Proc. Estonian Acad. Sci. Biol. Ecol., 1997, 46, 1/2, 12–26
https://doi.org/10.3176/biol.ecol.1997.1/2.02

A CLASSIFICATION OF RIVER REACHES ON THE BASIS OF WATER QUALITY WITH REFERENCE TO STREAMS OF SAAREMAA ISLAND

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Received 29 October 1996, revised version received 28 January 1997, accepted 21 March 1997

Abstract. River reaches of Saaremaa Island were typified on the basis of 17 water quality parameters using cluster analysis. Although the pollution load is not high in the region, the following three types of river reaches were established: (i) unpolluted, (ii) affected by diffuse agricultural pollution, and (iii) affected by a point pollution source. The most essential parameters for discriminating the types were the content of biogenous elements (NO_3-N, NO_2-N, tot-P, PO_4-P), chlorophyll *a*, dissolved oxygen, and the values of BOD_5 and pH.

Key words: streams, water quality, typification, cluster analysis.

INTRODUCTION

The typology of the Estonian lakes has attracted the attention of researchers of the Limnological Station of the Institute of Zoology and Botany for a long time. As a result, a hydrobiological classification of lakes was developed (Mäemets, 1965, 1974). However, the rivers of Estonia have not yet been typified.

There exist several classifications of running waters, one of the earliest and best known of these is the "Saprobiensystem" suggested by Kolkwitz and Marsson. These systems have been considered by Hynes (1974). However, they are not directly applicable in Estonia because of different geographic, climatic, etc. conditions. Thus, there is a need for a typification of the Estonian rivers taking into account local conditions. The working group of river biology of the Institute of Zoology and Botany is tackling this issue.

Cluster analysis has been used in ecology to distinguish species groups and site groups (Bakus, 1990). This paper introduces a possibility of using cluster analysis as a tool in typifying river reaches. The rivers of Saaremaa Island serve as a model.

Whenever a classification is performed there arises the problem that different parameters yield different results. We often met this difficulty when we estimated the degree of saprobity of river reaches considering two parameters (Järvekülg et al., 1994). In the case of a larger number of parameters, the problem may become even more complicated. Also, there arises the question which parameter should be used in making the final decision. In this study the aim was to typify the river reaches of Saaremaa Island on the basis of 17 different water quality parameters so that the obtained types or groups of river reaches would differ from one another in as many parameters as possible. The types are described and the parameters that proved to be the most essential are presented.

MATERIAL AND METHODS

A number of river reaches of Saaremaa Island and one river reach of Muhu Island were studied (Fig. 1). The term *river* is used in the context of Saaremaa Island though in fact rivulets with water discharge less than 1 m^3/s were considered. Water samples were collected and analysed by members of the working group of river biology, Institute of Zoology and Botany, during the summer expedition of 7–11 July 1994. The content of organic matter (COD: chemical oxygen demand, nonfiltered titrimetric determination of used K_2CrO_4) and that of biogenous elements were determined by Malle Viik according to Koroleff (1976). The biomass and number of phytoplankton specimens were found by Kai Piirsoo after Edler (1979). Chlorophyll *a* (Chl) and pheopigments were analysed by Valli Porgasaar according to Lorenzen (as cited in Edler, 1979). Biochemical oxygen demand (BOD_5) and microbiological data were provided by the author. The total abundance of bacterioplankton was fixed by direct counts on membrane filters stained with erythrosine. The number of saprophytic bacteria was determined by plate counts using fish peptonic agar. The number of total coliform bacteria was determined by the method of the most probable number (MPN). The pH value and the content of dissolved oxygen were determined by conventional methods.

Data processing was performed with the computer program STATISTICA. Different methods of cluster analysis were applied to obtain groups. Standardized data, logarithmic data, or factor scores received by principal component analysis were used. As in cluster analysis all parameters are considered equal, none of the determined water quality parameters had any superiority over the others. The suitability of the groupings obtained by cluster

