Standardisation of River Classifications:

Framework method for calibrating different biological survey results against ecological quality classifications to be developed for the Water Framework Directive

Deliverable N3

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Spatial scale study

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INTRODUCTION

1.1. Objectives

The EU Water Framework Directive (Directive 2000/60/EC - Establishing a Framework for Community Action in the Field of Water Policy) defines a framework for assessing all kinds of waterbodies. A focus of the assessment systems demanded for by the Water Framework Directive is the use of biotic indicators (macrobenthic fauna, fish fauna and aquatic flora). The organism groups proposed by the Water Framework Directive indicate environmental change on different scales. It is generally assumed that the scale at which communities exhibit the greatest variation is the scale over which important physical/chemical gradients or biotic interactions control assemblage composition (Li et al. 2001). According to Thompson et al. (2001), the topic of spatial scale is one of the four paramount frontiers in ecology for "understanding how biological and physical processes interact over multiple spatial and temporal scales to shape the earths' biodiversity". Although focus has been placed on trying to determine if stream ecosystems are structured by abiotic (e.g. physico-chemical), biotic (e.g. predation) or by a combination of abiotic/biotic factors, contention still exists as to whether large-scale (regional or catchment) or small-scale (local or habitat) environmental factors are of main importance for structuring the communities (and thus the changes in species biodiversity) (e.g., Lammert & Allan 1999; Sandin & Johnson 2000a; Sandin & Johnson 2000b). In bioassessment, our ability to detect change is often confounded by natural spatial and temporal variability. In selection of robust indicators of biodiversity and ecological status, effort should be placed on selecting indicators that exhibit low natural, but high human-induced variance (Johnson 1995). Simply put, our ability to detect change if/when change occurs is, for the most part, a function of indicator variance and observed change (Johnson 1998; Sandin & Johnson 2000c). Accordingly, robust biodiversity indicators or metrics must have a low spatial and temporal variability compared to the change in index value caused by human perturbation (Johnson 1998; Sandin 2001).

Fish may be suited for the reach scale or the catchment scale, while changes in the macrobenthos better indicate change on the site scale. Phytobenthos may be useful in viewing even smaller scales. Thus, there is a further need to standardise which organism group or groups are to be used at which scale and under which circumstances. This understanding can be used to develop recommendations for integrated monitoring programmes and sampling networks that deliver cost-effective assessments at appropriate levels of scale and spatial resolution.

The estimation of effective spatial scales of the various taxonomic groups included in the WFD for the assessment of the Ecological Status of watercourse is an important task for monitoring, management and restoration of the biodiversity of aquatic ecosystems.

The aim of the workpackage is:

- to contribute to an understanding of different spatial scale stream biodiversity and use of different taxonomic groups for the assessment of ecological status of streams and how that can be used in implementing the WFD.

For this purpose key issues are:

- an identification of factors driving local and regional biodiversity;
- ecological scales that are relevant to both driver and response variables.

A nested hierarchical sampling design of high quality reaches from medium sized lowland streams was used to test at what ecological scale the different taxonomic groups (fish, macrophytes, benthic macrofauna and phytobenthos) are most variable. The lowest level of replication consists of samples collected within a stream stretch and the highest level of replication consists of individual catchments.

1.2. Format of the deliverable

The deliverable comprises two complementary components:

- Written Report on WP 18
- Databases containing all the data specifically collected for the WP 18

1.3. Participating partners

2 of the 22 partners participated in WP 18s:

- Swedish University of Agricultural Sciences........................ Sweden
- University of Latvia.. Latvia

A preparation and identification of phytobenthos samples were carried out by partners from Poland (Prof. Barbara Kawecka and Janina Kwandrans).

2. METHODS

2.1. Site selection

For the purposes of WP 18 a nested hierarchical propose was used (catchment area→stream→reach) for studies of stream biodiversity in accordance with spatial scale. In regard with Sytem A typology (WFD, Annex II) high quality reaches from medium-sized (catchment area 100 – 1000 km^2), deeper lowland (< 200 m) streams of Ecoregion 15 (Baltic) were recognised for this purpose.
The first step to reach these objectives was acquisition of existing data and selection of sampling sites. The data were obtained from previous investigations of medium-sized streams by Institute of Biology, University of Latvia, and monitoring data of Latvian Environment agency.
The problem was that existing set of sampling sites was not created in regard with WFD approach, and there was no real reference site network as well as all of necessary data for evaluation of reference sites.
Existing information was committed to experts' evaluation, and potential sampling sites were chosen considering Criteria for Reference site selection according STAR field protocols. The reference conditions reflect minimal anthropogenic disturbance, and selected sites corresponded with following characteristics: diversity of substrate material; natural channel structures not affected by major geomorphologic change; spawning habitats for the natural fish population; extensive, natural riparian vegetation dominated by native species; seasonal flow regime minimally altered; no significant point sources waste water discharge and major urban area (> 5000 population) within 20 km upstream; no sign of acidification and salinity. No signs of diffuse inputs or factors that suggest such inputs were expected.

Preliminary examination of the high quality river sites (dams, point source pollutants, land use pattern, accessibility) was done from topographical maps (1:50 000).

All of initially selected sites were examined in nature. The main problem for the selection of high quality sites was some inadequacy between theoretically chosen sampling sites based on previously available data and the real situation in nature (mainly due to beaver dams and hydro-power plants). The another problem was that the selection criteria for reference sites in several cases did not correspond with the demands for the percentage of agricultural lands e.g. it was larger than 20%. At the same time use of agricultural lands was not intensive, especially in comparison with EU countries. In Latvia very low level of fertilizers is typical in comparison with that in European countries: in 2000 in comparison with 1990 the use of mineral fertilizers decreased tenfold, and the use of organic fertilizers - fourfold. For example, in 1998, the use of fertilizers (N, P, K) was 23 – 34 kg/ha. The presence of agricultural lands in river basin in most of cases doesn't mean that there is a considerable diffuse pollution from catchments areas.

Considering that for fish sampling choice method is electrofishing, for sampling sites were selected wadeable reaches with < 1.2 m depth.

After final selection number and spatial location of sampling sites were as follows:

- Three streams from three selected catchments with an utmost high ecological status were sampled. Within each stream three reaches were sampled for spatial scale study (Fig. 2.1.1.). In total for spatial scale study 27 sites were sampled. List of sampling sites for WP18 and their coordinates is given in the Table 2.1.1.

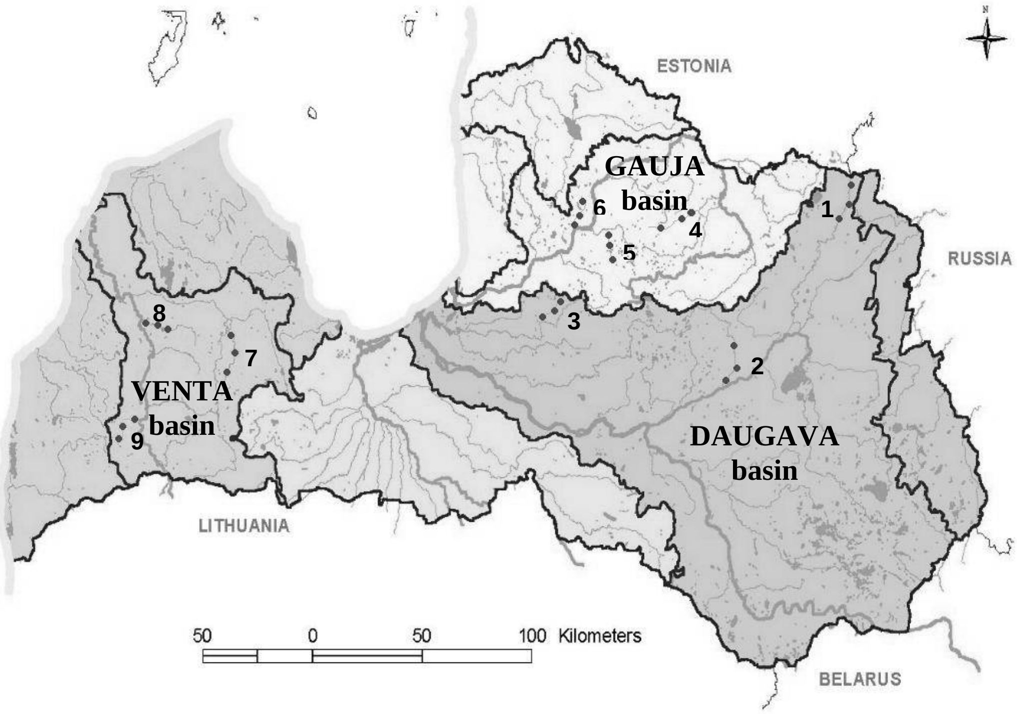


FIGURE 2.1.1. LOCATION OF SAMPLING SITES WITHIN THE TERRITORY OF LATVIA. (NUMBERS IN THE MAP CORRESPONDS TO STREAM BASINS NUMBERS IN THE TABLE 2.1.1.)

TABLE 2.1.1. WP18 SAMPLING SITES COORDINATES AND PERCENTAGE OF LANDUSE PATTERN

Stream basin	Sampling site	Coordinates		Land use pattern			
		Longit.	Latit.	Forests, %	Agricult. land, %	Bog area, %	Others, %
1 - Pededze	Pededze 1	27°20'58"	57°30'51"	75.7	23.6	0.7	0.00
	Pededze 2	27°19'43"	57°26'35"	57.8	40.1	1.2	0.87
	Pededze 3	27°17'06"	57°23'29"	62.6	33.1	4.0	0.31
				65.4	**32.3**	**2.0**	**0.47**
2 - Arona	Arona 1	26°05'28"	56°53'49"	51.6	46.9	0.7	0.81
	Arona 2	26°07'41"	56°49'44"	57.0	41.9	0.1	1.03
	Arona 3	26°02'49"	56°42'49"	55.3	41.7	0.5	2.47
				54.6	**43.5**	**0.4**	**1.4**
3 - Mergupe	Mergupe 1	25°14'36"	57°05'27"	53.2	46.0	0.1	0.67
	Mergupe 2	25°12'03"	57°04'30"	65.0	30.3	4.4	0.50
	Mergupe 3	25°02'39"	57°00'20"	58.2	39.6	1.5	0.68
				58.8	**38.6**	**2.0**	**0.6**
Daugava basin				**59.6**	**38.1**	**1.5**	**0.87**
4 – Rauza	Rauza 1	25°52'56"	57°19'58"	57.6	40.7	0.0	1.73
	Rauza 2	25°57'06"	57°21'59"	40.0	59.2	0.0	0.72
	Rauza 3	26°08'53"	57°24'46"	80.7	18.5	0.3	0.53
				59.4	**39.5**	**0.1**	**0.99**

5- Raunis	Raunis 1	25°28'32"	57°16'04"	56.5	42.0	0.2	1.20
	Raunis 2	25°26'05"	57°17'29"	31.7	64.0	0.0	4.64
	Raunis 3	25°24'26"	57°19'33"	47.2	52.4	0.0	0.41
				45.1	**52.8**	**0.1**	**2.1**
6- Strikupe	Strikupe 1	25°15'23"	57°24'50"	46.4	49.7	0.2	3.73
	Strikupe 2	25°15'52"	57°23'00"	80.5	19.5	0	0.00
	Strikupe 3	25°14'31"	57°21'46"	74.8	25.1	0	0.04
				67.3	**31.4**	**0.1**	**1.3**
Gauja basin				**57.3**	**41.2**	**0.1**	**1.44**
7- Amula	Amula 1	22°38'26"	56°49'19"	54.8	44.0	0.4	0.80
	Amula 2	22°40'27"	56°51'32"	40.9	54.6	1.9	2.59
	Amula 3	22°38'44"	56°59'58"	51.0	48.1	0.7	0.19
				48.9	**48.9**	**1.0**	**1.2**
8- Riezupe	Riezupe 1	22°05'19"	56°59'15"	58.4	38.0	0.9	2.74
	Riezupe 2	22°03'16"	56°59'22"	42.7	55.0	2.20	0.02
	Riezupe 3	21°59'17"	57°00'26"	50.0	45.0	2.2	3.31
				50.4	**46.0**	**1.8**	**2.0**
9- Koja	Koja 1	21°47'44"	56°34'47"	50.5	48.0	1.2	0.37
	Koja 2	21°50'33"	56°34'44"	83.6	15.7	0	0.70
	Koja 3	21°57'48"	56°37'38"	60.7	37.5	1.2	0.63
				64.9	**33.7**	**0.8**	**0.7**
Venta basin				**54.7**	**42.9**	**1.2**	**1.38**

In each stream in one of the reaches (lower one) the replicate sampling (three samples in total per point) was carried out in regard with benthic macroinvertebrates and diatoms. These nine reaches at the same time were also a core stream type (medium-sized, deeper lowland streams) high quality sites for WP7. Thus 27 samples (including replicates) from lower reaches were also sampled for the needs of WP 7 reducing the total number of samples for the project.

In addition to WP18, sites for studies of different grades of organic pollution were selected in accordance with WP7: six sites - Ecological Status = 'Good', three sites - Ecological Status = 'Moderate', four sites - Ecological Status = 'Poor' and two sites - Ecological Status = 'Bad'.

