COMPARISON OF SYSTEMS OF BIOLOGICAL INDICATION APPROVED DURING THE COURSE OF THE JOINT ANGLO-SOVIET INVESTIGATIONS HELD UNDER THE AUSPICES OF THE INSTITUTE OF HYDROBIOLOGY OF THE ACADEMY OF SCIENCES OF THE UKRAINIAN SSR

by

V A Abakumov and V V Polishuk

(Institute for Applied Geophysics of the State Committee of the

USSR on Hydrometeorology and Environmental Monitoring, Moscow;

Institute of Hydrobiology of the Academy of Sciences of the Ukrainian SSR, Kiev)

In accordance with the plan for joint Anglo-Soviet scientific and technical collaboration on environmental problems, the comparative evaluation of systems of hydrobiological analysis of the surface water quality started in 1977 at the Regional Laboratory of the Severn-Trent Water Authority in Nottingham were continued in the spring of 1978. The investigations were carried out under the auspices of the Institute of Hydrobiology of the Academy of Sciences of the Ukrainian SSR.

The following scientists took part on the Soviet side:

From the Institute for Applied Geophysics of the State Committee of the USSR on Hydrometeorology and Environmental Monitoring – V A Abakumov, N V Umnova.

From the Institute of Hydrobiology of the Academy of Sciences of the Ukrainian SSR – O G Kaftannikova, V V Polishuk, I G Garasevich.

From the Hydrobiology Laboratory of the Hydrometeorological Service of the Ukrainian SSR – Yu I Onanko, L V Usenko.

From the Hydrobiological Laboratory of the North-West Hydrometeorological Service – S L Basova.

The British representatives were:

H A Hawkes (Aston University),

J R Leeming (North Western Water Authority),

D J Lowson (Forth River Purification Board, Scotland),

A Jenkins (Welsh Water Authority), and

G Fretwell (Severn-Trent Water Authority).

Hydrobiological and hydrochemical samples were collected by Soviet and British specialists from the Kiev reservoir and the rivers Dnieper, Sozh, Desna and Snov. The samples were processed on the expedition ships and in the Laboratory for the Hydrobiology of Small Water Bodies of the Institute of Hydrobiology of the Academy of Sciences of the Ukrainian SSR. The possible approved methods to be adopted were evaluated from the samples using the phytoperiphyton, phytoplankton, zooplankton and zoobenthos against a background of hydrochemical characteristics.

HYDROCHEMICAL CHARACTERISTICS OF THE TEST SITES

At the test sites the degree of mineralisation in the Kiev reservoir varied from 234 to 290 mg/l with a slight increase from the surface to the bottom. According to the ratio of the main ions, the water was in the bicarbonate class, Ca group, of the third, less commonly, the second type. Water hardness was between 2.6 and 3.1 mg equiv./l. The mineralisation of the left-hand tributary of the River Dnieper and the River Sozh, was about the same – 261 mg/l. The total content of ions in the water of the River Desna above the mouth of the River Snov during this period was considerable – 327-351 mg/l. Of the cations, Ca^{++} predominated and of the anions, HCO_3^-. The degree of mineralisation in the water of the Snov was around 250 mg/l. The main ions were characterised by the index C_{III}^{Ca}. The hardness levels in the Desna and Snov varied between 3.7 and 4.1 mg equiv./l. Accordingly, the methods were tested at sites with average water mineralisation.

At the sampling points the concentration of biogenic elements decreased from the upper reaches of the reservoir to the lower. The content of NH_4^+ ions varied from 0.77 to 1.15, NO_2^- ions from 0.03 to 0.024, NO_3^- from 0.21 to 0.50 mg N/l, PO_4^{---} from 0.009 to 0.017 mg P/l. In the Dnieper above the Kiev Reservoir the concentration of nutrients was also comparatively high.

The highest concentration of NH_4^+ ions was noted on the right-hand shore at the Domantov islands dam where local pollution from waste water from shore settlements was observed. At this same point the maximum concentration for the Kiev reservoir of biochemically unstable substances was noted: the BOD_5 was up to 4.0 mg O_2/l compared with 1.3 on the right-hand shore in the upper part of the reservoir.

In the River Sozh, above its entry into the Dnieper, the concentration of nutrients was about the same as in the Kiev reservoir, except for nitrates the amount of which rose to about 3 times higher and reached 1.47 mg N/l.

In the River Desna and its tributary the Snov the concentration of nutrients at the sampling sites varied widely: NH_4^+ from 0.81 to 0.98; NO_3^- from 0.24 to 0.26; NO_2^- from 0.003 to 0.006, PO_4^{---} from 0.10 to 0.22 mg P/l. The iron content did not exceed 0.15 mg/l. BOD_5 inthe Desna was low (2.0 mg O_2/l), while in the Snov it reached 4.7 mg.

The gas regime was satisfactory. In the Kiev reservoir and in the rivers Dnieper and Sozh the concentration of dissolved oxygen was 7.3–11.9 mg/l which, at a water temperature of 9–11°C, corresponded to 64–107% saturation. The carbon dioxide content was mainly around 20-30 mg/l, though in the River Sozh it reached 57 mg/l. The pH varied from 7.4 in the River Sozh to 7.7 in the Kiev reservoir. In the Desna and its tributary the Snov the concentration of dissolved oxygen was generally around 9.3 mg/l, equivalent to about 90% saturation at a temperature of 15-16°, ie it was somewhat higher than in the Kiev reservoir. The carbon dioxide content varied between 30.8 and 52.8 mg/l. Table 1 gives a comparative view of the hydrochemical data (content of biogenic elements and dissolved gases) together with the saprobic indices using the ecological zone method. Later on, data using the ecological zone method will be used as a basis in the comparison of approved systems for biological indication of the quality of surface water, concerning which more details will be given below.

Table 1.