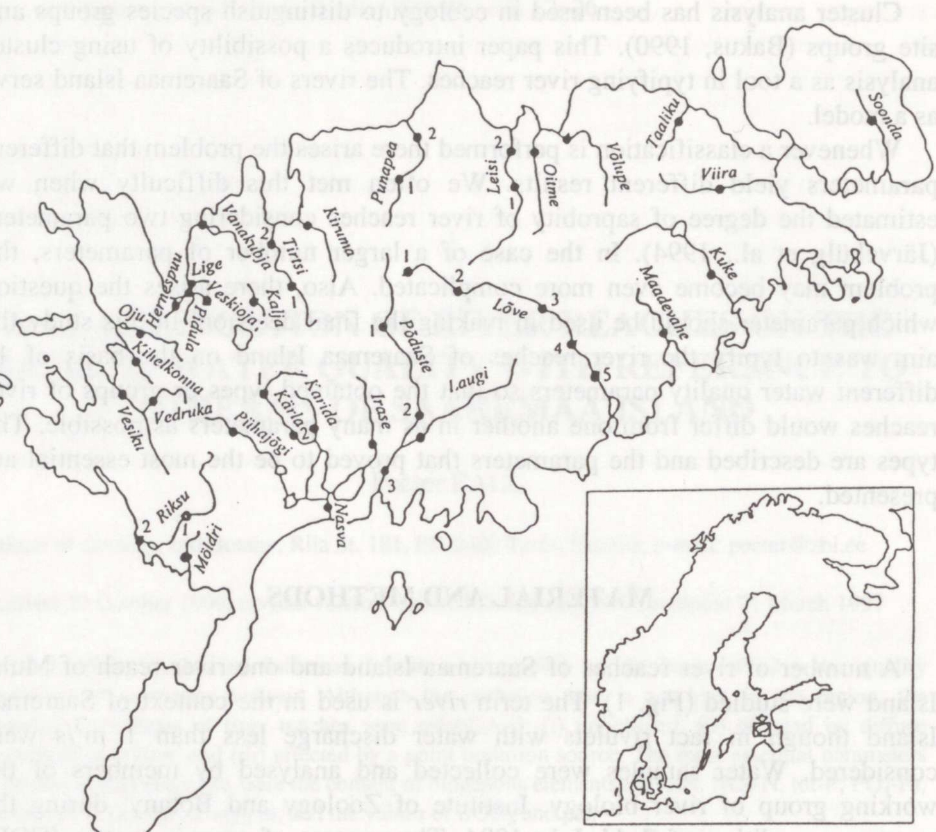

Fig. 1. The study area. The sampling sites are denoted by •.

analysis was first judged visually. In case groups were formed, the analysis was continued; if, however, river reaches could be distinguished individually, the clustering method was discarded. As our aim was to establish such types that would differ from one another in as many parameters as possible, we had to determine in all groupings the number of parameters that were different in different groups or clusters. For this the Kruskal–Wallis test (on raw data) was used. Performing a statistical test on the result of cluster analysis may seem senseless; it is indeed senseless if only one parameter is clustered. In our case 17 different parameters were clustered jointly, and the Kruskal–Wallis test was performed to check whether any single parameter was significant. In other words, we forgot about how the groups were obtained, and considered them as such; next, we tested in what respect these groups differed from one another. If a clustering method yielded groups with more than half of the parameters (nine or more) significantly different at the $p < 0.05$ level, the method was considered suitable. In case the number of such parameters was smaller, the method was discarded. With the groupings that proved to be suitable, the final grouping was performed excluding river reaches which fell into different groups with the application of different clustering methods. The final groups or types of river reaches were described and the significant parameters were established.

RESULTS

The studied river reaches, water quality parameters, and their values are given in Table 1. The following clustering methods turned out to be suitable for obtaining groups or types of river reaches:

F7W – seven-factor scores (eigenvalues ≤ 1) were received by principal component analysis; the Ward clustering method (Euclidean distance) was used; three clusters were established;

F2KM – two-factor scores were received by principal component analysis; the K-means clustering method was used; three clusters were established;

F2W – two-factor scores were received by principal component analysis; the Ward clustering method (Euclidean distance) was used; three clusters were established;

S17KM – standardized values of 17 parameters and the K-means clustering method were used; three clusters were established;

S17W – standardized values of 17 parameters and the Ward clustering method (Euclidean distance) were used; three clusters were established.

By means of other clustering methods individual river reaches could be discriminated, but no distinct groups were obtained. According to the results of the Kruskal–Wallis test, two four-cluster methods proved suitable as well; however, as the additional group revealed only a negligible difference, these methods were discarded, and only three-cluster variants were further applied. Although the methods of the nearest neighbour, furthest neighbour, UPGMA, WPGMA, as well as centroid clustering are widely used in biology (Bakus, 1990; Quicke, 1993), our aim was not to get a hierarchical result but rather to produce groups, and so the less exploited methods proved more appropriate. The K-means clustering represents a nonhierarchical method. The Ward method differs from the others in using analysis of variance to evaluate the distance between clusters.

Grouping variants and the significance levels of the respective parameters are presented in Table 2. The groups are given in Table 3.