After sampling one of WP18 sites (Rauza 3) was transposed from High quality to Good quality status, so at the same time 8 sites from WP18 belongs to High status sites for WP7, and 1 site – to Good status of WP7.
Total number of sampling sites is given in the Table 2.1.2.

Table 2.1.2. Number of planned and sampled sites for WP18 and WP7

Ecological status of sampling sites	Number of sampling sites				Total sampling sites
	Preliminary planned		Sampled		
	WP 18	WP 7	WP 18	WP 7	
high	24	8*	26**	0	26
good	0	4	1***	6	7
moderate	0	4	0	3	3
poor	0	4	0	4	4
bad	0	4	0	2	2
Total sampling sites	**24**	**24**	**27**	**15**	**42**
	48		**42**		

* 3 of sites at the time are WP18 sites
** 8 of sites at the same time are WP7 sites

*** Site at the same time is WP7 site

2.2. Biological Quality Elements

The EU WFD defines the assessment systems for all kinds of waterbodies including streams. In EU countries historically benthic macroinvertebrates are most frequently used for stream assessment. At the same time the evaluation of ecological status is focused on a use of such biotic indicators as fish fauna and aquatic flora phytobenthos and macrophytes as well. These components react in different ways to changes in different environmental variables and indicate environmental change on different scales. Fish may be suited for the reach scale or the catchment scale, while changes in the macrobenthos better indicate change on the site scale. Phytobenthos may be useful in viewing even smaller scales.
The understanding of which organism group or groups are to be used at which scale can be used to develop recommendations for integrated monitoring programmes and sampling networks that deliver cost-effective assessments at appropriate levels of scale and spatial resolution.
Thus, all of WFD demanded Biological Quality Elements (BQE), except phytoplankton that isn't relevant characteristic for streams, were collected for spatial scale study (Table 2.2.1.).

Table 2.2.1. Number of Biological Quality Elements (BQE) samples for WP18 spatial scale study

BQE Number		Macro- invertebrates	Phyto- benthos	Macrophytes	Fish
Number of main samples	planned	27	27	27	27
	collected	27	27 x 3	27	26
	analysed	27	27 x 2	27	26
Number of Replicates	planned	18	18	none	none
	collected	18	18	none	none
	analysed	18	none	none	none
Total	planned	45	45	27	27
	collected	45	54	27	26**
	analysed	44*	54	27	26

* one of samples was spoiled
** one of sampling sites was not suited (too deep) for sampling

2.3. Sampling methods

Sampling for WP18 in general was done according STAR field protocols' instructions.
For acquaintance of sampling methods used for STAR project, training courses carried out in Poland for NAS countries were attended:

- Macroinvertebrate and phytobenthos training courses were attended by Elga Parele, Agnija Skuja (macroinvertebrates), Ivars Druvietis (phytobenthos)
- Macrophyte and RHS training course were attended by Andris Urtans (macrophyte) and Agrita Briede (RHS).

The participants were instructed: macrophytes by Nigel Holmes (Alconbury Environmental Consultants, UK), River Habitat Survey (RHS) by Paul Raven (UK

Environment Agency), Duncan Hornby (CEH, UK) and Pete Scarlett (CEH, UK).

- Standardised macrophytes surveys were undertaken using Mean Trophic Rank (MTR) standard protocol. According detailed "Guidance for the field assessment of macrophytes of rivers within the STAR project" macrophyte flora and physical character of 100 m watercourses were surveyed using a standard checklist.

- Fish sampling was carried out in regard with Fish sampling protocol that in general follows CEN standard CEN/TC230/WG2/TG4/N8. Site length was at least 10 times stream width, and varied between 50 to 80 m, mainly 70 to 80 m. Identification to species level and measurement of fish were taken place at the bank side, if possible.

- Macroinvertebrate samples were taken according to AQEM standard protocol focused on a multihabitat scheme designed for sampling major habitats proportionally according to their presence within sampling reach at all WP18 spatial scale sampling sites. Surber sampler with frame 25x25 cm was used.

- Diatoms were sampled using STAR benthic diatoms sampling protocol. Samples were collected from three different substrates: stones, sand (recommended for Core stream type 2) and macrophytes. For stones a minimum of five cobbles were selected randomly.

- River corridor/habitat surveys were undertaken using RHS (River Habitat Survey) protocols. For each sampling site the AQEM site protocol containing 130 hydrological, abiotic and morphological parameters was completed to gain comparable information on the ecological status.

2.4. Sampling programme

As diatoms' sampling for STAR WP 7 was planned in spring, WP 18 sampling also was shifted to this period for economies of time, labour and money. During sampling the temperature changed (increased) quite substantially about halfway through the sampling programme, but there were clearly not an option to delay the rest of the sampling until autumn, so sampling continued. The sampling of benthic macroinvertebrates, diatoms, water chemistry and measurements of discharge for WP18 was therefore completed during spring-early summer.

2.4.1. Macrophytes

Standardised macrophytes surveys were done according nested hierarchical scheme (Fig. 2.1.1): within three river basins three streams were selected, and within each stream three 100 m long reaches were surveyed in summer 2003 using MTR standard protocol.
In total all of 27 spatial scale sampling sites were investigated for macrophyte studies.

In addition to high quality WP18 streams those with different ecological quality for WP7 were studied (Table 2.1.2.).

2.4.2. Fish

Fish sampling was carried out according with Fish sampling protocol (http://www.eu-star.at) Like as for macrophyte surveys within three streams from three river basins three reaches were sampled (50 to 80 m long) in summer 2003. Sampling was started at the end of July, and the main part of samples was collected on August. Some problems arose for fish sampling due to heavy rain on August, and too high water level. Sampling was finished at the beginning of October (2 streams). Due to the same reason some offset from planned site location was done for 2 reaches.

In total 26 sites from 27 were investigated for fish spatial scale studies. One of sites (Koja 2) in summer was heavily modified and too deep for fish sampling due to beavers' actions since spring sampling of macroinvertebrates and phytobenthos.

In two of spatial scale sites – Arona 3 and Pededze 3 – for fish sampling it was not possible (gluepots, deep places) to catch more than 30 individuals per sampling unit necessary for further calculations.

In addition to high quality WP18 streams those with different ecological quality for WP7 were studied at the same time (Table 2). From these streams for two of them fish caught was less than 30 due to the same reasons as for WP18.

2.4.3. Macroinvertebrates

Macroinvertebrate samples for WP18 spatial scale study were taken according to AQEM standard protocol (http://www.eu-star.at) in all of WP18 sampling sites. Sampling was carried out in spring – early summer 2003. As it was late spring in 2003, sampling started after spring floods at the end of April and lasted to the middle of June.

In all of lower reaches of every stream in addition to main samples two replicate samples were collected. In total for WP18 45 macroinvertebrate samples were gathered. Sorting and identification of macroinvertebrate samples (except one sample from Koja 2, which was spoiled) were done in the laboratory using prescriptive procedures in standard manuals. Identification was done to the species level wherever possible or to the best achievable level.

Additionally to WP18 macroinvertebrate sampling for WP7 was done. It was provided in two seasons: in spring – early summer, the same time as for WP18, and in autumn – mainly September.

Eight of WP18 sites were high quality sites, one – good quality site also for WP7. Besides these sites 15 different quality - good, moderate, poor and bad – sites were sampled for WP7. In addition also 12 replicates were sampled for WP 7.

For 24 sites of WP7 also Latvian Standard LVS 240:1999 method (Water quality – Operative evaluation of biological quality of small stream by saprobity index of macro-zoobenthos community) for the purpose of methods' inter-calibration was used. By this method 12 replicates were sampled for six streams of different quality, and in total 36 samples were collected. For Latvian Standard LVS 240:1999 identification was provided according Protocol of indicator species list (Latvian Standard LVS 240:1999).

2.4.4. Phytobenthos

Diatoms were sampled using the standard Trophic Diatom Index (TDI) protocol in spring/early summer 2003. In total 27 main samples were collected from stones, 27 from sand and 27 from macrophytes. In each of lower reaches two replicate samples were collected from all three substrates, thus in total 54 replicate samples were collected. Samples collected from stones and sand were sent to Poland, where Polish partners leading by Prof. Barbara Kawecka and Janina Kwandrans prepared slides and carried out the identification of phytobenthos samples.
Problem arised due to misconception and only main samples without replicates were sent to Poland. At the same time identification of main samples were carried out twice as much as planned and phytobenthos from two different substrates (hard – cobbles, and soft – sand/silt) were analysed.

2.4.5. Environmental data and River Habitat Survey (RHS)

Samples for investigation of chemical composition of water were collected in spring-early summer 2003 according to Standard methods. (Anonymous, 1992). In total water samples from all 42 sampling sites were collected and pH-value, conductivity [µS/cm], dissolved oxygen content [mg/l] oxygen saturation [%], alkalinity [mmol/l], total hardness [mmol/l], chloride [mg/l], BOD5 [mg/l], ammonium [mg/l], nitrite [mg/l] nitrate [mg/l], ortho-phosphate [µg/l], total phosphate [µg/l] were analysed. Water colour, odours, reduction phenomena were evaluated visually.

The RHS method data collection was based on 500 m length river stretch and it included about 200 compulsory data entries for each site. At each spot-check located at 50 m interval the channel substrate, habitat features, aquatic vegetation type, the complexity of bank structure and type of artificial modification to the channel and banks are recorded. Also "sweep-up" checklist was completed for features that are not observed in each spot-check. Cross-section measurements of water and bankfull width, bank height and water depth were measured at one representative location of the each stream.

3. DATA HANDLING AND ANALYTICAL APPROACH

3.1. Macrophytes

For assessment of stream ecological quality regarding aquatic macrophytes a number of different metrics were selected indicative of composition, tolerance and trophic status.
Values of these metrics were calculated centralized by STAR project macrophyte group (lead by K. Szoszkiewicz, Poland).

Composition metrics are: species number, genus number, total families number, Shannon's diversity index, Simpson's diversity index and evenness.
Tolerance metrics were represented by hemeroby index that is an integrative measure for impacts of all human interventions on ecosystems It compares present vegetation with a reference vegetation, which can be pristine vegetation or present potential natural vegetation (Jalas, 1955; Sukopp, 1969; Kowarik, 1998).
Mean Trophic Rank (MTR) (Dawson et.al., 1999), Ellenberg Nitrophyllous index (Ellenberg_N) (Ellenberg, 1985) and Macrophyte Biological Index for Rivers (IBMR) (Haury et.al., 2002) were used as **trophic metrics**.
For single metrics of reaches, streams and basins descriptive statistics and coefficients of variation (CV) have been used.
Metrics among stream reaches, streams and river basins were analysed by Sign test (SPSS software).

3.2. Fish

Fish metrics for STAR project were selected according to the FAME project proposal (http://fame.boku.ac.at), and fish guilds were represented by **overall composition** (number N of all species which all were native ones), **abundance** – by density (n/ha) and biomass (kg/ha). Fish species were analysed by their **tolerance** (intolerant, tolerant), **habitat** (water column, benthic, rheophilic, limnophilic, eurytopic), **reproduction** (lithophilic, phytophilic), **longevity** (long lived, short lived), **feeding** (piscivorous, insectivorous/invertivorous, omnivorous), **migration** (long distance, potamodron), **historical metrics** and **sentinel species**.

Fish metrics for WP18 were calculated for all sampling sites except three of them. In two of spatial scale sites – Arona 3 and Pededze 3 – for fish sampling it was not possible (gluepots, deep places) to catch more than 30 individuals per sampling unit necessary for further calculations. One site – Koja 2 – was too deep for electrofishing in summer period due to beavers' action.

Calculation of **European Fish Index** (EFI) was provided by FAME. Lithuanian fish researchers proposed new **Index of Biotic Integrity** (IBI) for rivers of Ecoregion 15 adapted to the conditions of **Lithuania** (Lith_FI) (Kesminas, Virbickas, 2000). This multimetric index includes 11 metrics, which were proved to respond significantly to changes of the river status. There are two groups – responding positively or negatively to these changes.

Table 3.2.1. Metrics (1 – 11) selected for Lithuanian IBI for Ecoregion 15 and their response to degradation (Kesminas, Virbickas, 2000)

<table>
<tr><th rowspan="4">Measurement unit</th><th colspan="8">Metrics</th></tr>
<tr><th colspan="3">Positive response (metrics increases)</th><th colspan="5">Negative response (metrics decreases)</th></tr>
<tr><td colspan="3">Ecological guilds</td><td colspan="2">Ecological guilds</td><td colspan="3">Sentinel species</td></tr>
<tr><td>Tolerant</td><td>Eurytopic</td><td>Omni-vorous</td><td>Litho-philic</td><td>Insecti-vorous</td><td>Native salmonids</td><td>Cottus gobio</td><td>Alburnoides bipunctatus</td></tr>
<tr><td>Abundance(%)}*</td><td>1</td><td colspan="2" rowspan="2"></td><td>5</td><td>8</td><td>9</td><td>10</td><td>11</td></tr>
<tr><td>Biomass (%)**</td><td>2</td><td>6</td><td colspan="4" rowspan="2"></td></tr>
<tr><td>Number of species (%)</td><td></td><td>3</td><td>4</td><td>7</td></tr>
</table>

* - relative abundance of individuals
** - relative biomass of individuals

Lithuanian IBI was calculated for Latvian fish communities using algorithm of ecological status class assessment in accordance with WFD (Fig. 3.2.1).
For single metrics of reaches,streams and basins descriptive statistics and coefficients of variation (CV) have been used.
Metrics among stream reaches, streams and river basins were analysed by Sign test (SPSS software).