No	Sampling Site	Date (May 1978)	Temp. °C	CO_2 mg/l	O_2 mg/l	O_2 % sat.	BOD_5 mg O_2/l	NH_4^+ mg N/l	NO_2^- mg N/l	NO_3^- mg N/l	PO_4^{---} mg P/l	pH	e mg/l	Saprobicity using ecology zone method
1	Kiev reservoir, bottom end, centre, surface	15	10,1	35,2	9,9	86	2,0	0,77	0,003	0,21	0,009	7,7	0,11	osp
2	Kiev reservoir, bottom end, centre, 7 m deep	15	10,1	35,2	9,9	86	2,0	0,80	0,003	0,23	0,012	7,7	0,13	o-βM
3	Kiev reservoir, bottom end, right-hand side, surface	16	9,1	29,9	9,9	84	2,0	0,88	0,003	0,28	0,010	7,6	0,18	o-βM
4	Kiev reservoir, middle part, centre, surface	16	9,1	27,3	10,3	88	2,7	0,88	0,006	0,32	0,017	7,7	0,26	o-βM
5	Kiev reservoir, middle part, centre, 8 m deep	16	9,1	19,4	10,3	88	3,0	1,02	0,005	0,34	0,013	7,6	0,22	o-βM
6	Kiev reservoir, middle part, right-hand side	16	11,5	19,4	11,9	107	4,0	1,11	0,004	0,27	0,014	7,7	0,22	βM
7	Kiev reservoir, middle part, left-hand side	16	11,5	17,6	10,3	92	3,0	0,81	0,012	0,36	0,010	7,7	0,13	βM
8	Kiev reservoir, top end, right-hand side	17	9,5	35,2	9,9	85	2,7	0,80	0,021	0,30	0,014	7,4	0,15	o-βM
9	Kiev reservoir, top end, right-hand side	17	11,5	35,2	7,3	64	1,3	0,88	0,014	0,47	0,017	7,4	0,15	o-βM
10	Kiev reservoir, top end, centre, 7 m deep	17	9,5	22,0	9,6	83	1,7	1,15	0,024	0,50	0,015	7,5	0,26	βM
11	Kiev reservoir, top end, centre, surface	17	9,5	30,8	8,6	74	1,3	0,88	0,024	0,33	0,014	7,6	0,14	βM
12	River Dnieper at Osarevich', centre, surface	17	10,9	35,2	9,3	83	2,6	0,98	0,027	0,26	0,017	7,4	0,18	o-βM
13	River Sozh, estuary area, centre, surface	18	10,2	57,2	9,3	82	2,6	0,85	0,006	1,47	0,010	7,4	0,13	o-βM
14	River Desna above Snov mouth, centre, surface	21	13,8	30,6	9,3	86	2,0	0,85	0,003	0,26	0,017	7.9	0,15	o-βM
15	River Desna above mouth of Snov, right-hand shore	21	16,1	52,8	9,6	95	2,0	0,81	0,006	0,24	0,014	7,8	0,12	o-βM
16	River Desna above the mouth of the Snov, left-hand shore	21	14,7	35,2	9,3	90	2,0	0,83	0,006	0,23	0,022	7,8	0,12	o-βM
17	River Snov 5 km above the estuary, centre	21	15,5	52,8	9,3	91	3,4	0,88	0,004	0,25	0,014	7,8	0,12	βM
18	River Snov 5 km above the estuary, right-hand shore	21	15,9	35,2	9,3	92	4,7	0.98	0,004	0,25	0,010	7,7	0,14	β-LM

BIOLOGICAL INDICATION OF THE QUALITY OF WATER USING PHYTOPERIPHYTON INDICATORS

Among the systems for the biological indication of the quality of surface water, special attention has been given to the indication using the Kolkwitz-Marsson indicator organism system and its subsequent modifications, with clear preference often being shown to periphyton organisms in comparison with other groups of hydrobionts (Sladeckova, 1962; Sladeckova & Sladecek, 1964; Nikulina, 1976, et al).

Bearing in mind the possible relationship between the composition of the periphyton and the substratum which many authors have referred to (Tippett, 1970; Wetzel & Hough, 1973; Harlin & Lindbergh, 1977, etc), algae are collected from different submerged objects and water plants. Quantitative evaluation of the abundance of periphyton algal flora was carried out using a six-point visual scale (Raskina, 1968; Nikulina, 1976):

1 – single (single specimen in sample);

2 – very rare (single specimen in each preparation);

3 – rare (in a few fields of view);

4 – frequent (not in all fields of view);

5 – very frequent (in all fields of view);

6 – abundant (very frequent in all fields of view).

Those in groups 5 and 6 were classified as dominant, those in the other groups as subdominant.

Table 2 gives data on the different species found, the relevant quantities of periphyton algae and the saprobicity at the test sites. As the most favourable conditions for the existence of the species are, as a rule, limited by a low range of fluctuation in the environmental factors, the dominant species in the community, ie those under optimum conditions, are the best indicators of the state of a water body. On this basis we did not aim at a detailed investigation of the flora of the water bodies concerned and the number of algae taxa recorded by us is by no means exhaustive.

Table 2: Species, quantity of periphyton algae and saprobicity at the test points.

No	Species	Saprobicity	Section 1			Kiev reservoir Section 2			Section 3			R Dnieper			R Sozh		R Desna		R Snov	
		β $\mathcal{L}$	R	C	L	R	C	L	R	C	L	R	C	L	R	L	R	L	R	L
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	Cyanophyta																			
1.	Chamaesiphon incrustans Grun.f. incrustans	0				6	4		3		3									
2.	Lyngbya aerugineo-coerulea /Kutz/Gom.f.aerugineo-coerulea							4		4										
3.	L.Kuetzingii f.ucrainica/ Schirsch./Elenk.					5	6	3		3	3									
4.	Oscillatoria limosa Ag.f.limosa	β–$\mathcal{L}$					1													
5.	O. tenuis Ag.f.tenuis	$\mathcal{L}$	4					4		3										
6.	O. tenuis f. woronichiniana Elenk.							2-4		3										
7.	Sphaeronostoc coeruleum/Lyngb./ Elenk.																			1
	Bacillariophyta																			
8.	Achnanthes minutissima Kutz.var. minutissima	O-β	4																	

R = right-hand shore, C = centre, L = left-hand shore

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
9.	Amphora ovalis Kutz.var.ovalis	O-β					2	2											2	2
10.	Asterionella formosa Hass	O-β	2																	
11.	Cocconeis placentula Ehr.var. placentula	β					4	3	4				6		2	4				
12.	Cymatopleura solea/Breb./W. Sm.var.solea	β-d						2				1						3	2	2
13.	Cymbella cistula/Hamp./Grun. var. cistula	β						4-5				3								2
14.	C.lanceolata/Ehr./V.H.var. lanceolata	β		3			3	2-5				2			2			3	2	
15.	C.prostrata/Berkeley/Cl.	β		3			3						4			3				
16.	C. ventricosa Kutz.var. ventricosa	β		4			3	3-5	4	4	4	5		4	4	4	3			
17.	Diatoma elongatum/Lyngb./ Ag.var. elongatum	β-O					2		3		3	4				3		3		
18.	D. vulgare Bory var. vulgare	β	2	4	3			3-4	4-6	3	3		5	3						
19.	D. vulgare var. productum Grun.		4																	
20.	Eunotia gracilis/Ehr./Rabenh.								2		2									
21.	Pragilaria capucina Desm.var. capucina	O-β	3	3	3	3	4	3-5	5	4	4	5		5	5	4	4	6	3	5
22.	F. construens/Ehr.B.Grun. var construens	β							4											
23.	F. intermedia Grun. var. intermedia			4																
24.	F.virescens Raifs var. virescens	X					4	2-3												3
25.	Gomphonema acuminatum Ehr. var. acuminatum	β					2	3				2	3			4				3