Table 1

Water quality parameters in the river reaches investigated on Saaremaa Island

The following water quality parameters were determined: biochemical oxygen demand (BOD_5), content of organic matter (COD), biogenous elements (tot-N, NO_3-N, NO_2-N, NH_4-N, tot-P, PO_4-P), dissolved oxygen (O_2), pH, number of phytoplankton specimens (PN), phytoplankton biomass (PB), content of chlorophyll *a* (Chl), pheopigments (pheo), total abundance of bacterioplankton (TC), number of saprophytic bacteria (PC), and total coliform bacteria (coli)

Study reaches	Parameters																
	BOD_5, mgO_2/l	COD, mgO_2/l	tot-N, mg/m^3	NO_3-N, mg/m^3	NO_2-N, mg/m^3	NH_4-N, mg/m^3	tot-P, mg/m^3	PO_4-P, mg/m^3	O_2, mg/l	pH	PN $10^6/l$	PB, mg/l	Chl, mg/m^3	pheo, mg/m^3	TC $10^6/ml$	PC per ml	coli per l
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Põduste 1	2.0	37	658	7	1.0	41	41	7.0	8.4	7.8	0.2	0.10	1.6	0.4	1.2	2500	620
Põduste 2	1.6	11	1417	842	3.0	3	26	13.0	7.7	7.4	0.1	0.10	0.6	0.1	1.2	3500	2400
Põduste 3	2.2	15	1247	352	7.0	4	40	19.0	7.0	7.6	0.5	0.20	2.2	0.8	1.9	4500	2400
Laugi	1.9	28	801	210	2.0	4	40	13.0	7.5	7.6	0.1	0.05	0.6	0.2	8.7	2100	7000
Nasva	3.5	100	1063	5	1.0	36	28	2.0	9.0	8.5	0.6	0.20	1.8	0.1	6.8	2600	7000
Kärla 1	1.5	24	1228	476	4.0	13	19	1.0	8.0	7.7	0.1	0.10	1.6	0.3	4.8	2200	230
Kärla 2	1.6	33	1002	439	3.0	0	48	18.0	10.2	7.9	0.2	0.10	1.8	0.1	1.2	2400	2400
Karida	2.1	6	614	90	2.0	4	36	24.0	9.0	7.9	0.2	0.10	0.9	0.8	1.6	2200	230
Pühajõgi	1.9	42	1181	194	3.0	19	24	8.0	8.1	7.5	0.1	0.01	0.8	0.7	3.4	1900	7000
Irase	1.7	28	1595	1	1.0	0	61	32.0	6.5	7.7	0.1	0.10	1.2	0.6	1.8	2700	7000
Möldri	3.8	39	1890	378	9.0	70	130	82.0	5.3	7.4	1.2	0.30	4.0	0.2	1.8	2300	60
Riksu 1	2.0	37	1314	265	9.0	47	23	2.0	8.2	7.6	0.2	0.10	2.1	0.3	1.7	2500	2400
Riksu 2	2.6	68	1134	2	0.5	0	15	3.0	8.6	7.9	0.6	0.30	1.8	0.5	5.4	1300	130
Vesiku	3.9	37	689	28	1.0	63	32	10.0	8.8	7.7	0.1	0.10	1.5	0.2	5.2	1200	620
Vedruka	5.1	53	1153	52	5.0	118	41	12.0	6.5	7.6	0.3	0.10	3.0	2.2	11.0	1600	620
Kihelkonna	2.5	42	515	41	3.0	37	62	41.0	9.0	7.8	0.2	0.10	2.1	0.1	1.4	1800	620
Oju	2.1	24	451	14	1.0	11	10	2.0	8.7	7.8	0.1	0.10	1.0	0.1	3.0	1600	7000