3.3. Macroinvertebrates

To obtain consistent data and ensure unambiguous data processing, the exported data from AQEM Dip database were taxonomically adjusted according to the AQEM guidelines.
Two adjustment methods were applied: aggregating species to a higher taxonomic level and omitting a higher taxonomic level, but discarded third method - distributing individuals which are “only” determined to genus level according to the relative share of individuals determined to species level.
The lowest possible taxonomic level - especially species level - was preferred. If the frequency of occurrence of genus was more than 20 % of the frequencies of occurrence of the underlying species together, all species were aggregated to the genus level.
Consequently we managed three taxonomic adjustments: only for STAR data (sampled according to the AQEM method), only for data of Latvian national method and for both data together according to the restricted taxa list (62 indicator species) of Latvian national method.

For calculation of metrics AQEM assessment software Version 2.3 was used. Metrics were grouped in 7 subgroups:

- **Eutrophication metrics:** Saprobic Index (Zelinka & Marvan), Biological Monitoring Working Party;
- **Diversity indices:** Diversity (Simpson-Index), Diversity (Shannon-Wiener-Index), Diversity (Margalef Index) and DSFI Diversity Groups;
- **Diversity metrics:** Number of Families, Number of Genera, Evenness and Abundance [ind/m²];
- **EPT-Taxa:** EPT-Taxa, EPT/OL, EPT/Diptera, OD/Total-Taxa, EP-Taxa, EPTCOB (Eph., Ple., Tri., Col., Odo., Bivalv.), EPT-Taxa (%), EPT/OL (%),EP (%), EPind/Totind (%) and EPT (%) (abundance classes);
- **Taxonomic group (%):** Porifera (%),Turbellaria (%),Nematoda (%),Nematomorpha (%),Gastropoda (%), Bivalvia (%),Oligochaeta (%),Hirudinea (%),Crustacea (%),Ephemeroptera (%), Odonata (%), Plecoptera (%),Heteroptera (%),Megaloptera (%),Trichoptera (%),Lepidoptera (%),Coleoptera (%),Diptera (%),Hydrachnidia (%) and Others (%).
- **Number of taxa:** Turbellaria, Nematoda, Nematomorpha, Gastropoda, Bivalvia, Oligochaeta, Hirudinea, Crustacea, Ephemeroptera, Odonata, Plecoptera, Heteroptera, Megaloptera, Trichoptera, Lepidoptera, Coleoptera, Diptera, Hydrachnidia and Others.
- **Abundance of taxonomic groups:** Nematoda, Nematomorpha, Gastropoda, Bivalvia, Oligochaeta, Hirudinea, Crustacea, Ephemeroptera, Odonata,

Plecoptera, Heteroptera, Megaloptera, Trichoptera, Lepidoptera, Coleoptera, Diptera, Hydrachnidia and Others.

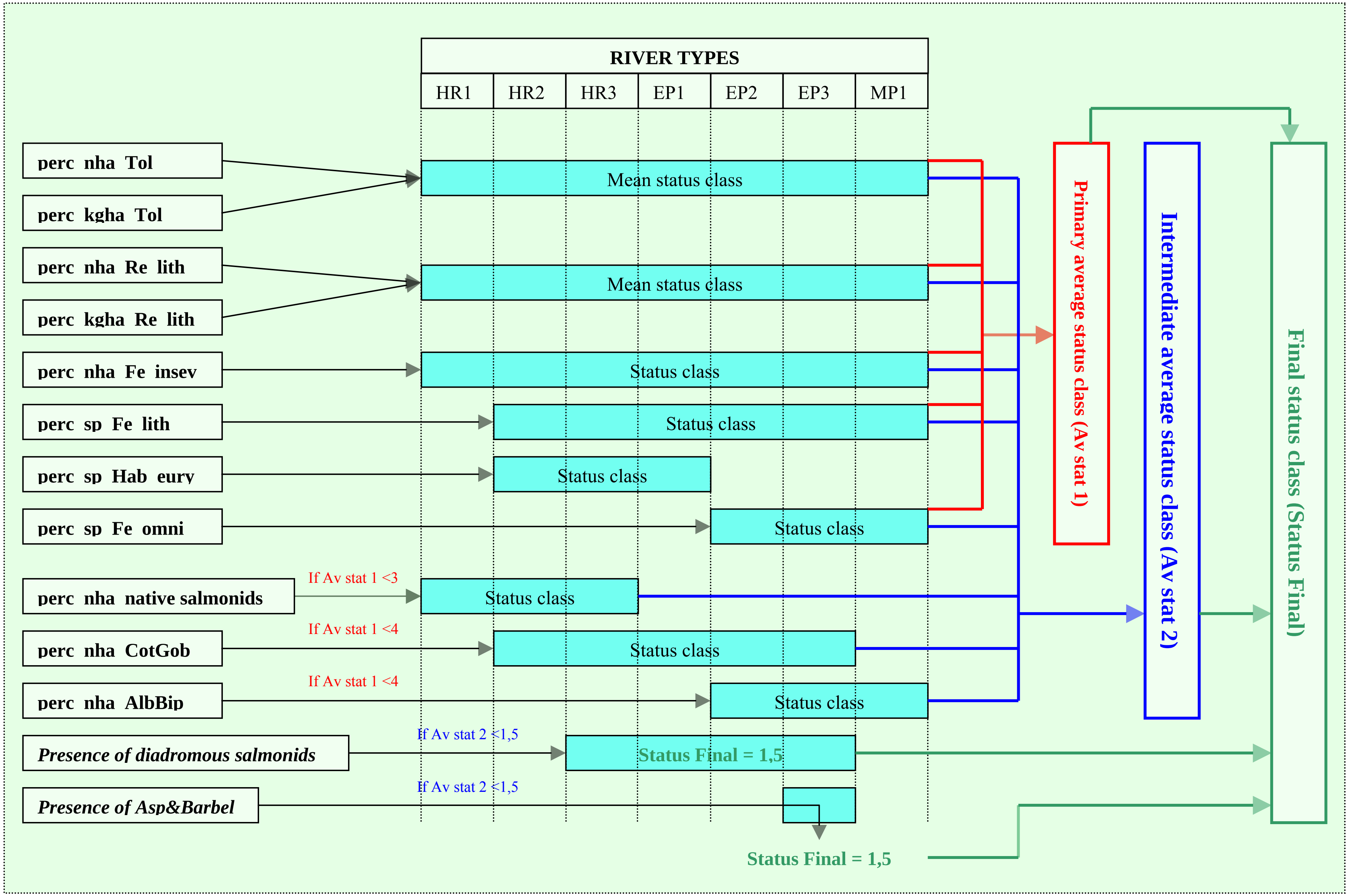
For single metrics of reaches,streams and basins descriptive statistics and coefficients of variation (CV) have been used.
Similarity of metrics among replicates, stream reaches, streams and river basins were analysed by Sign test (SPSS software).

3.4. Phytobenthos

Thirteen diatom indices based on relative abundance of epilithic diatom species were calculated using OMNIDIA software by STAR diatom expert group (Piet Verdonschot, Dutch partner): Specific Pollution Sensitivity Index (IPS), Sládecek's pollution index (SLAD), Descy's pollution index (DESCY), Leclercq & Maquet's pollution index (L&M), Steinberg & Schiefele trophic index (SHE), Watanabe et al pollution index (WAT), Trophic Diatom index (TDI), Pollution index based on diatoms (EPI_D), Trophic index (ROTT), Generic Diatom Index (IDG), Commission for Economical Community index (CEE), Biological Diatom Index (IBD), Indice Diatomique Artois Picardie (IDAP).

For single metrics of reaches,streams and basins descriptive statistics and coefficients of variation (CV) have been used.
Metrics among stream reaches, streams and river basins were compared by Sign test (SPSS software).

Fig. 3.2.1. Algorithm of stream status assessment according Lithuanian Fish Index



3.5. RHS

The calculations of **Habitat Quality Assessment** (HQA) and **Habitat Modification Score** (HMS) indices were conducted according to the scoring system used in the UK (Raven et al. 1997, Raven et al. 1998) and done within STAR project. The mean sum of total HQA (habitat quality assessment) scores for each stream site was used to assess richness and quality of the physical structure of a stream site. The scores of HMS (habitat modification scores) to assess modifications for each stream site were added in the set of environmental variables.

Defined classes in accordance with HMS index are following: Class 1- pristine and semi-natural with scores 0 to 2; Class 2 - predominantly unmodified with scores 3 to 8; Class 3 - obviously modified with scores 9 to 20; Class 4 - significantly modified with scores 21 to 44 and class 5 - severely modified with score ≥ 45.

Samples for investigation of chemical composition of water were collected in spring-early summer 2003 and processed in laboratory according to Standard methods. (Anonymous, 1992).

3.6. Statistics and relations of metrics with environmental factors

For single metrics of reaches, streams and basins descriptive statistics and coefficients of variation (CV) have been used.

Disparity between metrics at different scale and relation of metrics with environmental factors were tested by use of Sign test and by multivariate method – Principal components analysis (PCA). Significant sample disparity was not stated if Exact Sig. (2-tailed) > 0.05.

The set of environmental variables for Principal Component Analyses (from site protocols) included following parameters: catchment's size, altitude, gradient slope, distance from source, character of mineral substrates (megalith, macrolith, mesolith, microlith, akal, psammal/psammopelal) and % of coverage of biotic microhabitats (macro-algae, micro-algae, submerged macrophytes, xylal, CPOM and FPOM). Land use pattern (percentage of forests and agricultural lands) and size of catchments were main parameters characterizing catchments land use/cover. All measured chemical variables (pH, conductivity, oxygen concentration, alkalinity, hardness, chloride, BOD_5, ammonium, nitrite, nitrate, phosphate, tot-P) included in site protocol were added for that analysis.

For PCA analyses the set of environmental variables have been included in main matrix and biological metrics in second matrix. We calculated only loadings for 1st and 2nd axis and each matrix was anlaysed seperately.

About 40 parameters from the Site protocol of the STAR project describing morphology (character of mineral substrates and % of coverage of biotic microhabitats), hydrology (discharge, velocity, width, depth), chemistry (pH, conductivity, oxygen concentration, alkalinity, hardness, chloride, BOD_5, ammonium, nitrite, nitrate, phosphate, tot-P), catchments characteristics (catchment's size, altitude, gradient slope, distance from source, percentage of forests and agricultural lands) as well as the Habitat Quality Assessment Index (HQA) and Habitat Modification Score (HMS) from River Habitat Survey (Raven, et al., 1997; 1998) were also analysed by correlation coefficients (the significant correlations $r = \pm 0.66$; $\alpha = 0.05$). Linear regression analysis done after standardization of environmental variables. Since the environmental variables conformed to normal distributions, the relationship with metrics were assessed using linear regression and Pearson's correlation coefficients. For further analyses only environmental variables, which have a significant correlations with BQE metrics (Shannon's and Simpson's indices) were used in the linear regression model. These indices have been used as dependent variables and environmental variables as predictors.

All the above-mentioned statistic testing were carried out using MS Excel and SPSS 12.0.1 as well as the PC-ORD software (McCune & Mefford, 1999).

4. SPATIAL VARIABILITY OF THE DIFFERENT BIOLOGICAL QUALITY ELEMENTS

4.1. MACROPHYTE

4.1.1. Macrophyte metrics

Values of macrophyte metrics at studied reaches, streams and river basins in total and mean values per streams and river basins are found in Annex I.

Results of the study demonstrate that in general investigated river reaches were represented by 1 to 20 macrophyte species, 1 to 17 genus and 1 to 16 families that were distributed quite unevenly (Fig. 4.1.1.1.). Between species number and genus number ($r = 0.99$; $\alpha = 0.01$) as well as between species number and family number ($r = 0.98$; $\alpha = 0.001$), there was a strong correlation.

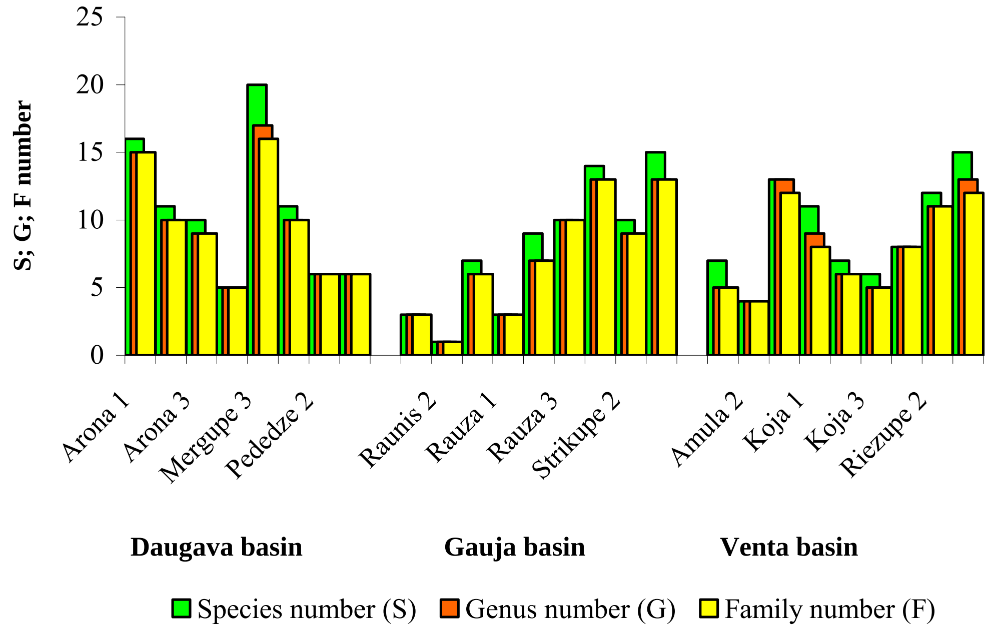


Fig. 4.1.1.1. Number of macrophyte species, genus and families for streams' reaches.