26. G.constrictum Ehr. var. constrictum	β		3				3		3									
27. G. olivaceum/Lyngb./Kutz. var olivaceum	β		4		4	3	6	4	5	5			4	5				
28. Gyrosigma acuminatum/Kutz./ var.acuminatum	β				2	2									3	3		
29. Melosira varians Ag.var. varians	β	3		2	4	3-5	3		3	3		4	3	4	4	5	3	4
30. Navicula cryptocephala var. intermedia Grun.	β			2	4	3	3									3		
31. Nitzshia dissipata/Kutz/Grun.	O-β	4	4															
32. N.sigmoidea/Ehr/W.Sm.var. sigmoidea	β			1		2-3	3		3		2		2		5	4		2
33. Opephora martyi Herib.var. martyi			3									2						
34. Rhoicosphaenia curvata/Kutz/ Grun.var.curvata	β		3		2	3	4-6		4		3	4	4	5				
35. Rhopalodia gibba/Ehr./O.Mull. var. gibba	0																1	
36. Stephanodiscus astraea/Ehr./ Grun. var. astraea	O-β					2												
37. S.astraea var.minutulus/Kutz./Grun		3	3															
38. Surirella linearis W.Sm.var. linearis	β			1														
39. Synedra tabulata/Ag/Kutz. var. tabulata	£					6		6	6			4	4					6
40. S. ulna/Nitzsch/Ehr.var. ulna	β	2	4	2	4	3-4	3	9	3	5	4	3	5	6	6	6	3	6

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
41.	S. ulna var. danica/Kutz/ Grun.	0	1			2														
42.	S. vaucheriae/Kutz/var. vaucheriae			6																
43.	**Euglenophyta**																			
	Trachelomonas hispida/Perty/ Steinemend. Defl. var.hispida	β																		2
	Chlorophyta																			
44.	Ankistrodesmus acicularis /A.Br./Korschik.var.acicularis	β																	2	
45.	A.falcatus/Corda/Ralfs var. falcatus	β-£																		2
46.	A. pseudomirabilis Korschik. var. pseudomirabilis			3			2	3	4	2	3	3				3				2
47.	Aphanochaete repens A.Br.																			2
48.	Cladophora fracta Kutz.	β												3		6		4		6
49.	C. glomerata/L/Kutz.	β	6			6		6					6		6					
50.	Closterium acerosum/Schr./Ehrenb.	£																3	2	2
51.	C. gracile Breb.		1																	
52.	C. parvulum Nag.	β															3	3		2
53.	C. Sp						2		2			2		2	1					

54. Dictyosphaerium pulchellum Wood. var. pulchellum	β																2	
55. Microspora amoena/Kutz/Rabenh	V-O											3						
56. M. pachyderma/Wille/Lagerh	0											6	3	4	3			6
57. M. tumidula Hazen		5																
58. Mougeotia sp., ster	0			2	2					2		3						
59. Oedogonium sp., ster							3	4	6			3		4	3			3
60. Pediastrum boryanum/Turp./ Menegh.	β	2	2		1		2											
61. Scenedesmus acuminatus/Lagerh./ Chod.var.acuminatus	β					2												
62. S. apiculatus/W.et w/Chod. var. apicuatus			1				2											
63. S. bijugatus/Turp/Kutz.var. bijugatus	β		2		2						2							
64. S. obliquus/Turp/Kutz.var. obliquus	β							2										
65. S. obliquus var. alternans Christjuk																		1
66. S. quadricauda/Turp./Breb. var. quadricauda	β	2			3	2	3		3						3	2		2
67. S. quadricauda var. abundans Kirchn			1															
68. S. quadricauda var.dentatus Deduss				1														
69. Spirogyra sp., ster						2	6	2				5	2	5	3	5	2	4
70. Staurastrum brebissonii Arch.						2			2						3			2
71. Stigeoclonium tenue Kutz.	ℒ	6	6	4	3		6					2						

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
72.	Tetraedron incus/Teiling/ G M Smith var. incus								2											
73.	Ulothrix variabilis Kutz.									6										
74.	U. zonata Kutz.	0		6		3														

In the periphyton at the test sites we found, during the period of the investigation, 74 species, varieties and forms of algae in 4 phyla as follows:

Cyanophyta 7 (9.4%)

Bacillariophyta 35 (47.3%)

Euglenophyta 1 (1.4%)

Chlorophyta 31 (41.9%)

The greatest taxonomic diversity was found in the periphyton at the test sites on the Kiev reservoir (Table 3) which, it would appear, is explained not only by the actual variety of the algal flora but by the more detailed investigations carried out here.

Table 3.

Number of phytoperiphyton species on the basis of systematic groupings at test sites.

Name of water body	Cyanophyta	Bacillariophyta	Euglenophyta	Chlorophyta	Total
Kiev reservoir	6	34	–	21	61
River Dnieper	–	17	–	11	28
River Sozh	–	13	–	7	20
River Desna	–	10	–	8	18
River Snov	1	13	1	14	29

Diatoms and green algae were dominant in the species composition of the periphyton in most of the water bodies studied (Table 2). Blue-green algae were mainly found in the Kiev reservoir with such oligosaprobic algae as *Chamaesiphon incrustans* and *Lyngbya kutzingii f. ucrainica* reaching abundant levels. As well as the blue-green algae mentioned, the following species reached dominant level in the Kiev reservoir: diatoms; β-mesosaprobic, *Cymbella cistula, C. lanceolata, C. ventricosa, Diatoma vulgare, Gomphonema olivaceum, Melosira varians, Rhoicosphaenia curvata;* oligo-β-mesosaprobic, *Fragilaria capucina;* alpha-mesosaprobic, *Synedra tabulata.* Among the green algae the following were frequent: β-mesosaprobic, *Cladophora glomerata, Microspora tumidula, Oedogonium* sp., ster. *Spirogyra* sp., ster.; alphamesosaprobic: *Stigeoclonium tenue, Ulothrix variabilis* and oligosaprobic, *U. zonata.*

In the periphyton of the River Dnieper the following diatoms were abundant: β-mesosaprobic, *Cocconeis placentula, Diatoma vulgaris, Gomphonema olivaceum, Synedra ulna;* oligo-β-mesosaprobic; *Microspora pachyderma, Spirogyra* sp., ster.; β-mesosaprobic, *Cladophora glomerata.* The dominant periphyton in the River Sozh included; oligo-β-mesosaprobic, *Fragilaria capucina;* β-mesosaprobic, *Gomphonema olivaceum, Rhoicosphaenia curvata, Synedra ulna, Cladophora fracta, C. glomerata* and *Spirogyra* sp., ster. The dominant species in the River Desna consisted of; oligo-β-mesosaprobic, *Fragilaria capucina;* β-mesosaprobic, *Melosira varians, Nitzschia sigmoidea, Synedra ulna* and *Spirogyra* sp. ster.

Finally, in the River Snov abundant were; oligo-β-mesosaprobic, *Fragilaria capucina;* alphamesosaprobic, *Synedra tabulata, β-mesosaprobic S.ulna* and *Cladophora fracta* and oligosaprobic, *Microspora pachyderma.*

Analysis of the composition of the dominant forms shows that the majority of the abundant species of algae were indicators of β-mesosaprobic conditions in the water body and only two species of alphamesosaprobic conditions *(Stigeoclonium tenue* and *Synedra tabulata)* were found in the Kiev reservoir and the River Snov, pointing to the presence of organic pollution in the water bodies. However, it should be borne in mind that when using algae as indicators for determining the degree of water pollution at different times of the year, many conditions and features of the biology of a species need to be taken into consideration as very often mass development of any indicator species is connected not so much with pollution as with its own ecological peculiarities, to which many researchers have referred (Kumsare, 1974; Nikulina, 1976a; McLean & Benson-Evans, 1974, et al).