Table 1 continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hernespuu	2.5	49	612	32	1.0	39	23	6.5	8.2	7.6	0.1	0.20	2.3	0.1	2.3	2400	2400
Pidula	3.3	20	419	65	1.0	28	24	1.0	8.8	7.8	1.9	0.40	2.8	0.1	3.2	1900	7000
Veskioja	1.6	33	547	359	1.0	38	76	16.0	8.0	7.6	0.1	0.10	1.4	0.6	3.5	1400	290
Lige	2.2	15	290	18	1.0	60	12	3.0	8.4	7.7	0.2	0.50	1.5	0.1	4.0	1400	60
Vanakubja	1.8	50	966	7	1.0	22	16	3.0	8.7	8.2	0.3	0.10	0.6	0.4	1.7	1300	2400
Kalja	2.3	57	934	16	1.0	86	36	15.0	8.4	7.7	0.1	0.10	1.2	0.1	4.0	1200	2400
Tirtsi 1	3.2	51	805	42	1.0	24	48	21.0	9.8	7.7	0.2	0.10	2.2	0.1	1.1	1400	230
Tirtsi 2	2.1	51	837	38	1.0	1	47	3.0	9.8	7.7	0.2	0.10	0.7	0.6	1.3	2300	2400
Kiruma	1.8	50	567	177	1.0	3	13	1.0	8.1	7.6	0.1	0.04	0.8	0.7	1.6	790	60
Punapea 1	1.9	46	1230	503	6.0	13	23	3.0	8.0	7.7	0.2	0.10	2.7	1.4	4.2	1700	620
Punapea 2	2.2	22	702	285	5.0	24	32	9.0	9.2	7.5	0.1	0.10	0.8	0.2	7.3	1700	60
Leisi 1	2.3	33	451	81	3.0	26	37	13.0	8.8	7.7	0.2	0.10	1.8	0.1	6.1	3400	2400
Leisi 2	3.6	55	406	101	3.0	7	37	16.0	10.6	7.8	0.2	0.10	1.8	1.0	5.3	1700	7000
Oitme	3.1	42	1063	303	6.0	286	98	59.0	10.4	8.2	0.3	0.20	2.9	1.0	3.8	2400	2400
Võlupe	2.5	34	869	526	4.0	12	32	15.0	9.2	7.7	0.2	0.20	1.7	0.4	4.3	2200	500
Taaliku	1.9	6	515	7	1.0	23	10	9.0	9.3	7.7	0.1	0.03	1.5	0.1	1.8	770	230
Viira	2.4	87	1513	1	1.0	1	37	10.0	9.2	7.6	0.4	0.10	3.3	1.5	3.7	2700	7000
Kuke	3.1	81	1088	45	4.0	22	65	35.0	6.1	7.4	0.1	0.10	1.8	0.5	5.1	2200	2400
Maadevahe	2.6	22	1191	461	3.0	34	45	27.0	8.1	7.5	0.1	0.20	1.8	1.0	4.1	2000	620
Soonda	3.7	20	901	137	11.0	20	81	16.0	7.0	7.5	0.1	0.20	13.1	1.4	6.1	6300	1300
Lõve 1	3.0	53	1399	2	2.0	1	87	21.0	3.3	7.6	0.5	0.20	4.9	0.6	1.8	2700	60
Lõve 2	1.8	27	1172	147	2.0	10	27	6.0	8.8	7.7	1.0	0.10	2.2	0.1	1.3	2600	60
Lõve 3	3.0	26	1625	244	2.0	3	54	32.0	9.6	7.6	0.3	8.00	2.5	0.1	1.9	2500	7000
Lõve 4	2.2	17	1421	196	2.0	7	50	24.0	8.5	7.7	0.4	0.40	2.0	0.1	1.4	1800	950
Lõve 5	2.8	4	733	296	3.0	1	43	22.0	11.0	7.6	0.4	0.60	1.2	4.4	1.3	1700	620

Table 2

Significance levels[a] of group-discriminating parameters after the Kruskal–Wallis test performed in different groupings

Parameter[b]	Method				
	F7W	F2KM = F2W	S17KM	S17W	Ideal
BOD_5	**0.0001**	**0.0006**	**0.0002**	**0.0011**	**0.0013**
COD	0.6338	**0.0040**	**0.0170**	**0.0042**	**0.0394**
tot-N	**0.0021**	**0.0006**	**0.0023**	0.0572	**0.0011**
NO_3-N	**0.0006**	**0.0001**	**0.0001**	**0.0000**	**0.0000**
NO_2-N	**0.0002**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
NH_4-N	0.2050	0.0777	0.1207	0.2349	0.2730
tot-P	**0.0009**	**0.0010**	**0.0013**	**0.0016**	**0.0024**
PO_4-P	**0.0057**	**0.0050**	**0.0183**	**0.0172**	**0.0140**
O_2	**0.0357**	**0.0184**	**0.0040**	**0.0287**	**0.0086**
pH	**0.0002**	**0.0114**	**0.0039**	**0.0469**	**0.0052**
PN	**0.0466**	0.6021	0.4267	0.5835	0.3031
PB	**0.0138**	0.2894	0.4000	0.3005	0.3803
Chl	**0.0090**	**0.0041**	**0.0037**	**0.0038**	**0.0044**
pheo	**0.0037**	**0.0309**	**0.0363**	0.0623	**0.0108**
TC	0.6059	0.2174	0.3447	0.3206	0.4619
PC	0.1183	0.0512	0.1005	0.0729	**0.0327**
coli	0.8487	0.4418	0.5522	0.0855	0.4645

[a] *p* values lower than 0.05 are set in bold.
[b] Refer to Table 1 for explanation of parameters.

