvulum* and *Synedra ulna var. oxyrhynchus* as well as the first records of *Nitzschia palea*, an community representing a constant and high organic input.

The most unstable sampling sites, according to diatom flora composition, in investigated period were T10 and T11 showing quite rich microflora and supporting development of numerous taxa with very different pollution tolerance and variable in their relative abudance. *Gomphonema olivaceum, Navicula lanceolata, Diatoma hiemale, Ceratoneis (Hannea) arcus* were very dominant, but *Nitzschia palea, Cymbella minuta, Surirella brebissonii var. kutzingii, Navicula capitatoradiata* were also recorded with high abudance. That part of investigated river is obviously under a critical influence of river Pčinja as an tributary with variable pollution load. Autopurification processes that are taking place after pollution input from Skopje give an opportunity for developing of non- pollution tolerant assemblages, but are frequently interrupted by high concentration organic (toxic) input manifested with sudden fish killings as well.

A special part of examined area represents T15 sampling site with ecologically disastrous recorded situation. *Nitzschia palea, Gomphonema parvulum, Navicula cryptotenella, Nitzschia amphibia, Synedra vaucheriae, Gomphonema olivaceum, Navicula phyllepta, Navicula lanceolata, Nitzschia dissipata* have their maximal densities interchanging among themselfs the dominance in time. Remarkable is the presence of *Surirella brebissonii var. kutzingii* and *Nitzschia umbonata* thus confirming the constant input of mineral nutrients. Although the devastated river banks seemed lifeless with stones covered by thick sulfate salt layer, the mineral input has its significance for quite variable microflora development in parts of the river where the direct wastewater inflow is sufficiently diluted. Stones which are directly in the wastewater flow showed no microflora assemblages and could be very easily broken with slight touch due to a long term exposure to strong acids and alkalii.

T16 sampling site was still under a strong influence of T15, but additionally polluted with vast amounts of organically polluted waters of river Bregalnica. Therefore, taxa dominant on T15 decreased their abudance, but sometimes (March 1993) they could again be found in dominance above 15%. This sampling site resembles T10 but strongly dominated by wastewaters from T15 site. Again autopurification processes took place together with physical sedimentation forces, but the river in this part is still heavily loaded with nutrients. It is sufficiently wide for supporting the plankton growth and *Asterionella formosa, Cyclotella meneghiniana, Cyclotella comta, Stephanodiscus astraea, Synedra acus* could be recorded although the huge benthic forms such as *Surirella* taxa were dominant on muddy habitats.

Tab. 7 and Fig. 2 represent the attempt of statistical evaluation of various floristic indices. According to similarity indices (Tab. 7) T1 sampling site has the lowest microflora similarity with all the other sampling sites what was expected. All other sampling sites have similarity indices ranging between 30 and 70% often very difficult for explanations, but on average the most distant sites show decreasing in similarity. The highest similarity index have T10 and T16 (69, 44%) in February 1993 and the lowest T1 and T10 (6, 82%) in March 1993. Remarkable are low similarities in April 1993, especially between T8 and greatly polluted T12, T15 and T16 what can once more be related to high water flow.

The indices of richness for all three months are supportive to increased richness on the most polluted sites due to well known mixotrophy abilities of diatoms. Diversity indices are high on organically polluted sites although quite variable through investigated months and increase downstream as well. Indices of equitability and domination degree are rather difficult for discussion because they are high on T1 as well. But, there is a tendency for them to be high on polluted sites and decreasing of domination degree on T10, T11 and T12 sampling sites might be related to low water temperatures, input of some toxic substances or frequent intense organic loads what is the most probable explanation. Further investigations over a much longer period of time should reveal the true cause.

CONCLUSIONS

Presented data on complex investigations on river Vardar for period February - April 1993 have insufficient amount of informations for establishing a certain pollution degree pattern. Nevertheless, investigated months and pointed sampling sites enabled us to form the following conclusions:

The source mountain waters (T1) of river Vardar show constant low water pollution level with low species indexed diatom flora dominated by taxa confirmed as non-pollution tolerant ones. Therefore, T1 sampling site is very useful as a reference point for further investigations.

Downstream river area starting after city of Skopje and spreading until beyond city of Veles (T8-T12 sampling sites) represents organically polluted part of the river (mainly originating from communal and food industry wastewaters input) variable in degree and intensity. That part of the river flow supports quite variable diatom flora communities with mixed dominance among species known as pollution tolerant and non-tolerant ones. *Nitzschia* and *Navicula* taxa dominate this area with *Diatoma* and *Cocconeis* forms still present in high percentage. Development of *Gomphonema parvulum* and *Nitzschia palea* make this area alfa-mesosaprobic zone but that situation is frequently changed to poly saprobity with sudden peaks far beyond mesosaprobity range of pollution in sense of particular polluters. The stated conclusions are in coordinance with Lange-Bertalot (1978) taxa list for rivers Rhine and Main and Van Dam et al. (1994) checklist for diatoms ecology indicators.