In the 74 species, varieties and forms found, 50 of the algae found (67.6%) were indicator species according to the CMEA lists (1977) with three Cyanophyta, 29 diatoms, 1 Euglenophyta and 17 green algae with the following saprobic rating: 1 – xenosaprobic, 1 – xeno-oligosaprobic, 6 – oligosaprobic, 7 – oligo-β-mesosaprobic, 28 – β-mesosaprobic, 3 – β-alphamesosaprobic and 4 – alphamesosaprobic.

Therefore, using phytoperiphyton indicators we can make a preliminary conclusion that all the water bodies investigated fall in the β-mesosaprobic class. To make a definitive conclusion and to select the optimum method for calculating the water quality all the data obtained were processed by several methods.

Using the Pantle and Buck method (Pantle and Buck 1955; Pantle 1956) each indicator species belongs to a specific degree of saprobicity which is given a figure from 0 to 5. The relative amount of the individual species (h) is evaluated as follows: single and very rare – 1; rare* and frequent – 3; very frequent and very abundant – 5; As a result of the data being processed using this method, saprobic indices were obtained which varied between 1.38 and 2.56 (Table 4). Most of the values characterised all the sites investigated as β-mesosaprobic. An exception was the left-hand side of Section 1 of the Kiev reservoir which was characterised as oligosaprobic with an index of 1.38.

Despite the fact that almost all the sites were β-mesosaprobic, there were fairly clear-cut distinctions within this range. Thus if we compare the mean values of the saprobic index along each section (1 – 1.78; 2 – 1.82; 3 – 2.11; 4 – 1.89; 5 – 1.95; 6 – 1.93; 7 – 1.88) then the cleanest section of the Kiev reservoir would appear to be Section 1 while the rivers Dnieper and Snov and the rivers Sozh and Desna are fairly similar as regards their organic pollution content.

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*Editor's note: 'rare' may be a slip since Pantle and Buck's Group 3 is häufiges Auftri ten.

TABLE 4. COMPARISON OF SYSTEMS OF BIOLOGICAL INDICATION OF THE QUALITY OF SURFACE WATER USING PHYTOPERIPHYTON INDICATORS

(overleaf)

Table 4. Comparison of systems of biological indication of the quality of surface water using phytoperiphyton indicators

Water body			Pantle/Buck saprobic index	Saprobicity	As 2 modif. by Sladecek	Saprobicity	Zelinik and Marvan weighted average saprobic valencies	Saprobicity	Rotschein index	Saprobicity
1			2	3	4	5	6	7	8	9
Kiev		R	2,56	£	2.32	β	0:0,88:3,59:5,53:0	£	37,87	£
	Section 1	R	1,88	β	1,78	β	0,20:3,47:4,95:1,73:0,15	β	53,43	β
reservoir		C	1,73	β	1,62	β	0,14:1,76:5,87:2,23:0	β	49,06	β
		L	1,38	0	1,38	0	0:8,0:1,67:0,33:0	0	66,55	0
		R	1,67	β	1,58	β	0,5:3,78:3,74:1,98:0	0	61,93	β
	Section 2	C	1,85	β	1,74	β	1,74:1,98:5,34:1,53:0	β	51,01	β
		L	1,97	β	1,89	β	0,77:1,70:5,99:1,54:0	β	50,35	β
		L	1,78	β	1,62	β	1,01:2,01:6,24:0,74:0	β	52,82	β
		L	2,10	β	1,93	β	0,11:1,83:5,59:2,33:0,08	β	48,97	β
		R	2,09	β	1,90	β	0,19:2,29:4,16:3,23:0	β	48,07	β
	Section 3	R	1,96	β	1,95	β	0,36:2,01:5,16:2,40:0	β	49,18	β
		C	2,31	β	2,11	β	0,18:1,40:4,06:4,22:0,13	£	39,33	£
		L	1,98	β	1,85	β	0,29:2,16:5,05:2,50:0	β	49,29	β
		R	1,86	β	1,72	β	0,25:3,44:6,13:0,84:0	β	55,00	
River Dnieper	Section 4	C	2,0	β	1,75	β	0,35:2,29:6,23:1,13:0	β	52,41	
		L	1,81	β	1,70	β	0,48:2,98:4,63:2,90:0	β	50,16	
River Sozh	Section 5	R	1,93	β	1,77	β	0,32:2,57:5,33:2,30:0	β	50,54	
		L	1,86	β	1,84	β	0,22:2,59:5,86:1,28:0	β	52,71	

River Desna	Section 6	R	1,85	β	1,82	β	0,15:1,63:6,72:1,50:0	β	50,27
		L	2,01	β	2,01	β	0,04:1,51:6,52:2,70:0	β	47,62
River Snov	Section 7	R	1,91	β	1,88	β	0,09:1,48:6,41:2,02:0	β	48,92
		L	1,84	β	1,81	β	0,69:1,44:5,42:2,45:0	β	47,84

R = right-hand; C = centre; L = left-hand.

The Pantle and Buck method is discussed extensively in the relevant literature and many authors have stressed that the basic fault of this method is that it rigidly allocates an individual species to one saprobic zone which does not accord with actual reality where, as a rule, a species can be found in zones with a different organic pollution content.

The Zelinka and Marvan method (Zelinka and Marvan, 1961, 1966) is based on the idea of saprobic valency and the indicator value. Each species is given an overall value of 10 — the saprobic valency value. When using this method the most frequently occurring species in the corresponding pollution zone must be used and, using the mean weighted valencies, it is possible to assess what conditions prevail in the water body and which side they are moving towards. The mean weighted saprobic periphyton values at the test sites calculated using the Zelinka and Marvan method show that almost all sites studied are in the β-mesosaprobic zone except for the left-hand shore of Section 1, the right-hand shore of Section 2 and the centre of Section 3 of the Kiev reservoir where the maximum values of this index fall in the oligosaprobic and alphamesosaprobic zones respectively (Table 4).

The Rotschein index (Rotschein 1959, 1962) is similar to the Pantle and Buck index in one respect while in the other, in the calculations, the saprobic valencies and indicator weight of the indicator organisms are used following the Zelinka and Marvan method, while unlike this method the result is expressed as a single figure which is undoubtedly easier for representing overall values. The results of calculations using the Rotschein index are given in Table 4 from which it can be seen that most of the sites investigated are in the β-mesosaprobic zone, similar to the results using the Zelinka and Marvan method. However, the Zelinka and Marvan method, like the calculation of the Rotschein index, demands cumbersome calculations.