DISCUSSION

Grouping variants. The methods of grouping selected as described above did not yield exactly the same results except methods F2KM and F2W. On the other hand, method F7W produced groups which differed from one another in the largest number of parameters. However, it is possible to construct "ideal" groups if we disregard some river reaches (Table 3, variable "ideal"). It is possible to typify the 11 discarded river reaches as well: three of them are intermediate between groups 1 and 2, four belong preferably to group 2, and three to group 1. The only uncertain reach is study reach 3 on the Lõve River. The existence of such intermediate reaches is quite plausible because according to the river continuum concept (Minshall et al., 1985) streams are regarded as longitudinally linked systems, and thus changes taking place in them are not abrupt. In the case

Table 3

Results of grouping river reaches by different methods

Study sites	Methods				
	F7W	F2KM = F2W	S17KM	S17W	Ideal
Põduste 1	1	1	1	1	1
Põduste 2	2	2	2	2	2
Põduste 3	2	2	2	2	2
Laugi	2	1	2	1	1
Nasva	1	1	1	1	1
Kärla 1	2	2	2	2	2
Kärla 2	2	2	2	2	2
Karida	1	2	1	2	
Pühajõgi	2	2	2	1	
Irase	2	2	2	1	
Möldri	3	3	3	3	3
Riksu 1	2	2	2	2	2
Riksu 2	1	1	1	1	1
Vesiku	1	1	1	1	1
Vedruka	3	3	3	3	3
Kihelkonna	1	1	1	1	1
Oju	1	1	1	1	1
Hernespuu	1	1	1	1	1
Pidula	1	1	1	1	1
Veskioja	2	2	2	2	2
Lige	1	1	1	1	1
Vanakubja	1	1	1	1	1
Kalja	1	1	1	1	1
Tirtsi 1	1	1	1	1	1
Tirtsi 2	1	1	1	1	1
Kiruma	2	1	1	1	
Punapea 1	2	2	2	2	2
Punapea 2	2	2	2	2	2
Leisi 1	1	1	1	2	
Leisi 2	1	1	1	1	1
Oitme	3	3	3	3	3
Võlupe	2	2	2	2	2
Taaliku	1	1	1	1	1
Viira	2	1	1	1	
Kuke	3	3	3	3	3
Maadevahe	2	2	2	2	2
Soonda	3	3	3	3	3
Lõve 1	3	3	3	3	3
Lõve 2	1	2	2	2	
Lõve 3	3	2	1	1	
Lõve 4	1	2	2	2	
Lõve 5	3	2	2	2	

the concept is applied directly, the classification systems that separate discrete reaches have little ecological value, as streams are best viewed as gradients. However, it should be born in mind that these gradients are broken by pollution sources, artificial lakes, etc. Besides, in this research different streams were studied rather than one stream where continuous changes could be observed.

Parameters. The following parameters turned out to be essential in typifying the river reaches: BOD_5, NO_3-N, NO_2-N, tot-P, PO_4-P, O_2, pH, Chl (in all distinguished groups), as well as tot-N, pheopigments, organic matter (in almost all groups) (Table 2). When the constructed "ideal" groups were tested after Kruskal–Wallis, all the 11 parameters as well as the number of saprophytic bacteria proved to be significantly different at the $p < 0.05$ level. Thus these parameters discriminate most effectively the types of river reaches of Saaremaa Island.

It is interesting to note that such sensitive water quality parameters as the total abundance of bacterioplankton, the number of coliform bacteria, and the content of NH_4-N turned out to be of little significance in the typification of river reaches. This may be explained by the absence of sources of heavy point pollution, or even by the hypersensitivity of these parameters. Nevertheless, the importance of these parameters as indicators of the state of a waterbody is well known. The low significance of phytoplankton is related to the fact that the streams under study were mostly short, and phytoplankton had not yet formed. On the other hand, the content of Chl turned out to be essential.

Descriptions of the types. The types are described as "ideal", intermediate reaches are neglected. The most important differences are illustrated in Figs. 2–9.