For composition metrics negative correlation between Shannon's index and Simpson's index was found at the reach scale (r = - 0.848; α = 0.01), and it was more obvious for stream scale (r = - 0.923; α = 0.01). For stream scale also strong positive correlation between Shannon's index and evenness was found (r = 0.993, α = 0.01).

Mean, standard error and range for macrophytes composition metrics - Shannon's diversity index, Simpson's diversity index, domination and evenness - for reaches, streams and river basins are in the Table 4.1.1.1. Among these metrics Simpson's index was in comparison less variable (Table 4.1.1.1).

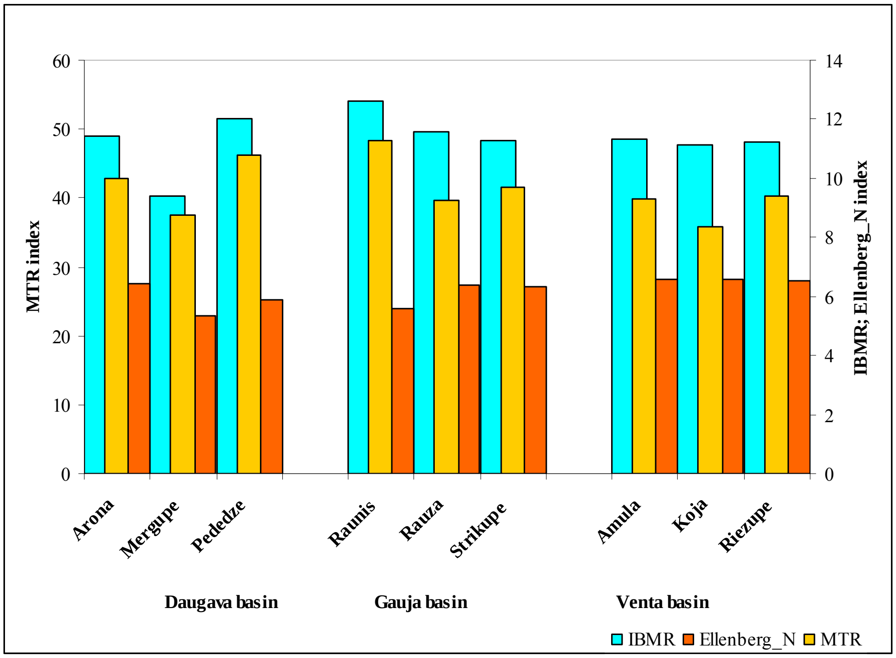


Figure 4.1.1.2. Mean trophic indices MTR, IBMR, Ellenberg_N per streams of Daugava, Gauja and Venta basins

Mean trophic indices MTR, IBMR, Ellenberg_N per streams of the Daugava, the Gauja and the Venta basins are shown in Fig. 4.1.1.2. Values of means, standard errors and ranges for MTR, Nitrophyllous index Ellenberg_N and IBMR for reaches, streams and river basins are given in the Table 4.1.1.2.
Analyses of trophic indices showed negative correlations between MTR and IBMR ($r = -0.884$; $\alpha = 0.01$) and between Ellenberg_N and hemeroby indices ($r = -0.934$; $\alpha = 0.01$) on stream scale.

Mean values for Hemeroby index that characterizes impacts of all human interventions on ecosystems are shown in Table 4.1.1.3.

The analyses of macrophytes on different scales showed that the largest CV were on the reach scale. Among macrophyte composition metrics the largest CV was found for Shannon's diversity index, followed by evenness, species number, and the least variable was for Simpson's diversity index. This group of metrics was more variable in comparison with trophic and tolerance metrics (hemeroby index), except Simpson's diversity index that was least variable of all calculated macrophyte metrics In comparison, the most variable metric was cover of macrophytes (Table 4.1.1.4.).

For the comparison of variability of macrophyte metrics within catchment, the most variable i.e., Shannon's diversity index and the least variable i.e., Simpson's diversity index were chosen for further analyses. Results showed that the values of Shannon's diversity index varied quite extensively (CV was 57.03 for the Daugava basin, 112.70 for the Gauja basin and 46.17 for the Venta basin), but differences of Simpson's diversity index were negligible (CV was 1.11 for the Daugava basin, 6.14 for the Gauja basin, and 1.07 for the Venta basin) within the river basins.

Sign test for macrophyte trophic metrics (MTR, IBMR, Ellenberg_N), composition metrics (species number, genus number, family number, Shannon's diversity index, Simpson's diversity index, domination, evenness), and trophic and composition metrics among samples confirmed that in most cases there was not statistically proved difference among reaches, streams and river basins. The difference among samples was found for composition metrics in two cases: between two reaches of the River Koja (the Venta basin) and between two streams on the Daugava basin (Annex II).

Table 4.1.1.1. Mean, standard error and range for macrophyte composition metrics (Shannon's diversity index, Simpson's diversity index, domination and evenness) for streams' reaches, streams and river basins

Area	Shannon's index			Simpson's index			Domination			Evenness		
	n	Range	Mean	n	Range	Mean	n	Range	Mean	n	Range	Mean
Reaches	25	0 – 0.64	0.15 ± 0.14	25	0.82 – 1.00	0.99 ± 0.04	25	0.14 - 1	0.42 ± 0.25	25	0 – 0.24	0.07 ± 0.05
Streams	9	0.07 - 0.41	0.15 ± 0.11	9	0.92 – 1.00	0.99 ± 0.02	9	0.24 – 0.83	0.42 ± 0.20	9	0.04 – 0.16	0.07 ± 0.04
Basins	3	0.11 – 0.18	0.15	3	0.97 – 1.00	0.99	3	0.34 – 0.58	0.42	3	0.05 – 0.08	0.07

Table 4.1.1.2. Mean, standard error and range for macrophyte trophic metrics (MTR, Nitrophyllous index Ellenberg_N and IBMR) for streams' reaches, streams and river basins

Area	MTR			Nitrophyllous index Ellenberg_N			IBMR		
	n	Range	Mean	n	Range	Mean	n	Range	Mean
Reaches	25	28.33 – 60.00	41.90 ± 7.45	24	4.00 – 6.97	6.23 ± 0.69	25	8.15 - 15	10.70 ± 1.45
Streams	9	35.54 - 48.33	41.50 ± 4.11	9	5.34 – 6.58	6.18 ± 0.45	9	9.02 – 12.60	10.60 ± 1.07
Basins	3	38.56 – 43.97	41.50	3	5.89 – 6.55	6.18	3	9.97 – 11.43	10.60

Table 4.1.1.3. Mean, standard error and range for macrophyte hemeroby index

Area	n	Range	Mean
Reaches	24	36.00 – 45.77	42.89 ± 2.45
Streams	9	40.39 – 44.80	42.79 ± 1.61
Basins	3	42.04 – 44.22	42.79

Table 4.1.1.4. Coefficients of variation (CV) for macrophytes metrics

Scale	Composition metrics					Trophic metrics			Tolerance metric	Σ cover
	N_species	Evenness	Domination	Shannon's index	Simpson's index	Ellenberg_N	MTR	IBMR	Hemeroby	
Reaches	49.8	77.9	59.0	89.53	3.78	11.1	17.8	13.6	5.7	134.9
Streams	33.4	61.4	48.7	71.92	2.47	7.4	9.9	10.1	3.8	101.6
Basins	15.0	23.2	33.0	25.31	1.35	5.5	6.6	7.1	2.9	45.1

4.1.2. Macrophyte correlation with environmental data

PCA Analyses were applied for environmental variables (as main matrix) and 10 metrics of macrophytes: MRT, IBMR, Ellenberg indices, Species, Genus and Family numbers, Shannon's and Simpson's indices, Domination and Evenness (as second matrix).

The first PCA axis in the **Daugava basin** accounts for 28.38 % of total variance (λ=10.22), the second axis – for 24.83 % (λ=8.94) and third axis accounts for 15.88 % (λ=5.72). In total three components explained 69.1 % (Table 4.1.2.1.).
The first principal component separated the physical (morphometrical variables and substratum) parameters, but there was no strict correlation between metrics and first component (Figure 4.1.2.1.).
The second component was factor of chemical variables of catchment's (mostly depending on basin character: hardness, alkalinity, conductivity, pH value), physical parameters (stream velocity), and land use/cover variables. The highest correlation with second factor is found for Ellenberg_N and Simpson's indices (-0.67 and -0.58, respectively and negative correlation with domination and evenness (0.88 and 0.75, respectively) (Annex III).

The first PCA axis for the **Gauja basin** analysis accounts for 30.4 per cent of total variance (λ=10.93), the second axis – for 23.7 % (λ=8.54) and third axis accounts for 13.5% (λ=4.84). In total three components explained 67.6 % and further set of them were used for the description of gradient (Table 4.1.2.2.).
The first axis highly correlated with catchment's physical parameters (morphometrical parameters and substratum), HQA, with BOD_5 value and in a less degree with land use pattern. The pronounced correlation with first component is found for domination index, genus, family and species numbers (0.84; -0.78; -0.78 and –0.77, respectively). In the Gauja basin first factor can be called as physical factor (Fig. 4.1.2.2).
The second component was chemical variables of catchment mostly depending of basin genesis (conductivity, hardness, alkalinity, pH value) and also oxygen. There is no association found between macrophytes metrics and the first component. Only Ellenberg_N index shows tendency of negative correlation (-0.5) with second axis (Annex IV)

The first PCA axis for the **Venta basin** accounts for 30.98 % of total variance (λ=11.15), the second axis – for 23.48 % (λ=8.45) and third axis accounts for 13.5% (λ=4.84). In total three components explained 67.91 % (Table 4.1.2.3.)

The first axis was highly correlated with local physical (morphometrical parameters - width, depth, substratum) and HQA, and to a lesser degree with land use pattern and pH. The marked correlation with first axis is seen for family, genus, and species numbers (0.69; 0.68; 0.61, respectively). The correlation of first axis with Shannon's index, evenness and IBMR is not statistically significant (Annex V).
The second axis has significant correlation with chemical variables. There is an association of Simpson's (r= 0.66) and evenness index (r = -0.64) with the second factor (Fig. 4.1.2.3.).

Table 4.1.2.1. Extracted variances for the streams in the Daugava basin

Axis	Eigenvalue	Percentage of Variance	Cum.% of Var.
1	10.218	28.383	28.383
2	8.938	24.828	53.211
3	5.717	15.88	69.091
4	3.879	10.776	79.867
5	3.238	8.995	88.862
6	2.427	6.742	95.604
7	1.583	4.396	100
8	0	0	100
9	0	0	100
10	0	0	100