Sladecek proposed a saprobic index based on the Zelinka and Marvan saprobic valencies and calculations using the Pantle and Buck method (Sladecek 1973). The results of data processed using this method are given in Table 4 as well. As can be seen from the figures in Table 4, all the methods using the saprobic valencies give very similar results, however, the best would seem to be the Pantle and Buck method as modified by Sladecek which should be given preference in processing phytoperiphyton samples.

Particularly promising is the study of periphyton as a hydrobiological indicator of the quality of surface water in a system intended to include a large number of water-courses and water bodies in a large expanse of territory in a network of continuous observations. There are at least two reasons for this: first, in the literature there are sufficient data about the consistency of the results of monitoring using periphyton indicators and other parameters and, second, the relative ease of collection of periphyton (and fairly often even of qualitative samples) in comparison with other groups of hydrobionts and also the very simple collecting equipment, such as hydrobiological scoops, scrapers, scalpels, knives, etc. Collection of material in this way can be done by staff who do not have specialised training. This means that hydrobiological methods can be rapidly introduced into the surface water quality monitoring system over a large area. However, for subsequent processing of the samples collected, specialists are needed who have adequate biological training, as all methods based on indicator organisms require accurate identification of species.

BIOLOGICAL INDICATION OF WATER QUALITY USING PHYTOPLANKTON INDICATORS

The various possibilities of the Pantle and Buck method and the Sladecek modification of this method were also evaluated in the indication of water quality using phytoplankton indicators.

The sedimentation method was used for processing phytoplankton samples. After three weeks' settlement the samples were siphoned down and reduced to a quantity of 100 ml. Quantitative consideration of the organisms was carried out using a counting slide.

0.1 ml was transferred by pipette from the concentrated sample (water agitation) to the counting slide, slightly dried, covered with a cover glass and the quantity of organisms and species determined under a microscope. Calculation of the cells is repeated twice on 20 counting slides.

In order to determine diatoms more precisely, specimens were prepared using the generally accepted method (Diatom algae of the USSR, Vol 1, 1974).

At the test sites 166 algae taxa were identified consisting of 57 diatoms, 12 Pyrrophyta, 18 Euglenophyta, 10 Volvocaceay, 57 Protococcaceae, 6 chrysophyceae, 4 blue-green algae and 2 desmids.

A list of the phytoplankton found in the water bodies is given in Tables 5, 6 and 7*. The list does not lay claim to being complete as detailed investigation of the plankton algae in the water-courses and water bodies investigated was not the aim of the work carried out. Data on the quantities of phytoplankton indicators at the appoval stations are given in Table 8.

*Editor's note. These lists are not included but are available on request.

Table 8.

QUANTITATIVE PHYTOPLANKTON INDICATORS AT TEST SITES

No	Water-course and water body	Number of phytoplankton, 10^3 cells/l Left side	Centre		Right side
	Kiev reservoir				
1.	Lower section by Lyutezh	252	2856		2504
2.	Middle section by Domantovo	1160	784	surface	888
			1176	bottom	
3.	Upper section	1768	2440		3584
4.	Dnieper below Sozh mouth	2632	2072		1680
5.	Sozh, estuarine section	2232	1632		2576
6.	Desna, above Snov mouth	6792	7816		7368
7.	Snov 5 km from estuary	4856	3408		4312

The high spring flood and long cold spring affected the number and variety of species of phytoplankton in almost all the water bodies but in particular the species diversity found in the Kiev reservoir and the River Dnieper.

The phytoplankton at the test sites of the Kiev reservoir during the sampling period was very poor. The lowest number was recorded in the lower section by Lyutezh on the left-hand side – 252,000 cells/l. The highest number was in the upper section on the right-hand side – 3,584,000 cells/l. The number of species varied between 19 and 39.

The organisms found are indicators of almost every saprobic zone. However, β-mesosaprobes dominated as a rule. Of the alphamesosaprobes, the most frequently found and greatest in number was *Stephanodiscus hantzschia.*

At almost all points were present the representative indicators of the transitional zone from oligo- to β-mesosaprobic – *Kephyrion spirale* and *Pseudokephyrion schilleri.*

The calculations to determine the degree of saprobicity using the Pantle and Buck method as modified by Sladecek, as a whole show the moderate degree of pollution of the water in the Kiev reservoir and indicate β-mesosaprobic conditions. The values of the coefficient of species diversity using the Shannon formula confirm this (Table 9).

Table 9.

COEFFICIENT OF SPECIES DIVERSITY FOR PHYTOPLANKTON AT TEST SITES, CALCULATED USING THE SHANNON FORMULA

No	Water-course or water body	Left side	Centre	Right side
1	Kiev reservoir, lower section	3.81	3.82	4.50
2	Kiev reservoir, central section	4.21	4.86 surface 4.25 bottom	3.75
3	Kiev reservoir, upper section	3.51	3.62	3.83
4	River Dnieper, below Sozh mouth	4.28	4.19	4.53
5	River Sozh, estuarine section	4.32	4.08	3.98
6	River Desna, above mouth of Snov	3.41	3.24	3.58
7	River Snov, 5 km from estuary	3.43	3.25	3.21

At the test sites on the Dnieper, below the Sozh mouth, the lowest number of phytoplankton was recorded on the right-hand shore – 1,680,000 cells/l. The transitional indicator organisms from the oligo- to the β-mesosaprobic zone, *Kephyrion spirale* and *Asterionella formosa,* were found.

As regards the numbers of species and abundance of the organisms, indicators of the β-mesosaprobic zone predominated. An insignificant number of alphamesosaprobes were found. *Stephanodiscus hantzschii* and also the β-alphamesosaprobe *Cyclotella meneghiniana* were found at all sites. This section of the River Dnieper was in the β-mesosaprobic zone. The value of the coefficient of species diversity varied between 4.28 and 4.53.

A similar pattern was also observed at the test sites on the River Sozh, with the same alpha- and β-mesosaprobes. The value of the saprobic index at all sites varied between 2.19 and 2.23. The coefficients of species diversity were 4.32, 4.08 and 3.98.

At the test sites on the River Desna the maximum amount of phytoplankton was observed – 7,791,000 cells/l. The species diversity did not increase significantly. At all sites the oligosaprobes *Kephyrion rubri claustri, Synedra acus* var. *angustissima* and the oligo-β-mesosaprobes *Asterionella formosa* and *Kephyrion spirale* were observed. The alpha-β-mesosaprobes *Cyclotella meneghiniana* and the alpha-mesosaprobe *Stephanodiscus hantzschii* were also found. However the saprobic index values indicated moderate pollution. The values of the coefficient of species diversity were somewhat lower – 3.24, 3.41 and 3.58 (Table 9).

At the test sites on the River Snov the number and diversity of species was somewhat lower. The greatest number was, as with the others, formed by β-mesosaprobes. The saprobic index at these points varied between 2.19 and 2.33. The coefficient of species diversity was 3.43, 3.25 and 3.21 respectively.

The abundance of phytoplankton at the test sites varied between 25,200 and 7,791,000 cells/l (Table 8). The large number of algae at almost all the test sites on the River Desna should be noted.