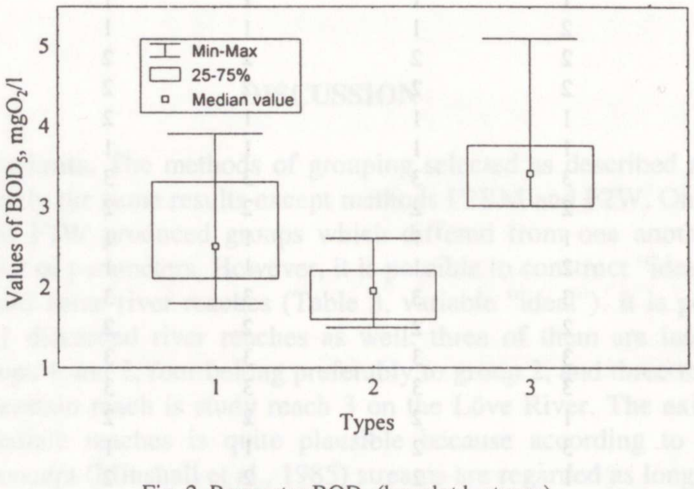

Fig. 2. Parameter BOD_5 (boxplot by types).

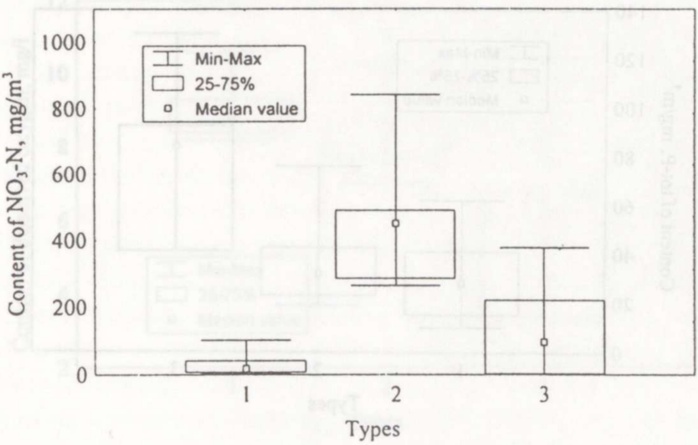

Fig. 3. Parameter NO_3-N (boxplot by types).

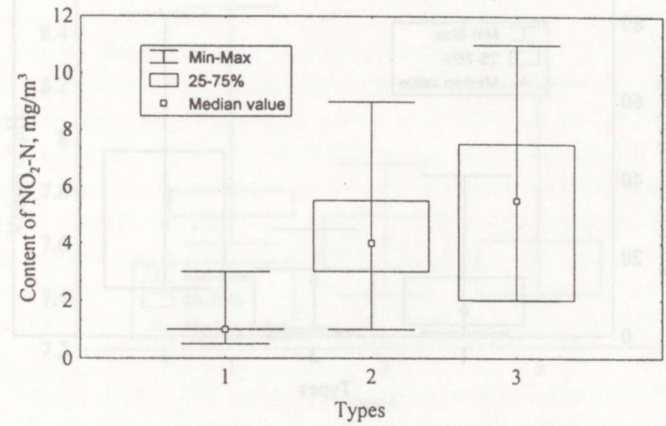

Fig. 4. Parameter NO_2-N (boxplot by types).

The first type is characterized by a very low content of NO_2-N, low content of Chl, NO_3-N, tot-P, and PO_4-P, by a predominantly low content of tot-N and pheopigments, and a small number of saprophytic bacteria. The value of pH is 7.7–7.8 or higher. The content of dissolved oxygen is high.

The second type is described by a high content of NO_3-N. The content of organic matter, Chl, tot-P, and PO_4-P, as well as the value of BOD_5 are low.

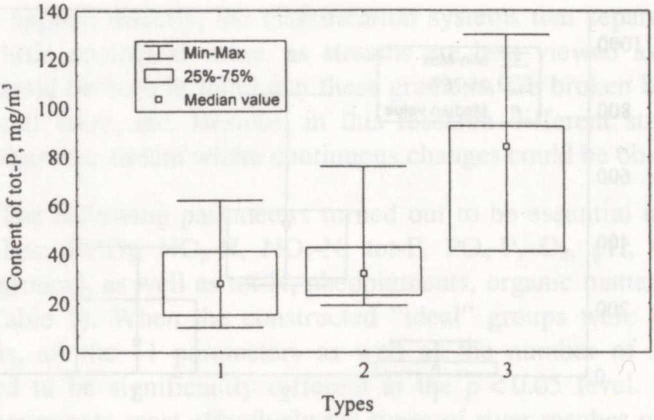

Fig. 5. Parameter tot-P (boxplot by types).