T15 sampling site represents an unique ecological catastrophe site with waste inorganic input far in ultra saprobity range. The river banks immediately after wastewater inlet are completely lifeless with thick layers of hardly degradable sulfate and phosphate compounds. Epilithic diatom flora communities develop on places where wastewater is sufficiently diluted. Diatom assemblages never rich so high percentage abudance due to frequent shocks and are again composed of taxa known for severely polluted waters. According to all stated data this point is the most critical one in all river flow and the river can not improve its quality even very far downstream. Records of *Pinnularia* and *Epithemia* taxa, although with very low abudance, confirm the acidity pattern of this site.

T16 sampling site is somehow recovery one, but additionally loaded with waste organic input from Bregalnica tributary. Diatom flora recovery can be seen in species richness and their percentage abudance, but the pollution degree still remains in alpha to poly saprobity zone. *Nitzschia* taxa have their maxima in these waters and developing of planktonic forms is also supported.

REFERENCES

Amblard, C., Couture, P. & Bourdier, G. (1990). Effects of a pulp and paper mill effluent on the structure and metabolism of peryphytic algae in experimental streams. Aquatic toxicology, 18, 137-162.

A. P. H. A. (1985). Standard Methods for the Examination of water and Wastewater. 16th ed., American Public Health Ass., 1268 pp.

Descy, J. P. (1979). A new approach to water quality estimation using diatoms. Nova Hedwigia, B. 64: 305-323.

Gaševski, M. (1978). The basic characteristics of the river network in SR Macedonia. Soc. De Geogr. de la R. Macedonie, Skopje, T. 15-16, 29-42.

Hustedt, F. (1930). Bacillariophyta (Diatomeae). 10, Jena.

Karr, J. R. (1971). Structure of avian communities in selected Panama and Ilinois habitats. Ecol. Monogr., 41, 3: 207-233.

Keithan, E. D., Lowe, R. L. & De Yoe, H. R. (1988). Benthic diatom distribution in a Pennsylvania stream. Role of pH and nutrients. Journal of Phycology, 24: 581-585.

Khan, I. S. A. N. (1991). Effects of urban and industrial wastes on species diversity of the diatom community in a tropical river, Malaysia. Hydrobiologia 224: 175- 184.

Krstić, S., Stojanovski, P. & Kungulovski, Dž. (1990). Floristic and saprobiologic investigations of the mouth waters of river Lepenec at river Vardar. God. zb. Biol., Skopje, T. 41-42, 251-261.

Krstić, S., Kungulovski, Dž. & Stojanovski, P. (1992). The microflora as indicator of saprobity level in Bregalnica mouth waters at river Vardar. God. zb. Biol., T. 45, 149-161.

Krstić, S. & Stojanovski, P. (1993). Comparative microflora analysis in mouth waters of rivers Bošava and Anska, Macedonia. God. zb. Biol., T. 46, 101-110.

Krstić, S. & Melovski, Lj. (1994). Preliminary results from saprobiology investigations on river Vardar. Proceedengs of the Symposium "Environmental monitoring" - Macedonian Ecological Society, May 1993, Skopje.

Kungulovski, Dž., Krstić, S. & Stojanovski, P. (1990). Comparative investigations of bacterial microflora in the mouth waters of rivers Pena and Treska. God. zb. Biol., Skopje, T. 41-42, 275-283.

Kungulovski, Dž., Krstić, S. & Stojanovski, P. (1992). Comparative microflora investigations of the mouth waters of rivers Topolka and Babuna. God. zb. Biol., T. 45, 135-148.

Lange-Bertalot, H. (1978). "Differentiating species" of diatoms: a better criterium of water pollution than "leading indicators". Arch. Hydrobiol. /Suppl. 51, 393-427.

Lange-Bertalot, H. (1979a). Tolerance and population dynamics of benthic diatoms under varying waste water loading. Arch. Hydrobiol. /Suppl. 56, 184-219.

Lange-Bertalot, H. (1979b). Pollution tolerance of diatoms as a criterion for water quality estimation. Nova Hedwigia, B. 64: 285-304.

Marczewski, M. & Steinhaus, H. (1959). On the taxonomic distance of biotopes. Zastosowania matem. 4: 195-203.

Margaleff, D. R. (1958). Informatical theory in ecology. Year book of the Society for General Systems Research. Vol. 3., 36-71.

Pasternak, K. & Starzecka, A. (1979). Chemism of the river Nida water and some ralations between its bacteriological and chemical features. Acta Hydrobiol., 21, 4, Krakow, 361-395.

Patrick, R. & Palavage, D. M. (1994). The value of species as indicators of water quality. Procc. of the Acad. of Nat. Sci. of Philadelphia, 145: 55-92.

Pielou, E. C. (1975). Ecological diversity. Wiley, New York.

Round, F. E. (1991). Diatoms in river water-monitoring studies. Journal of Applied Phycology, 3: 129-145.

Schoeman, F. R. (1976). Diatom indicator groups in the assesment of water quality in the Jukskei-Crocodile river system (Transvaal, Republic of South Africa). Journal of Limnological Society of Southern Africa, 2 (1): 21-24.