Table 10 shows the results of processing the data using the Pantle and Buck method and also the Pantle and Buck method as modified by Sladecek.

Comparison of these results with the data obtained by other methods (Tables 4,17) permits the conclusion that processing the samples using the phytoplankton method of Pantle and Buck and this method as modified by Sladecek give relatively acceptable results, however the modified Sladecek method is preferable.

BIOLOGICAL INDICATION OF WATER QUALITY USING ZOOPLANKTON INDICATORS

Zooplankton samples were taken at the same sites and transects as the phytoplankton samples. The samples were taken by filtering 50 litres of water from the surface of the water bodies through a plankton net with No. 67 gauze. Laboratory processing of the samples was done by the counting method in a Bogorov chamber using the generally accepted methodology.

In the Ukrainian sections investigated, 63 taxa of zooplankters were found; 24 rotifers, 15 copepods and 24 cladocerans. A list is given in Tables 11, 12 and 13.*

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*Editor's note: These lists are not included, but are available on request.

Table 10. Evaluation of the degree of saprobicity of water-courses and of water bodies on the basis of the development of phytoplankton at the test sites, using the Pantle and Buck method and the Sladecek modification.

No	Water-course	Pantle and Buck Left	Pantle and Buck Centre	Pantle and Buck Right	Sladecek Left	Sladecek Centre	Sladecek Right	Saprobic zone
1	Kiev reservoir, lower section	2.26	2.10	2.25	2.19	2.14	2.14	β-mesosaprobic
2	Kiev reservoir, middle section	2.31	2.24	2.40	2.15	2.28	2.31	β-mesosaprobic
3	Kiev reservoir, upper section	2.42	2.44	2.30	2.35	2.33	2.23	β-mesosaprobic
4	River Dnieper, below Sozh estuary	2.25	2.31	2.21	2.23	2.27	2.18	β-mesosaprobic
5	River Sozh, estuarine area	2.28	2.31	2.32	2.19	2.23	2.22	β-mesosaprobic
6	River Desna, above the mouth of the Snov	2.12	2.32	2.32	2.18	2.26	2.27	β-mesosaprobic
7	River Snov, 5 km from estuary	2.35	2.18	2.36	2.30	2.19	2.33	β-mesosaprobic

The unusually high spring flood and the cold spring had a significant effect on the number and species diversity of the zooplankton in the Kiev reservoir, upper Dnieper and River Sozh. The zooplankton at the test sites in the Kiev reservoir during the sampling period was extremely poor and was only relatively richer in the lower section. In general, the indicators of the β-mesosaprobic zone and of the transitional zone between β-mesosaprobic and oligosaprobic were found in the reservoir. The zooplankton in the upper Dnieper below the mouth of the River Sozh was very poor too and was also generally β-mesosaprobic. The zooplankton in the estuary of the River Sozh was somewhat richer. However, the number of organisms was still very low. Almost all the indicator organisms found in the Sozh estuary belonged to the β-mesosaprobic and oligosaprobic zones and also the oligo-β-mesosaprobic zone.

An improvement in the hydrometeorological conditions (an increase in temperature) coinciding with the second period of the tests affected the composition of the zooplankton in the rivers Desna and Snov where samples were taken somewhat later. There was greater richness – 38 species – and also a greater number and biomass of zooplankton. The main group was Rotifera. Oligosaprobes and β-mesosaprobes dominated. On the River Snov the dominance passed to the Cladocera, although there were also large numbers of rotifers and copepods. The number of zooplankton in the water-courses investigated varied between 0.04 and 25.6 thousand/m^3 (Table 14). The high number of zooplankton on the left shore of the rivers Desna and Snov should be noted, this was due to the high level of the development of higher equatic plants.

The data given above were used to evaluate the suitability of the Pantle and Buck and Sladecek modification methods for indicating water quality using zooplankton indicators. The data on saprobity at the test sites are given in Table 15.

Table 14. Quantitative zooplankton indicators at the test sites

No	Water body or watercourse	Number of zooplankton '000/m^3 Left	Centre	Right
1	Kiev reservoir, lower section	0.28	0.40	0.54
2	Kiev reservoir, middle section	0.06	0.04	0.10
3	Kiev reservoir, upper section	0.20	0.06	0.06
4	Dnieper below Sozh estuary	0.20	0.04	0.02
5	Sozh, estuarine area	0.66	0.16	0.22
6	Desna, above mouth of Snov	11.70	25.60	25.00
7	Snov, 5 km from estuary	21.60	2.26	4.29

Comparison of these data with data obtained by other methods (see Tables 4 and 17) permits the conclusion that processing samples using the Pantle and Buck method as modified by Sladecek gives acceptable results. The Pantle and Buck method as modified by Sladecek can be recommended for evaluating the quality of water using zooplankton indicators as it makes it possible to obtain results which can be easily compared both in time and space. This method is preferable to others as it is more widely used, simple and does not entail high costs.

BIOLOGICAL INDICATION OF THE QUALITY OF WATER USING ZOOBENTHOS INDICATORS

The study of the bottom and weed bed fauna was one of the most important sections of the joint Anglo-Soviet work. This was due to the fact that large aquatic invertebrates are the sole indicators used by our colleagues from Great Britain and also that large hydrobionts are the most suitable organisms for rapid determination of saprobity. In addition, this group is the easiest for determination purposes and so suitable for a wide range of investigators.

There were two further reasons for including the large invertebrates as a basic component of the ecological zonal method developed in the Institute of Hydrobiology of the Academy of Sciences of the Ukraine. In this method, when determining saprobity the main indicator species of the large aquatic invertebrates and macrophytes are used, as are the most important indicator species of the zooplankton, phytoplankton, phytobenthos and ichtofauna, for the given type of water body. In contrast to the Kolkwitz and Marsson system, correcting coefficients are used to take into account the influence of various ecological factors which misrepresent the proper saprobity of a given section.

These factors, as related to water-courses in the Ukraine where the various methods were approved, are primarily current speed, nature of the biotope, influence of highly humic, natural, marshy waters and the landscape-zonal situation of the water body.

A most important feature of this method is that it takes into account the historical-geographical factor. Rivers which are basically different have ecologically different strains of the same species which react differently to pollution and respond to different degrees of saprobity. An example of this is *Lithoglyphus naticoides* which, in the Dnieper basin, is in the oligosaprobic zone, while in the Dunai basin it is in the transitional zone between β- and alpha-mesosaprobic. *Sialis lutaria, Asellus aquaticus* and *Clinotanypus nervosus* in the marshy Poles's are β-mesosaprobic, whereas in other water bodies they are alphamesosaprobic or even polysaprobic. *Chironomus reductus* in the forest area of the Ukraine is met within the transitional zone between oligo- and β-mesosaprobic, whereas in the rivers of the Donbass and the Dunai they are β-alphamesosaprobic, and so on. For this reason, the ecological zonal method includes an indication of the quality of surface water using lists of organisms that indicate saprobity differentiated according to the type of water body.