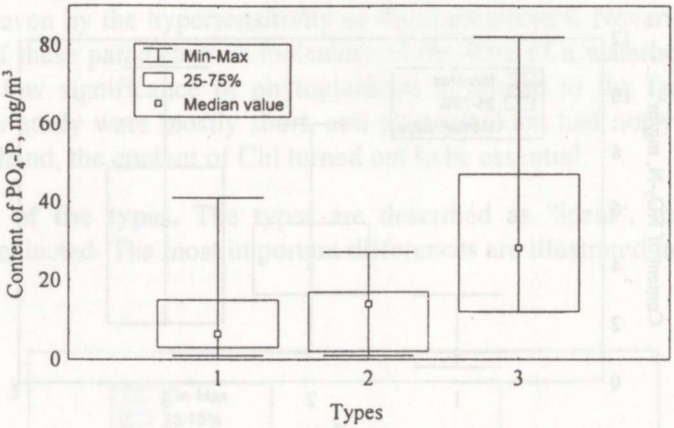

Fig. 6. Parameter PO_4-P (boxplot by types).

The third type is characterized by a high content of tot-P, PO_4-P, and Chl, and a high value of BOD_5. The value of pH and the content of dissolved oxygen are low. The content of tot-N, NO_2-N, and pheopigments and the number of saprophytic bacteria are mostly high.

The third type differs from the others primarily in the higher content of tot-P, PO_4-P, and Chl, as well as in a relatively high content of NO_2-N, tot-N, and pheopigments. The content of dissolved oxygen and the value of pH are lower,

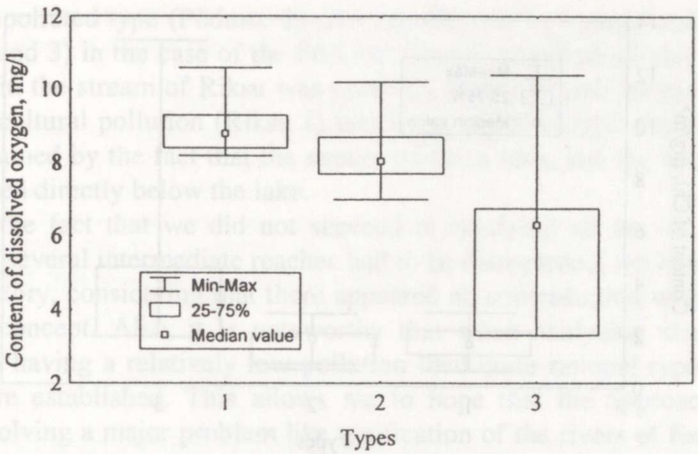

Fig. 7. Parameter O_2 (boxplot by types).

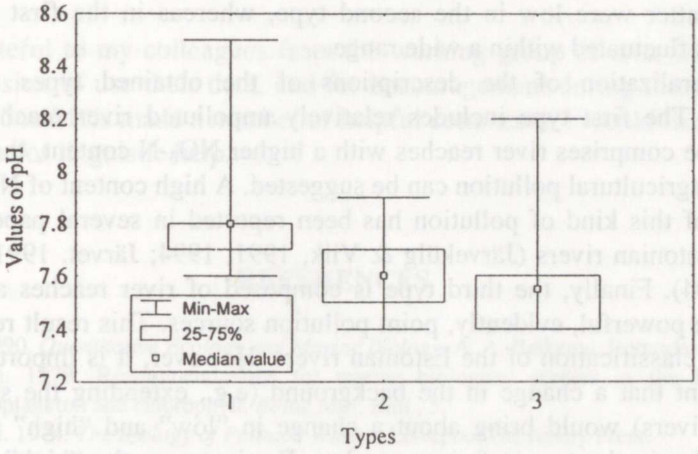

Fig. 8. Parameter pH (boxplot by types).

whereas BOD_5 values are higher in this type. So, the third type appears in some ways extreme: here one can find both maximum (BOD_5, tot-P, PO_4-P, tot-N, NO_2-N, Chl, pheopigments, saprophytic bacteria) and minimum (pH, O_2) values of several essential parameters, which indicates potential point pollution sources.