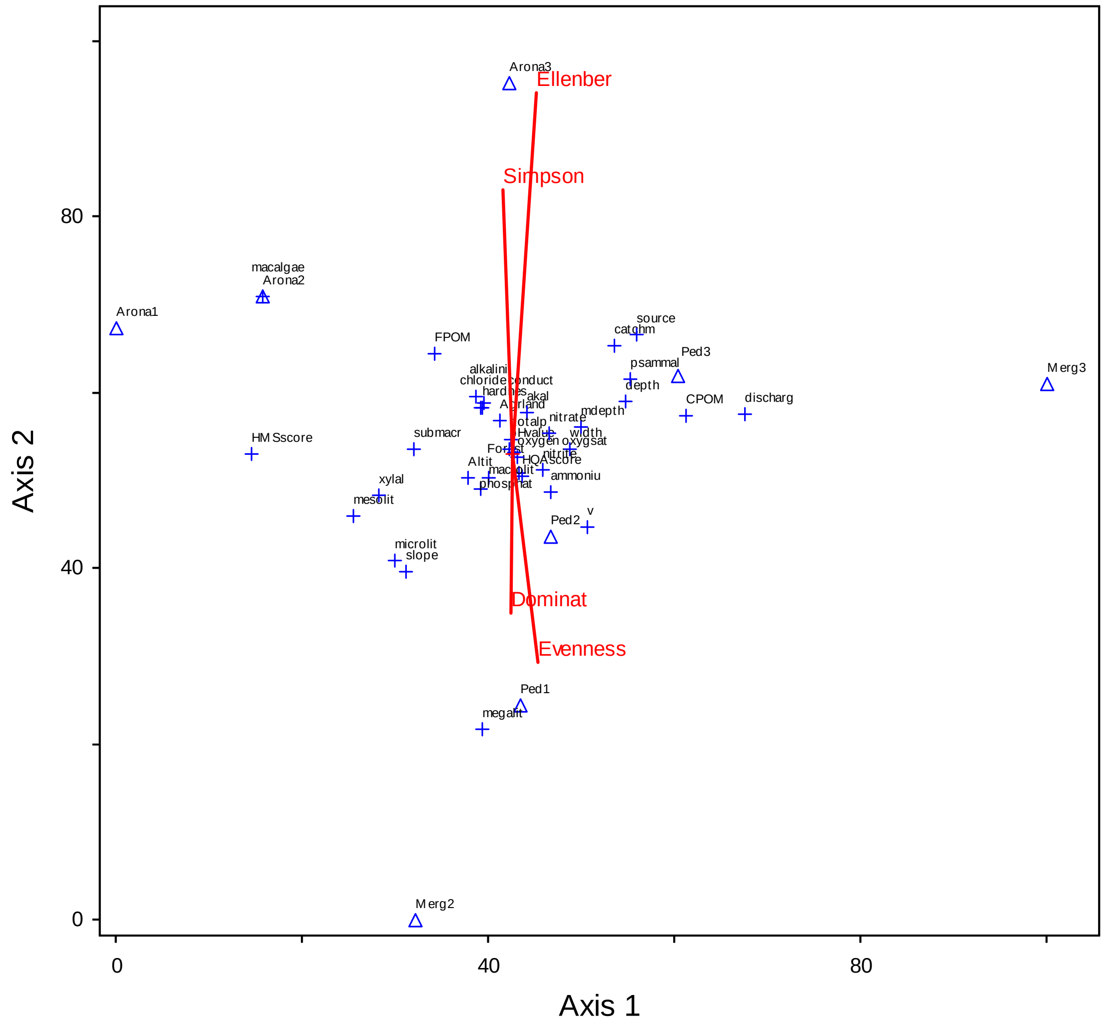


Figure 4.1.2.1. PCA of macrophytes metrics and environmental variables for the Daugava basin streams

Table 4.1.2.2. Extracted variances for the streams in the Gauja basin

Axis	Eigenvalue	% of Variance	Cum.% of Var.
1	10.938	30.383	30.383
2	8.545	23.735	54.118
3	4.843	13.452	67.57
4	3.804	10.567	78.137
5	2.492	6.921	85.059
6	2.07	5.751	90.81
7	1.762	4.894	95.704
8	1.547	4.296	100
9	0	0	100
10	0	0	100

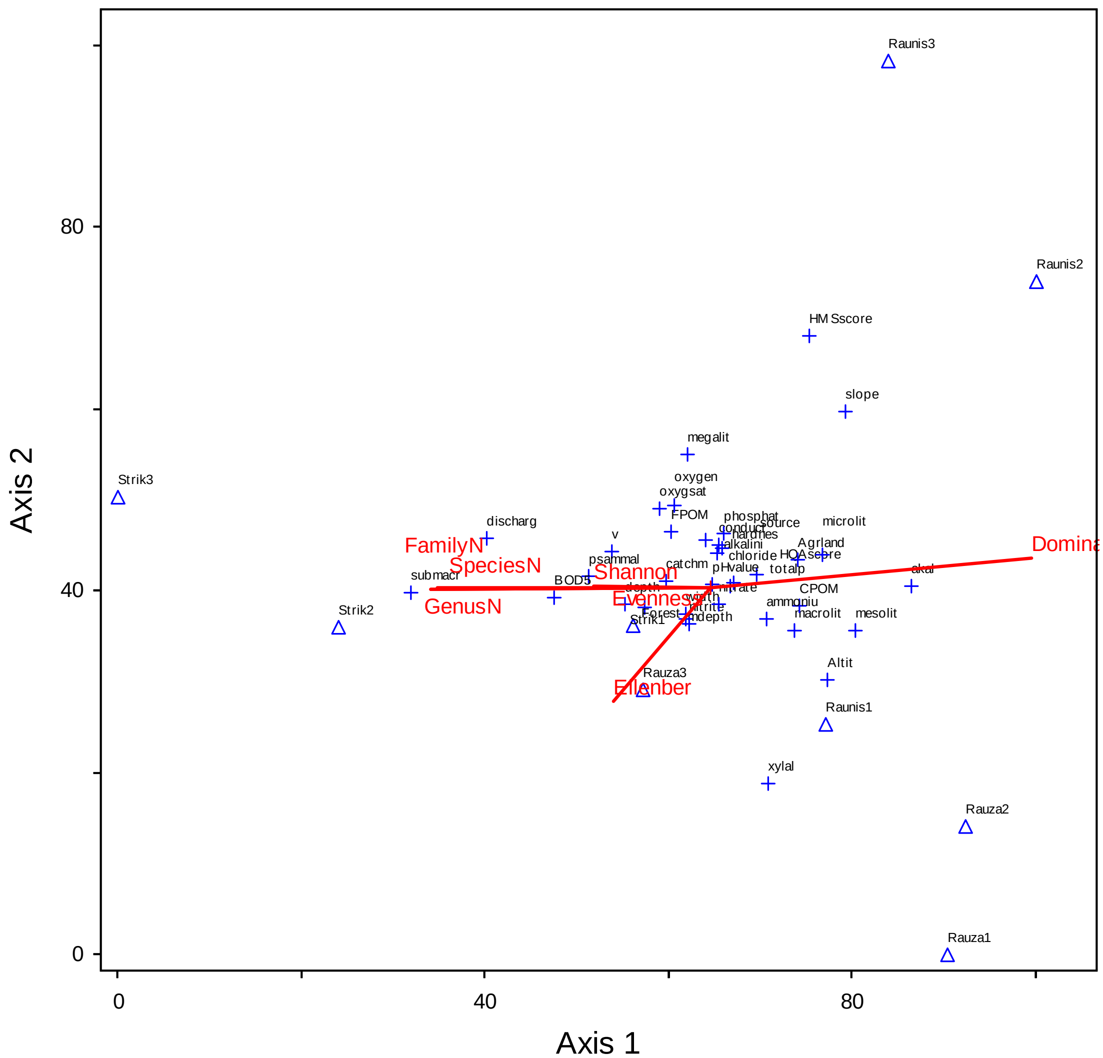


Figure 4.1.2.2. PCA of macrophytes metrics and environmental variables for the Gauja basin streams

Table 4.1.2.3. Extracted variances for the streams in the Venta basin

Axis	Eigenvalue	% of Variance	Cum.% of Var.
1	11.152	30.978	30.978
2	8.455	23.485	54.464
3	4.84	13.443	67.907
4	4.369	12.137	80.044
5	2.673	7.426	87.47
6	1.867	5.187	92.657
7	1.462	4.061	96.718
8	1.181	3.282	100
9	0	0	100
10	0	0	100

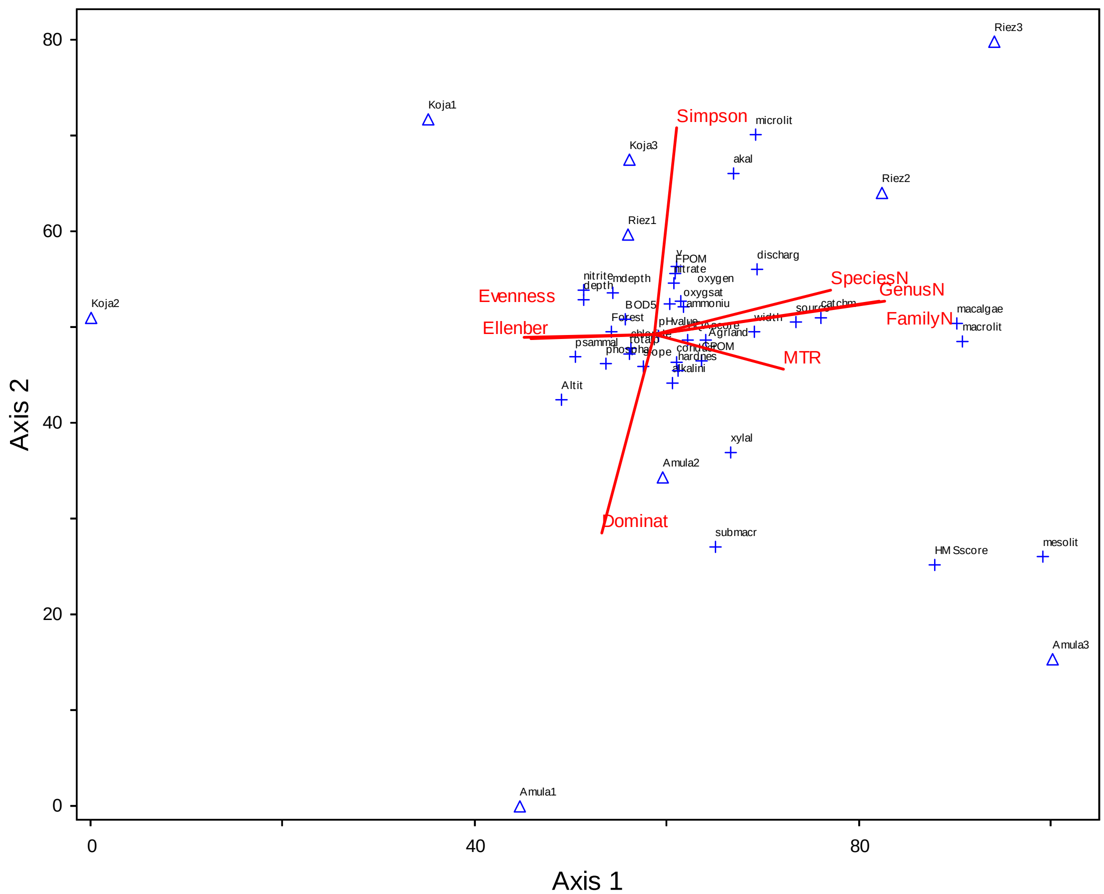


Figure 4.1.2.3. PCA of macrophytes metrics and environmental variables for the Venta basin streams

Table 4.1.2.4. Significant Pearson's correlation coefficients (in bold) for environmental variables and macrophyte diversity indices in the Daugava, the Gauja and the Venta basins

Parameters	Daugava Shannon's index	Daugava Simpson's index	Gauja Shannon's index	Gauja Simpson's index	Venta Shannon's index	Venta Simpson's index
HQA score	0.25	**-0.68**	-0.19	-0.2	0.08	-0.03
slope	0.02	**-0.75**	-38	0.28	-0.15	0.31
velocity	0.5	**-0.73**	0.11	0.1	0.23	0.2
altitude	-0.08	-0.06	**-0.67**	0.45	0.15	-0.53
psammal	0.38	-0.09	**0.68**	-0.37	-0.2	-0.41
CPOM	0.54	-0.11	-0.1	-0.03	**-0.74**	0.07
oxygen	**0.66**	**-0.76**	-0.04	0.17	-0.05	0.63
alkalinity	-0.33	**0.69**	0.11	-0.15	0	**-0.66**
hardness	-0.3	**0.67**	-0.01	-0.04	-0.05	-0.55
chloride	-0.53	**0.74**	-0.27	0.16	-0.26	0.02
ammonium	0.03	0.01	**-0.79**	0.54	-0.09	0.38
phosphate	0.11	-0.36	-0.15	0.04	0.35	**-0.8**
tot- phosphorus	-0.09	0.25	0.27	-0.52	0.09	**-0.68**
nitrite	**0.84**	-0.52	0.1	0.08	0.1	0.43

Table 4.1.2.5. Characteristics of multiple linear regression model with macrophyte diversity indices (dependent variables) and significance of environmental variables (predictors)

Shannon's macrophyte diversity index					
Daugava basin		**Gauja basin**		**Venta basin**	
Environmental variables	*Sign.of coeff.*	Environmental variables	Sign.of coeff.	Environmental variables	*Sign.of coeff.*
Oxygen sat.	0.028	Ammonium	0.166	Catchment size	0.03
Nitrite	0.007	psammal	0.912	macrolithal	0.59
Sign. of model: 0.003		*Sign. of mode:* 0.058		*Sign. of model:* 0.004	
R Square: 0.90		*R Square*: 0.61		*R Square*: 0.95	
Simpson's macrophyte diversity index					
Daugava basin		**Gauja basin**		**Venta basin**	
Environmental variables	*Sign.of coeff.*	Environmental variables	Sign.of coeff.	Environmental variables	*Sign.of coeff.*
Slope	0.003	Tot- P	0.047	Phosphate	0.017
oxygen	0.003	psammal	0.072	Alkalinity	0.049
Sign. of model: 0.004		*Sign. of model:0.073*		*Sign. of model:* 0.009	
R Square: 0.95		*R Square*: 0.58		*R Square*: 0.85	

In general, the linear regression analyses of relationships between macrophyte's diversity indices (Shannon's and Simpson's) and environmental variables didn't reveal any common relationships (Tables 4.1.2.4. and 4.1.2.5). Significant correlation coefficients for macrophytes Simpson's diversity indices and environmental variables were more expressed for the Daugava basin in comparison with the Gauja and the Venta basins. In the Daugava and Gauja basin the most important environmental variables were chemical parameters linked with water quality - nutrients and oxygen. In the Venta basin an important role was found for phosphorus and alkalinity for macrophytes Simpson's diversity index, and multiply regression models also was found for macrophytes (Table 4.1.2.5).