Table 15. Evaluation of the degree of saprobicity of water-courses and water bodies on the basis of the development of zooplankton at the test sites, using the Pantle and Buck and Sladecek modification methods.

No	Water-course	Pantle and Buck			Sladecek modification			Saprobic zone
		Left	Centre	Right	Left	Centre	Right	
1	Kiev reservoir, lower section	1.68	1.55	1.50	1.65	1.60	1.60	β-mesosaprobic tending to oligosaprobic
2	Kiev reservoir, middle section	1.83	1.75	1.50	1.71	1.67	1.49	β-mesosaprobic
3	Kiev reservoir, upper section	1.86	2.00	1.75	1.61	2.00	1.75	β-mesosaprobic
4	Dnieper, below Sozh estuary	2.00	2.00	—	2.00	2.00	—	β-mesosaprobic
5	Sozh, estuarine section	1.66	1.63	2.00	1.65	1.60	1.94	β-mesosaprobic tending to oligosaprobic
6	Desna above mouth of Snov	1.80	1.78	1.95	1.92	1.82	1.96	β-mesosaprobic
7	Snov 5 km from estuary	1.58	1.60	1.59	1.58	1.64	1.60	β-mesosaprobic tending to oligosaprobic

Table 17. Comparison of data on saprobity at test sites in the Dnieper basin, obtained by differing methods.

Approval point		Zooplankton Pantle Buck/Sladecek		Phytoplankton Pantle Buck/Sladecek		Oligochaete index	Chironomid index	Ecological zonal method
Kiev reservoir, bottom	Left	0–βM	0–βM	βM	βM	βM	βM	βM
	Centre	0–βM	0–βM	βM	βM	βM	£M	β–£M
	Right	OS	OS	βM	βM	βM	£M	βM
Kiev reservoir, middle	Left	βM	βM	βM	βM	£M	β–£M	βM
	Centre	βM	βM	βM	βM	£M	£M	βM
	Right	OS	OS	βM	βM	£M	£–OS	βM
Kiev reservoir, top	Left	βM	βM	βM	βM	£M	β–£M	βM
	Centre	βM	βM	βM	βM	£M	£M	OS
	Right	βM	βM	βM	βM	£M	βM	βM
Dnieper	Left	βM	βM	βM	βM	£M	£M	β–£M
	Centre	βM	βM	βM	βM	£M	£M	OS
	Right	βM	βM	βM	βM	?	?	β–£M
Sozh	Left	βM	βM	βM	βM	£–ps	£M	βM
	Centre	0–βM	0–βM	βM	βM	£M	βM	0–βM
	Right	βM	βM	βM	βM	βM	βM	βM
Desna	Left	βM	βM	βM	βM	βM	βM	βM
	Centre	βM	βM	βM	βM	βM	£–M	OS
	Right	βM	βM	βM	βM	β–£		
Snov	Left	0–βM	0–βM	βM	βM	£M	βM	βM
	Centre	0–βM	0–βM	βM	βM	βM	βM	0–βM
	Right	0–βM	0–βM	βM	βM	£M	£M	βM

The ecological zonal method was developed by the Institute of Hydrobiology especially for water bodies in the Ukraine and, as a result, it is more accurate than other methods tested on the water bodies in the Ukraine. For this reason it was accepted as a basic method in comparing systems of biological indication tested during the joint Anglo-Soviet investigations carried out under the auspices of the Institute of Hydrobiology (v. Tables 1 and 17).

Bottom and weed bed fauna was collected both on a quantitative and qualitative basis. In deep areas, the quantitative samples were collected by means of a Petersen 1/40 m^2 bottom grab and in shallow water using a suction bottom sampler (1/100 m^2). The qualitative samples were generally collected using a hydrobiological handnet but sometimes repeated with a drag and trawl. The samples were processed using standard methods. Overall 146 taxa of the aquatic fauna were collected (Table 16)*most of which were indicators of one or other saprobic zone.

In indicating water quality by zoobenthos indicator organisms as well as the ecological zonal method and the Chandler score** method, the oligochaete method (relationship between number and biomass of oligochaetes to the total zoobenthos number and biomass) and the chironomid index (proportion of amounts of individual groups of chironomids) were also evaluated. The results are given in Table 17. The oligochaete and chironomid methods are clearly unsatisfactory when it comes to comparisons and give insufficiently reliable results in the cleanest zones.

The Chandler score method was sufficiently exact for evaluating the quality of water in littoral areas but was inadequate for the centre of large water bodies. For example, in the centre of the upper section of the Kiev reservoir, where typical oligosaprobes dominated in the benthos, data obtained by the Chandler score method indicated an alphamesosaprobic zone; in the centre of the Desna, where there were also oligosaprobes, the Chandler method indicated a polysaprobic zone; in the centre of the middle section of the Kiev reservoir, with typical β-mesosaprobic conditions, the Chandler method indicated a polysaprobic zone, and so on.

In indicating the quality of water in small rivers and littoral areas of large water-courses and water bodies in the Ukraine, the Chandler score method would require some modification. For example, the Caenidae family, considered in the Chandler method as an indicator of pure water, in waters in the Ukraine is represented by the genus *Ordella*. In the Ancylidae family in the Ukraine there is the oligosaprobe *Ancylus fluviatilis*, which is not found in England. Therefore is it impossible for this family to be allocated as a whole to the β-mesosaprobic zone. Some families of pond skaters (Mesovelidae, Hydrometridae, Gerridae) should not be considered as indicators of increased pollution of waters since, in water bodies in the south-west of the USSR they are generally found in relatively pure water. A more detailed breakdown of the indicating significance of various chironomids and oligochaetes is needed.

As already mentioned above, the most reliable results were obtained with the ecological zonal method. The main deficiency in this method is its limited adaptation to water-courses and water bodies in the Ukraine. Whether the principles behind this method can be used for a modified method adapted to other regions needs further research.

Evaluations of the quality of water at the test sites, obtained from data using periphyton, phytoplankton, zooplankton and zoobenthos, were very close to one another. Analysis of the

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* Editor's note. Table 16 is not included but may be obtained on request.

** An evaluation of the Chandler score is given in Hawkes et al in this volume.

data obtained showed that, for the practical purposes of monitoring the quality of surface water, in many cases it was quite possible to limit the data to one of these populations. However, it is obvious that when a comprehensive study of the state of an aquatic ecological system is required, an analysis must be made of data using all populations since they indicate the condition of aquatic ecological systems from various points of view. In this respect, a comparison of the data obtained using phytoplankton, phytoperiphyton, zooplankton and zoobenthos is appropriate, with photographs taken from different points of view. None of these biota can lay claim to special accuracy compared with the others.