Shannon, C. E. & Weaver, W. (1949). A mathematical theory of communication. Univer. Ilinios Press., Chicago, London, 125 pp.

Sladeček, V. (1973). System of water quality from the biological point of view. Arch. Hydrobiol., Be. 7, 1-220, Stuttgart.

Stojanovski, P. & Krstić, S. (1991). Saprobiology characteristics of mouth waters of river Pčinja. God. zb. Biol., T. 43-44, 147-154.

Šapkarev et al. (1990). The influence of saprobity level on composition and abudance of the living world from the mouth waters of several streams and rivers in Macedonia. Project elaboration, Faculty of Nat. Sci., Skopje.

Van Dam, H., Martens, A. & Sinkeldam, J. (1994). A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. Netherlands Journal of Aquatic Ecology, 28 (1): 117-133.

Watanabe, T., Asai, K. & Houki, A. (1986). Numerical water quality of organic pollution using diatom assemblages. Proceedings of the 9th Diatom Symposium.

КОМПЛЕКСНИ ИСТРАЖУВАЊА НА РЕКАТА ВАРДАР. II. НАЈЗАГАДЕНИТЕ ТОЧКИ ВО ПРВИТЕ ТРИ МЕСЕЦИ

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РЕЗИМЕ

Во февруари 1993 година, како основа за идната изведба на проектот „Вардарска Долина" започнати се комплексни екосистемски истражувања на реката Вардар. Вкупното течение опфатено во рамките на границите на Република Македонија изделено е на 20 мерни точки концентрирани околу потенцијалните загадувачи (градови, индустриски центри) со поретки мерни места помеѓу нив.

По класично утврдената методологија со месечна фреквенција на теренски истражувања следени се 25 параметри на физичко-хемиската состојба и собиран е алголошки материјал како епилитон или перифитон врз субмерзната вегетација. Квалитативниот и квантитативниот состав на дијатомејските популации утврден е преку 1600 трајни препарати со броење на процентната застапеност на просечно 200 фрустули по препарат.

Презентираните осум мерни точки (T1, T8, T9, T10, T11, T12, T15 и T16) се потврдија како најинтензивно загадени по целото течение, освен точката T1 во изворишниот дел кај с. Вруток која е типична референтна точка. Според сите физичко-хемиски параметри подрачјето помеѓу T8 и T12 (Сл. 1) претставува силно оптеретена област со органски отпадни материи кои потекнуваат од комуналните и отпадните води на прехрамбената индустрија од градовите Скопје и Велес. Во тој поглед посебно отскокнуваат T8, T9 и T12 каде забележаните појави на исталожување на тешко разградливи мрсни материи по дното, кои предизвикуваат анаеробни микробни процеси на деградација, предизвикуваат намалување на достапниот кислород и осетно ја наголемуваат БПК5 вредноста, а поткрепени се и со развој на микрофлора позната за алфа до поли сапробна зона на загадување.

Точките T10 и T11 претставуваат зона на автопурфикациски процеси, но на T10 впечатливо е влијанието на реката Пчиња која во реката Вардар внесува вода од полисапробен карактер драстично смалувајќи го процентот на слободен кислород поради што на тој дел се забележани чести помори на хидробионтите. Дијатомејската микрофлора е составена од алфа до поли сапробни таксони, но и претставители на чисти водени текови со релативно висока абундантност.

Еколошки најзагрозен се покажа речниот тек под испустот на ХИВ (Хемиска Индустрија Велес - T15) каде живиот свет под влијание на отпадните води е потполно уништен, дебели слоеви на исталожени сулфурни и фосфорни неоргански соединенија во целост го прекриваат дното, а камењата се распаѓаат во делови и при најмал удар. Микрофлората е повторно составена од асоцијации на високата полуција, но со смалена процентна застапеност поради честите хемиски шокови. Појавата на *Pinnularia* и *Nitzschia* таксоните, иако со многу мала бројност, потврдува континуитет на испуст на отпадни води со ниска pH реакција.

Точката T16 покажува очигледна но силно успорена тенденција на рехабилитација дополнително оптоварена со вливот на алфа до поли сапробните води на реката Брегалница. Доминантни се таксоните на родовите *Navicula, Nitzschia, Surirella* но се забележува и средна застапеност на планктонските *Asterionella* и *Synedra* таксони. Реката Вардар во тој дел е сеуште во рамките на високата алфа до поли сапробност со впечатливо влијание на

Т15 (ХИВ) од кое долниот тек на испитуваниот екосистем не успева да се прочисти се до границата со Р. Грција.

Статистичката обработка на податоците преку различните флористички индекси ги потврдува изнесените констатации, но бидејќи е базирана само на тримесечни податоци и 8 контролни точки во поедини моменти не може во целост да се објасни. На резултатите големо влијание има и високиот водотек во месец април 1993 година кој донекаде ги прекрива вистинските резултати. Понатамошните истражувања во подолг временски период и со поголем број на мерни точки треба да ги објаснат сите забележани неправилности.