4.2. FISH

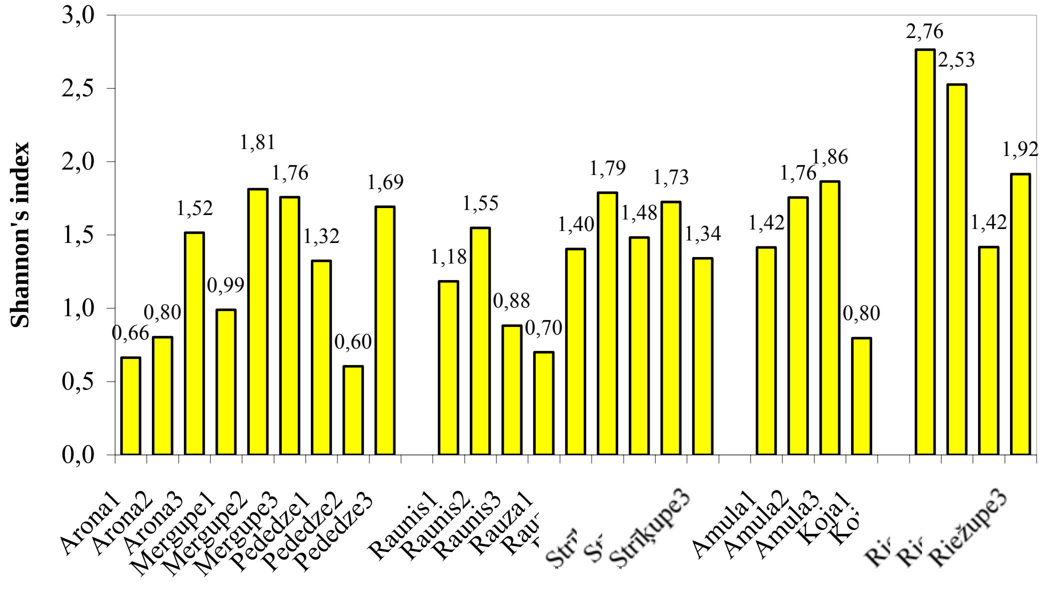
4.2.1. Fish metrics

In total 23 fish species were catched in studied streams (Alburnus alburnus, Alburnoides bipunctatus, Cobitis taenia, Cottus gobio, Esox lucius, Gasterosteus aculeatus, Gobio gobio, Lampetra fluviatilis, Leuciscus cephalus, Leuciscus leuciscus, Leucspius delineatus, Lota lota, Noemacheilus barbatulus, Perca fluviatilis, Phoxinus phoxinus, Pungitius pungitius, Rhodeus sericeus, Rutilus rutilus, Salmo salar, Salmo trutta, Scardinius erythropthalmus, Thymallus thymallus and Tinca tinca), and according Lithuanian Fish index native salmonids (Salmo salar, Salmo trutta), Cottus gobio and Alburnoides bipunctatus represented sentinel species. All of the fish species belong to native ones.
Mean values and range for fish species for streams' reaches, streams and river basins are in Table 4.2.1.1.

Table 4.2.1.1. Mean, standard error and range for fish species number for stream reaches, streams and river basins

Area	n	Range	Mean
Reaches	26	3 - 10	5.38 ± 1.65
Streams	9	3.7 - 7.7	5.37 ± 1.12
Basins	3	4.9 – 5.7	5.37± 0.42

Fish biodiversity was evaluated by Shannon's index (Fig. 4.2.1.1.). It varied from 0.42 to 1.92 (mean 1.00) on reach scale.



Daugava basin (mean 1.25) **Gauja basin (mean 1.34)** **Venta basin (mean 1.8)**

Figure 4.2.1.1. Shannon's index for streams' reaches of Daugava, Gauja and Venta basin

Fish guilds represented by density (n/ha) and biomass (kg/ha) varied quite largely (Table 4.1.2.2.). These metrics correlated in reaches (r = 0.59, α = 0.01) and streams (r = 0.67, α = 0.05).

Table 4.2.1.2. Mean, standard error and range for density (n/ha) and biomass (kg/ha) of fish species for reaches, streams and river basins

Area	Density of species			Biomass of species		
	n	Range	Mean	n	Range	Mean
Reaches	26	310 - 16000	4013.42 ± 3588.73	26	2 - 88	30.61 ± 21.76
Streams	9	1325 - 6409	4002.55 ± 1704.15	9	13 - 66	30.17 ± 15.94
Basins	3	2718 - 4767	4002.56	3	21 - 40	30.17

Fish species were analysed by their tolerance (intolerant, tolerant), and 0 to 3 intolerant (mean 1.7 ± 0.9) and tolerant (mean 0.85 ± 0.84) species were found per reach.

In all river basins rheophilic species dominated in comparison with limnophilic and eurytopic ones on reach scale as well as on stream scale (Table 4.2.1.3.; Table 4.2.1.4).
In most of reaches and streams percentage of water habitat species was approximately the same as that of benthic habitat species, except two streams (in River Pededze prevailed benthic habitat species, and in River Koja – water habitat species) (Table 4.2.1.4.).

Fish metrics characterizing lithophilic and phytophilic reproduction (number of species n_sp; percentage of species perc_sp; number per ha n_ha; percentage of number per ha perc_nha, kg per ha kg_ha, percentage kg per ha perc_kg_ha) per reach, stream and river basin are in Annex VI. It is seen that lithophilic reproduction prevailed. Lithophilic reproduction was more expressed for the Daugava basin in comparison with the Gauja and the Venta basins (Fig. 4.2.1.2.).

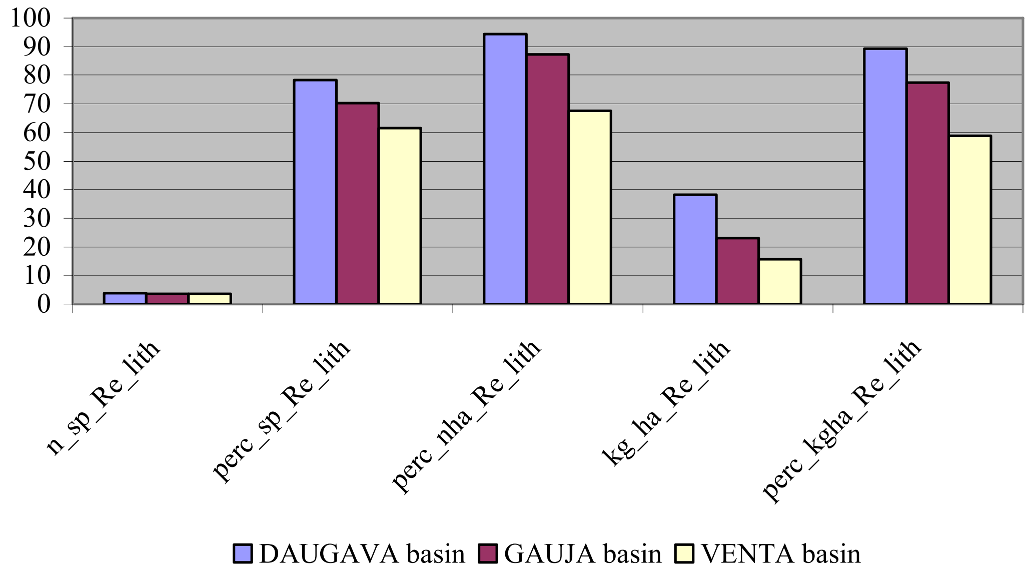


Figure 4.2.1.2. Fish metrics characterizing lithophilic reproduction per basins
(number of species n_sp_Re; percentage of species perc_sp_Re_lith; percentage of number per ha perc_nha_Re_lith, kg per ha kg_ha_Re_lith, percentage kg per ha perc_kg_ha_Re_lith).

In general for most of reaches and streams and all three river basins long lived species prevailed in comparison to short lived ones in regard with all characteristic metrics (number of species n_sp; percentage of species perc_sp; number per ha n_ha; percentage of number per ha perc_nha, kg per ha kg_ha, percentage kg per ha perc_kg_ha). Exception was two reaches (Amula 1 and Koja 3) and River Koja from Venta basin where short lived species characterized by kg per ha and percentage of kg per ha were larger than long lived species (Annex VII).

Insectivorous/invertivorous fish feeding was typical for most of reaches and streams of Daugava and Gauja basins. In comparison, for Venta basin increases role of omnivorous fish species per reaches and streams (Annex VIII). In most of streams fish production is provided only/most by insectivorous/invertivorous fish. Insectivorous/invertivorous fish production was typical for Daugava basin, but omnivorous fish production was essential for two of three Venta basin streams (Fig. 4.2.1.3.).

Numbers of potamodron and long distance migratory fish per hectare in reaches of Daugava, Gauja and Venta river basins show great dispersion (Fig. 4.2.1.4.).

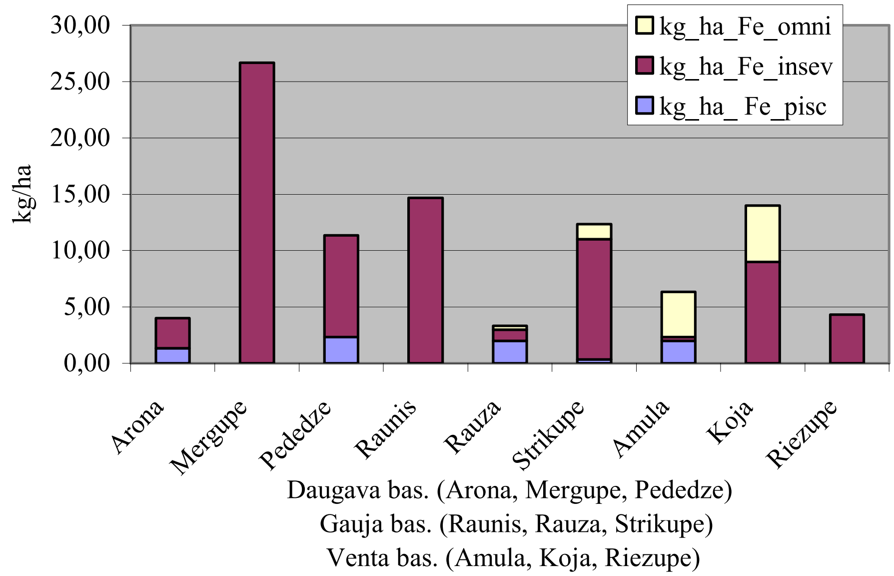


Figure 4.2.1.3. Fish production (kg/ha) by insectivorous/invertivorous and omnivorous fish species in streams of Daugava, Gauja and Venta river basins

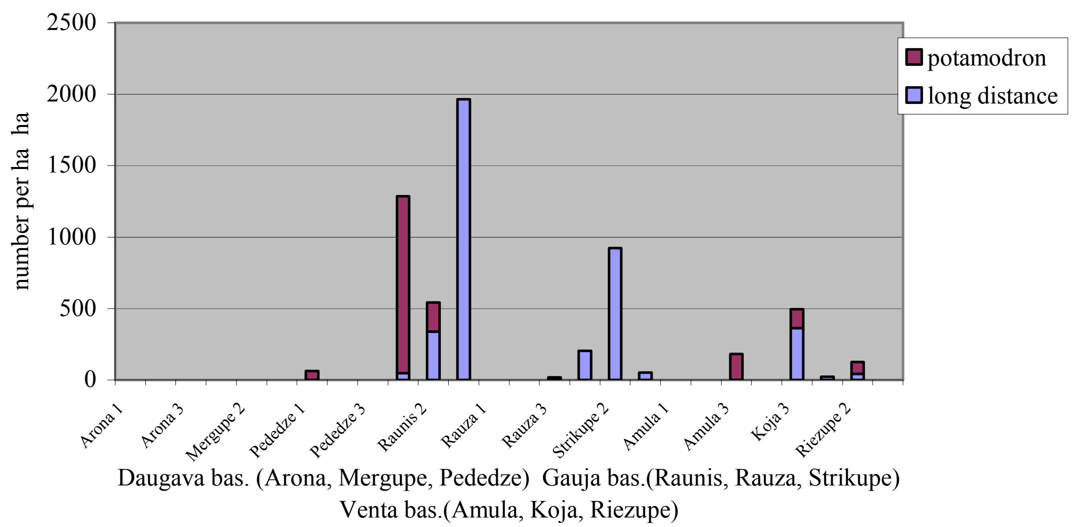


Figure 4.2.1.4. Number of potamodron and long distance migratory fish per hectar in streams' reaches of Daugava, Gauja and Venta river basins

Table 4.2.1.3. Mean values of fish species per different habitats (water column, benthic, rheophilic, limnophilic, eurytopic) of reaches and streams of Daugava, Gauja and Venta basins