The biological indicator systems for surface water quality approved under the auspices of the Regional Laboratory of the Severn-Trent Water Authority in 1977 and the Institute of Hydrobiology of the Ukraine in 1978 differed substantially from one another. This difference was due both to the ecological nature of the water-courses and water bodies where the approval tests were held and to the desire to test the greatest number of biological indication systems. For this reason we shall not go into any detail on the analysis of the Shannon-Weaver, William-Dorris and Margalef diversity indices nor the surface water quality biological indicator system developed by F S Woodiwiss, well known under the name of the Trent biotic index. This system was given full consideration during the joint work in Nottingham. As we can confirm the conclusions reached with regard to these systems in Nottingham in 1977, we have little to add.

The basic principle behind calculation of the William-Dorris, Shannon-Weaver and Margalef diversity indices is a study of the species in the populations of water-courses and water bodies or the individual communities of organisms inhabiting them. The figures obtained in many practical projects depend to a large degree on the effort expended by investigators. For this reason the values of the indices of diversity often carry a degree of subjectivity due to the specialisation of the investigators and the level of qualification and application of the investigators. This is a fairly important and difficult problem in comparing the values obtained by different investigators.

A basically different problem is that of the underlying principle which occurs in the ecological interpretation of the index of diversity; for example, in attempts to establish a cause and effect relationship between the diversity and stability of the ecological systems. This problem is due to the fact that the populations of different species can differ from one another in the degree of ecological multi-functionality.

The basic functional unit of population is the locus. The locus is the totality of individuals in a population at the same stage of development. Each locus has a system of connections with the environment which are inherent to it alone, and with basic ecological patterns of behaviour which are specific to it (Abakumov V A, 1970). Despite the long-held point of view, according to which the life span of an organism up to maturity is considered as pre-functional, determined by the autogenetic process of development, each locus carries out within a population a genealogical function inherent to it alone and within an ecosystem an ecological function inherent to it alone. Loci forming one population are so different in their ecological functions that they belong to different trophic levels. Differences in the ecological functions of loci have, in their own consequencies, the ecological polyfunctionality of populations. Thus, populations of lampreys — Petromyzonidae (order — Petromyzoniformes, Class — Cyclosomata) have a clearly defined ecological poly-functionality. Larval loci of lampreys inhabit silted sections of rivers and lead a benthic existence, burying themselves in silt. They generally feed on diatoms (Abakumov V A, 1966). Larval loci of many species of lamprey *(Petromyzon marinus, Lampetra fluviatis, L. japonica, Entosphenus tridentatus, Caspiomyzon wagneri)* are marine creatures and feed on fish.

The above shows that the inherent diversity of an ecological system depends not only on the number of species which make it up but also on the extent to which these species are polyfunctional. In calculating the indices of diversity, populations which basically differ in the degree of ecological polyfunctionality are fully equated with one another: a population of *Raciborskiella uroglenoides* (Class — Euchlorophyceae) is equated with a population of *Theodoxus fluviatilis* (Class — Gastropoda), a population of *Hyalosphaenia elegans* (Class — Sarcodina) is equated with a population of *Satracoobdella paludosa* (Class — Hirudinea) as if they made the same contribution to the inherent diversity of the ecological system we are studying. These examples make it possible to present more graphically those difficulties that occur in the ecological interpretation of diversity indices.

In conclusion we should point out that the spring season 1978 was abnormal as regards the hydrometeorological conditions in the Ukraine. The stronger spring flood led to a levelling out of the degrees of pollution at the points for testing the hydrobiological methods. At the same time there was also a rapid interchange in phalanges, forming complexes of ecologically interrelated loci and characteristic hydrometeorological and hydrochemical environmental conditions. All this significantly complicated the work on testing the systems of biological indication of water quality and made it inadvisable to use those methods of comparison which were used when similar work was carried out in Nottingham.

REFERENCES

1. Abakumov V A: Temporal population structure. Papers of the All-Union Scientific Research Institute for Sea Fishing and Oceanography. Vol 71, Moscow, Pishchepromizdat, 1970, pp 225-260.

2. Abakumov V A: Systematics and ecology of Ukrainian lampreys *(Lampetra mariae* Berg.) — Voprosy ikhtiologii, Vol 6, No 4(41), Moscow, 1966, pp 609-618.

3. Diatom algae of the USSR, Vol 1, Moscow, Nauka, 1974.

4. Kumsare A Ya: Algae as a factor in the self-purification of the estuarine area of the River Daugav. In "Factors in the self-purification of the estuarine area of the River Daugav". Riga, 1974, pp 48-61.

5. Makrushin A V: Biological analysis of water quality. Leningrad, Zoological Institute of the Academy of Science of the USSR, 1974, p 60.

6. Nikulina V N: An experiment in the use of various methods of evaluating the degree of pollution of water using the algoflora. In "Methods of biological analysis of fresh water", Leningrad, Zoological Institute of the Academy of Science of the USSR, 1976, pp 38-58.

7. Nikulina V N: Primary production and algofloral investigations of some rivers in the Leningrad region with different degrees of saprobity. In "Hydrobiological investigations of the self-purification of water bodies". Leningrad, Zoological Institute of the Academy of Science of the USSR, 1976, pp 18-43.

8. Raskina E E: Phytoplankton and fouling of the River Neva and its Tributaries. In "Pollution and self-purification of the Riva Neva", Leningrad, Nauka, 1968, pp 168-192.

9. CMEA Unified methods of investigating water quality. Methods of biological analysis of water. Indicators of saprobicity. Part III. Moscow, 1977, p 91.

10. Harlin M, Lindbergh I M: Selection of substrata by seaweeds: optimal surface relief. Mar. Biol., 40, 1, 1977, pp 33-40.

11. McLean R O & Benson-Evans K. Brit. Phycol. J. 9, 1, 1974, pp 83-89.

12. Pantle R and Buck H: Biological monitoring of water-courses and the representation of results. Gas- und Wasserfach, 96, 18, 1955, p 604.

13. Pantle R: Biological river monitoring. Wasserwirtschaft, 46, 8, 1956, pp 206-209.

14. Rotschein J: Biologicke hodnotenie cistory tokov a jeho graficke znazoznenie. Biolgia, 14, 1959, pp 833-842.

15. Rotschein J: Graficke znazornenie vysladkov biologickeho hodnotenia cistoty vod. Veda vyskum praxi, VUV, Bratislava, c. 9, 1962, pp 1-64.

16. Stadecek, V. System of water quality from the biological point of view. Arch. Hydrobiol. Engebn. Limnol. 7, 1-218, 1973.

17. Tippett, R. Artificial surfaces as a method of studying populations of benthic micro-algae. in fresh waters. Brit. phycol. J., 5, 187-199, 1970.

18. Wetzel & Hough R A. Poroductivity and the role of aquatic macrophytes in lakes, an assessment. Polskie Archivum. Hydrobiol, 20, 9-19, 1973.

19. Zelinka M & Marvan P. Zur Prazisierung der biologische Klassifikation der Reinhiet fliessender.

20. Geurassen. Arch. Hydrobiol, 57, 389-407. 1961.

21. Zelinka M & Marvan P. Bemerikungen zu neuen Methoden der saprobiologischen Wasserbeuriteilung Verh. int. Ver. theor. angew. Limnol, 16, 817-822, 1966.