The first and the second group are more similar. They are distinguished most clearly by the content of NO_3-N, but also by the content of tot-N, NO_2-N, and pheopigments and the value of pH. In addition, BOD_5 values and the content of

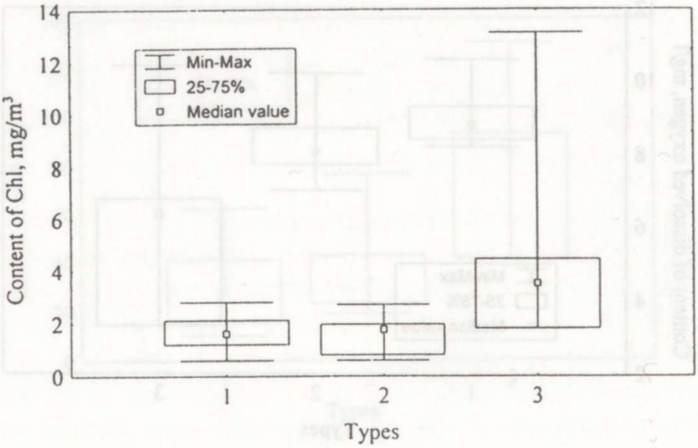

Fig. 9. Parameter Chl (boxplot by types).

organic matter were low in the second type, whereas in the first type these parameters fluctuated within a wide range.

A generalization of the descriptions of the obtained types shows the following. The first type includes relatively unpolluted river reaches. As the second type comprises river reaches with a higher NO_3-N content, the influence of diffuse agricultural pollution can be suggested. A high content of NO_3-N as an indicator of this kind of pollution has been reported in several papers dealing with the Estonian rivers (Järvekülg & Viik, 1991, 1994; Järvet, 1991; Loigu & Leisk, 1994). Finally, the third type is composed of river reaches affected by some more powerful, evidently, point pollution sources. This result reflects also a possible classification of the Estonian rivers. However, it is important to take into account that a change in the background (e.g., extending the study to all Estonian rivers) would bring about a change in "low" and "high" values and possibly also in the types of river reaches. For instance, the "high" content of NO_3-N in the water of the streams of Saaremaa is far from being "high" in case the streams of whole Estonia are considered.

A comparison of the trophic degree of the river reaches as estimated after Järvekülg (Järvekülg, 1994; Järvekülg et al., 1994) and the types constructed in this paper, shows that the results were quite reasonable: the water of the river reaches of the first and second types was either oligotrophic or mesotrophic, whereas the water of the reaches of the third type was eutrophic or even hypertrophic, that is with a higher trophic degree. There is only one exception, the stream of Vedruka.

In the case of rivers with several study reaches these fell into one type (Kärla, Tirtsi, Punapea) or into clearly different types (Põduste, Riksu). The transition from the unpolluted type (Põduste 1) into one affected by agricultural pollution (Põduste 2 and 3) in the case of the Põduste River is comprehensible. However, the change in the stream of Riksu was opposite, from the type characterized by diffuse agricultural pollution (Riksu 1) into the unpolluted type (Riksu 2). This can be explained by the fact that the stream passes a lake, and the second study site is situated directly below the lake.

Despite the fact that we did not succeed in typifying all the studied river reaches and several intermediate reaches had to be disregarded, the overall result was satisfactory, considering that there appeared no contradiction with the river continuum concept. Also, it is noteworthy that when analysing streams in a limited area having a relatively low pollution load quite rational types of river reaches were established. This allows me to hope that the approach can be applied in solving a major problem like typification of the rivers of Estonia as a whole.

ACKNOWLEDGEMENTS

I am grateful to my colleagues from the working group of river biology for their permission to use their data, and for encouragement during the writing of the paper. Tõnu Möls made a number of helpful comments. I would like to thank Ester Jaigma for linguistic help.

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JÕELÕIKUDE TÜPISEERIMINE VEEKVALITEEDI NÄITAJATE PÕHJAL SAAREMAA VOOLUVETE NÄITEL

Peeter PALL

Klasteranalüüsi abil on tüpiseeritud Saaremaa jõelõigud 17 veekvaliteedi näitaja alusel selliselt, et lõikude tüübid erinevad võimalikult rohkemate parameetrite põhjal. Hoolimata Saaremaa jõgede suhteliselt väikesest reostuskoormusest osutus parimaks järgnev jaotus: 1. tüüp – suhteliselt puhtad jõelõigud, 2. tüüp – suurenenud NO_3-N sisaldusega (ilmselt põllumajanduse hajureostus) jõelõigud ning 3. tüüp – suurenenud fosforisisaldusega (ilmselt punktreostus) jõelõigud. Olulisemateks näitajateks saadud tüüpide eristamisel osutusid NO_3-N, NO_2-N, üldfosfori, PO_4-P, O_2 ja klorofüll *a* sisaldus vees ning vee BHT_5 ja pH väärtus. Kasutatud lähenemisviis võiks olla paljulubav ka laiaulatuslike ülesannete lahendamisel, nagu kõigi Eesti jõgede tüpiseerimine.