Habitat	Scale	Daugava basin			Gauja basin			Venta basin		
		n	Range	Mean ± SD	n	Range	Mean ± SD	n	Range	Mean ± SD
Water column	Reach	9	1 - 4	2.33 ± 0.87	9	1 - 5	3.00 ± 1.32	8	2 - 4	3.25 ± 0.71
	Stream	3	1.7 - 3	2.33	3	2.3 - 4	3.00	3	3 - 3.5	3.27
Benthic	Reach	9	1 - 4	2.55 ± 0.88	9	1 - 5	2.55 ± 1.33	8	1 - 4	2.55 ± 0.93
	Stream	3	2 - 3.3	2.56	3	1.3 – 3.7	2.55	3	1.5 3	2.39
Rheophilic	Reach	9	3 - 6	4.22 ± 0.97	9	2 - 6	4.22 ± 1.20	8	1 - 6	4.12 ± 1.64
	Stream	3	3.7 – 4.7	4.22	3	3.7 - 5	4.22	3	3.5 – 4.7	4.06
Limnophilic	Reach	8	0 - 1	0.25 ± 0.46	9	0 - 1	0.22 ± 0.44	8	0 - 2	0.37 ± 0.74
	Stream	3	0 – 0.7	0.22	3	0. – 0.7	0.22	3	0 1	0.44
Eurytopic	Reach	9	0 - 2	0.44 ± 0.72	9	0 - 4	1.11 ± 1.27	8	0 - 2	1.25 ± 0.71
	Stream	3	0 - 1	0.44	3	0 - 2	1.11	3	0.5 – 1.7	1.67

Table 4.2.1.4. Percentage of fish species by habitats (water column_wc, benthic_b, rheophilic_rh, limnophilic_li, eurytopic_eury)

River/Basin	Site Name	perc_sp_Hab_wc	perc_sp_Hab_b	perc_sp_Hab_rh	perc_sp_Hab_li	perc_sp_Hab_eury
	Arona 1	60	40	80	0	20
	Arona 2	50	50	100	0	0
	Arona 3	40	60	60	0	40
Arona		**50,00**	**50,00**	**80,00**	**0,00**	**20,00**
	Mergupe 1	75	25	75	25	0
	Mergupe 2	50	50	100	0	0
	Mergupe 3	57	43	86	14	0
Mergupe		**60,67**	**39,33**	**87,00**	**13,00**	**0,00**
	Pededze 1	33	67	83	0	17
	Pededze 2	40	60	100	0	0
	Pededze 3	25	75	100	0	0
Pededze		**32,67**	**67,33**	**94,33**	**0,00**	**5,67**
DAUGAVA BASIN		**47,78 ± 14,13**	**52,22 ± 14,13**	**87,11 ± 7,17**	**4,33± 7,51**	**8,56 ± 10,31**
	Raunis 1	75	25	100	0	0
	Raunis 2	75	25	100	0	0
	Raunis 3	33	67	100	0	0
Raunis		**61,00**	**39,00**	**100,00**	**0,00**	**0,00**
	Rauza 1	60	40	80	0	20
	Rauza 2	33	67	67	0	33
	Rauza 3	50	50	75	0	25
Rauza		**47,67**	**52,33**	**74,00**	**0,00**	**26,00**
	Strikupe 1	50	50	50	10	40
	Strikupe 2	50	50	83	0	17
	Strikupe 3	57	43	71	14	14
Strikupe		**52,33**	**47,67**	**68,00**	**8,00**	**23,67**
GAUJA BASIN		**53,67**	**46,33**	**80,67**	**2,67**	**16,56**
	Amula 1	40	60	60	0	40
	Amula 2	50	50	83	0	17
	Amula 3	67	33	67	0	33
Amula		**52,33**	**47,67**	**70,00**	**0,00**	**30,00**
	Koja 1	75	25	25	50	25
	Koja 3	67	33	100	0	0
Koja		**71,00**	**29,00**	**62,50**	**25,00**	**12,50**
	Riezupe 1	60	40	80	0	20
	Riezupe 2	50	50	75	0	25
	Riezupe 3	50	50	67	17	17
Riezupe		**53,33**	**46,67**	**74,00**	**5,67**	**20,67**
VENTA BASIN		**58,89**	**41,11**	**68,83**	**10,22**	**21,06**

Environmental quality assessment according to European Fish Index (EFI) sampling sites were classified from poor (one reach, value 0.22) to (highest value 0.65), but in regard with Lithuanian fish index they corresponded with moderate to high status (Table 4.2.1.5.).

Table 4.2.1.5. European Fish Index (EFI) and status of streams' reaches in regard with EFI and Lithuanian Fish Index (Lith_FI)

Basin	Stream/reach	Index_EFI	Status_EFI	Class_Lith_FI	Status_Lith_FI
DAUGAVA					
	Arona 1	0.33	Moderate	2	Good
	Arona 2	0.42	Moderate	2	Good
	Mergupe 1	0.32	Moderate	2	Good
	Mergupe 2	0.44	Moderate	1	High
	Mergupe 3	0.48	Good	2	Good
	Pededze 1	0.51	Good	2	Good
	Pededze 2	0.46	Good	2	Good
GAUJA					
	Raunis 1	0.65	Good	2	Good
	Raunis 2	0.48	Good	2	Good
	Raunis 3	0.47	Good	1	High
	Rauza 1	0.22	Poor	2	Good
	Rauza 3	0.48	Good	1	High
	Strikupe 1	0.41	Moderate	2	Good
	Strikupe 2	0.47	Good	1	High
	Strikupe 3	0.39	Moderate	2	Good
VENTA					
	Amula 2	0.32	Moderate	3	Moderate
	Amula 3	0.34	Moderate	2	Good
	Koja 1	0.34	Moderate	4	Poor
	Koja 3	0.64	Good	2	Good
	Riezupe 1	0.45	Moderate	2	Good
	Riezupe 2	0.62	Good	1	High
	Riezupe 3	0.51	Good	2	Good

EFI values of sampled reaches are in Figure 4.1.2.5., mean EFI values for reaches of different river basins are in Table 4.2.1.6.

Table 4.2.1.6. Mean EFI values for reaches of Daugava, Gauja and Venta river basins

River Basin	Number of reaches	Range	Mean ± SD
Daugava	7	0.32 – 0.51	0.42 ± 0.07
Gauja	8	0.22 – 0.65	0.45 ± 0.12
Venta	7	0.32 – 0.64	0.46 ± 0.14

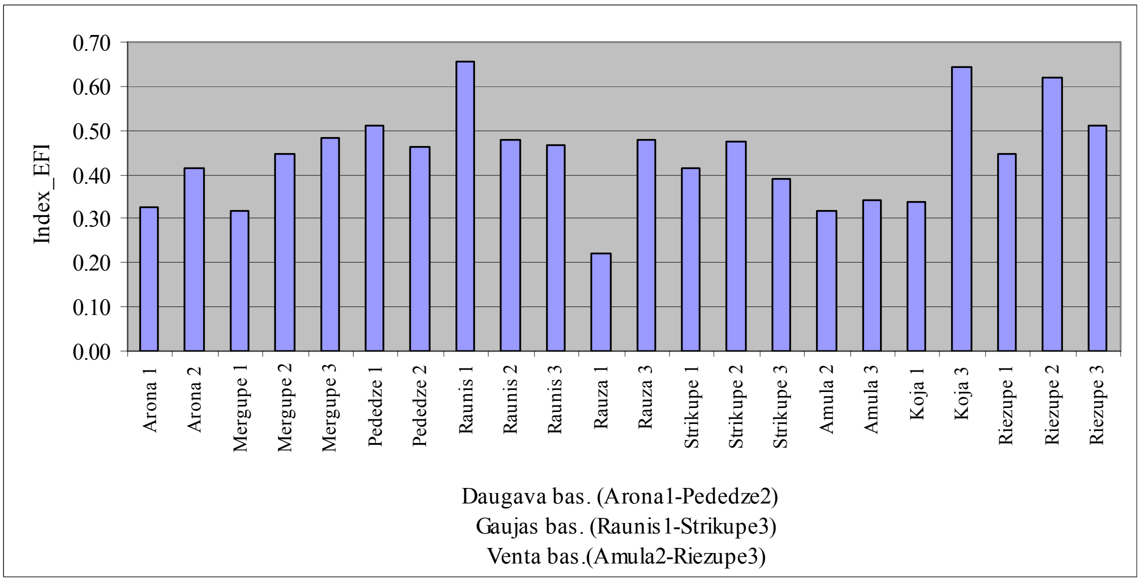


Figure 4.2.1.5. EFI values of sampled reaches.

CV of Shannon's diversity index on the reach scale was 37.1, but that of Simpson's diversity index was 33.3.

CV of other fish metrics are given in the Table 4.2.1.6.
The **abundance** metrics and **tolerance** metrics was in general more variable than the compositional metrics.
Among parameters characterizing **habitat** metrics the least variable was number of rheophilic species, and of benthic species per hectare. The most variable was number of species as number of limnophilic species per hectare.
Among **reproduction** metrics litophilic species were less variable than phytophilic ones according their species number and number of species per ha.
Analyses of fish **longevity** showed that number of species as well as number per ha was less variable for short-lived species than long-lived species
Among **feeding** metrics number of insectivorous/invertivorous species varied less than omnivorous and piscivorous fishes. Insectivorous/invertivorous species were less variable also according to the number per ha in comparison with piscivorous and omnivorous species.
Fish **migration** indices (long distance, potamodron) showed great dispersion, especially number of species and number per ha of potamodron as well as long distance migrating species.

In total, variability of fish metrics per ha was considerably larger than that of species number (Table 4.2.1.6.).

EFI was the least variable metric in comparison with other metrics used for characteristic of all fish guilds (Table 4.2.1.6.).

In general, the largest coeficients of variations (CV) of fish metrics were on the reach scale compared to streams and river basins scales.

Table 4.2.1.6. Coefficients of variation (CV) for fish metrics

Fish																
Spatial scale	EFI	Composition metrics	Abundance metrics		Tolerance metrics		Habitat metrics									
		N_species	Density_sp_all	Biom_sp_all	n_sp_Intol	n_sp_tol	n_sp_Hab_wc	n_sp_Hab_b	n_sp_Hab_rh	n_sp_Hab_li	n_sp_Hab_eury	n_ha_Hab_wc	n_ha_Hab_b	n_ha_Hab_rh	n_ha_Hab_li	n_ha_Hab_eury
Reaches	24.6	30.7	89.4	71.1	50.5	98.6	36.8	40.5	29.4	198.2	105.8	122.9	80.1	98.8	484.7	149.3
Streams	17.5	20.9	42.6	52.8	29.9	76.1	24.6	31.6	12.7	131.3	80.6	62.0	71.1	56.5	289.1	95.3
Basins	2.8	7.8	28.0	30.9	9.8	45.8	16.9	3.9	2.3	43.3	44.3	46.5	26.2	47.5	167.4	69.4

Fish																		
Spatial scale	Reproduction metics				Longevity metrics				Feeding metrics						Migration metrics			
	n_sp_Re_lith	n_sp_Re_phyt	n_ha_Re_phyt	n_ha_Re_lith	n_sp_Lon_ll	n_sp_Lon_sl	n_ha_Lon_ll	n_ha_Lon_sl	n_sp_ Fe_pisc	n_sp_Fe_insev	n_sp_Fe_omni	n_ha_ Fe_pisc	n_ha_Fe_insev	n_ha_Fe_omni	n_sp_Mi_long	n_sp_Mi_potad	n_ha_Mi_long	n_ha_Mi_potad
Reaches	34.1	220.8	295.7	101.6	126.1	39.0	166.2	122.3	186.2	50.5	110.9	241.0	122.1	388.5	148.5	168.0	275.9	331.2
Streams	8.6	101.1	179.1	58.9	80.1	26.1	106.4	59.3	106.1	29.9	77.5	141.7	88.9	244.9	132.1	84.9	177.3	210.3
Basins	2.3	56.8	141.2	50.6	45.4	11.4	57.2	39.3	50.0	9.8	69.6	65.1	34.6	156.8	100.0	52.9	136.9	108.7

A comparison of variability of the least variable (EFI) and the most variable (number per ha of limnophilic species) fish metrics within catchments were done. The results showed that the number per ha of limnophilic species varied largely on the basin scale (CV was 241.96 for the Daugava basin, 218.10 for the Gauja basin, and 277.92 for the Venta basin). Values of EFI were more similar within the catchments (CV was 17.67 for the Daugava basin, 26.82 for the Gauja basin, and 29.63 for the Venta basin). The assessment of variability of Shannon's diversity index and Simpson's diversity index for fish within the river basins showed that Shannon's diversity index was a little more variable for the Gauja (CV was 27.17) and for the Venta (CV was 34.85) basin than Simpson's diversity index (CV was 25.78 and 28.11). The exception was the Daugava basin where Shannon's diversity index (39.02) was less variable than and Simpson's diversity index (41.63). A comparison of different fish guilds demonstrated that there were some differences among the river basins. We found that lithophilic reproduction was more pronounced in the Daugava basin in comparison with the Gauja and the Venta basins. Insectivorous/invertivorous feeding fish production was typical for the Daugava basin, but omnivorous fish production was common in two of three streams in the Venta basin. In general, in all three river basins long-lived fish species prevailed in comparison to short lived ones. Exception was two reaches and one stream in the Venta basin where short-lived species characterized by kg per ha and percentage of kg per ha were larger than long lived species.

Test Statistics using Sign Test showed that there were not significant differences among reaches, streams and river basins if number of species, biomass and density metrics were compared. At the same time difference between samples was stated for two streams (Riezupe and Koja) in Venta basin in regard with feeding metrics (piscivorous, insectivorous/invertivorous, and omnivorous). The largest disparity was found if fish habitat metrics were compared – 6 cases from 27 on reaches scale (4 of them for Gauja basin) and 2 cases from 9 on stream scale. Disparity was not found for feeding metrics as well as habitat metrics on basin scale (Annex IX).

4.2.2. Fish relation to environmental variables

PCA Analyses were applied for environmental variables (as main matrix) and 4 fish metrics: number of all species, biomass, species density and EFI index (as second matrix).

The first PCA axis for the **Daugava basin** accounts for 31.1 per cent of total variance (λ=11.21), the second axis – for 21.78 % (λ=7.84) and third axis accounts for 16.99 % (λ=6.12). In total three components explained 69.9 % (Table 4.2.2.1.).

The first principal component separated the morphometrical variables (depth, discharge) and substrate. The pronounced correlation with fish metrics is seen only for number of species (-0.65) (Fig. 4.2.2.1.)
The second component was the factor of chemical variables depending on basin geochemistry (conductivity, alkalinity, pH value, hardness). The highest positive correlation with second factor is seen for fish biomass (Annex X).

Table 4.2.2.1.Extracted variances for the streams in the Daugava basin

Axis	Eigenvalue	Percentage of Variance	Cum.% of Var.
1	11.208	31.134	31.134
2	7.84	21.777	52.911
3	6.116	16.989	69.9
4	5.363	14.898	84.798
5	3.07	8.529	93.326
6	2.403	6.674	100
7	0	0	100
8	0	0	100
9	0	0	100
10	0	0	100

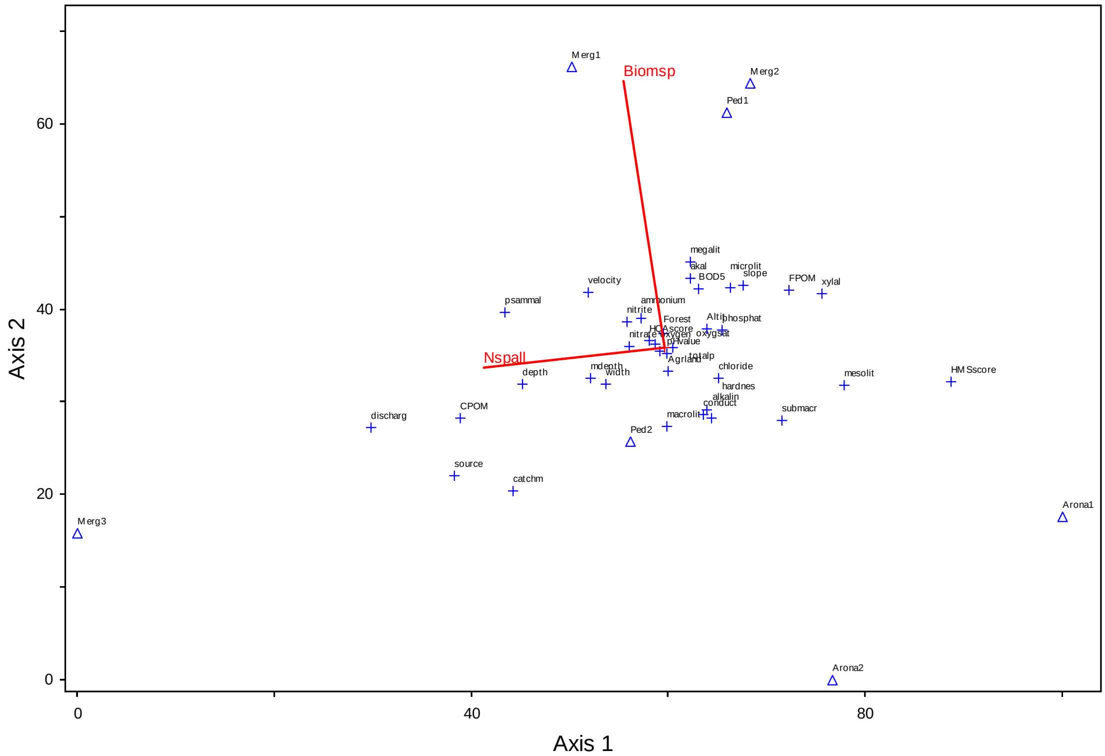


Figure 4.2.2.1. PCA of fish metrics and environmental variables for the Daugava basin streams

For the **Gauja basin** the first PCA axis accounts for 33.57 % of total variance (λ =12.09), the second axis – for 24.5 % (λ = 8.82) and third axis accounts for 12.42 % (λ = 4.47). In total three components explained 70.5 % and further set of them were used for the description of gradient (Table 4.2.2.2.).

The first axis was highly correlated with morphometrical parameters – mean and max depth, discharge, psammal substrate and percentage of forest. A significant negative correlation with 1st axis is stated for akal substrate, HQA and agricultural lands. Positive correlation with 1st axis is stated only for fish species number (Fig. 4.2.2.2).

The second axis showed significant positive correlation with conductivity, oxygen, hardness and alkalinity. That axis negatively correlated with fish density and biomass. (Annex XI).

Table 4.2.2.2. Extracted variances for the streams in the Gauja basin

Axis	Eigenvalue	% of Variance	Cum.% of Var.
1	12.086	33.572	33.572
2	8.821	24.503	58.075
3	4.474	12.427	70.502
4	3.944	10.956	81.458
5	2.706	7.516	88.974
6	2.259	6.274	95.248
7	1.711	4.752	100
8	0	0	100
9	0	0	100
10	0	0	100

The first PCA axis for the **Venta basin** accounts for 33.23 % of total variance (λ =11.96), the second axis – for 22.2 % (λ = 7.99) and third axis accounts for 15.85 % (λ=5.71). In total three components explained 71.3 % (Table 4.2.2.3.).
The first axis was highly correlated with catchment physical parameters (depth, slope, and substrate) and with HMS scores and some chemical parameters related to basin geochemistry (pH value, conductivity, alkalinity, and hardness). The second axis has significant negative correlation with chemical variables mainly associated with eutrophication (oxygen, BOD, ammonium nitrate and phosphate ions) (Fig. 4.2.2.3.).
The evident correlation with first component is found for fish density. The second component associated with biomass and EFI index (Annex XII).

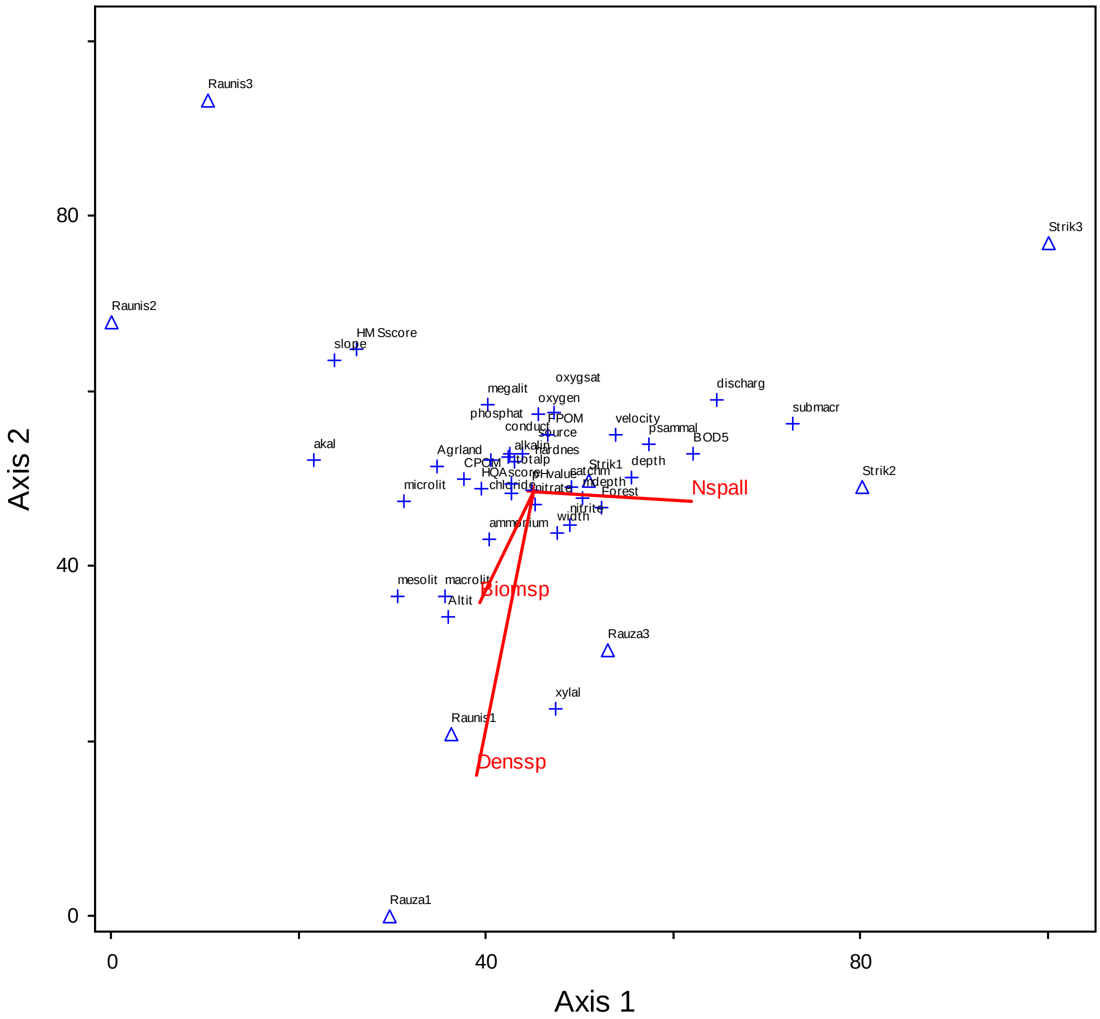


Figure 4.2.2.2. PCA of fish metrics and environmental variables for the Gauja basin streams

Table 4.2.2.3. Extracted variances for the streams in the Venta basin

Axis	Eigenvalue	% of Variance	Cum.% of Var.
1	11.964	33.234	33.234
2	7.996	22.211	55.445
3	5.707	15.852	71.297
4	4.516	12.544	83.841
5	3.42	9.499	93.34
6	2.398	6.66	100
7	0	0	100
8	0	0	100
9	0	0	100
10	0	0	100

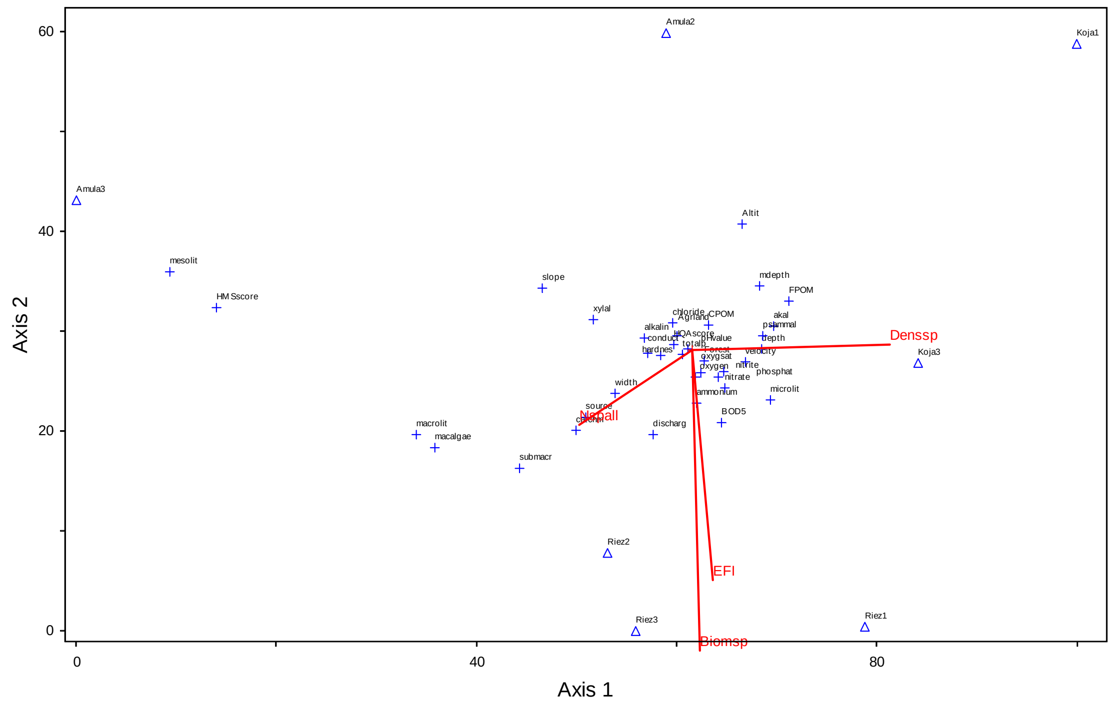


Figure 4.2.2.3. PCA of fish metrics and environmental variables for the Venta basin streams

Table 4.2.2.4. Significant Pearson's correlation coefficients (in bold) for environmental variables and fish diversity indices in the Daugava, the Gauja and the Venta basins

Parameters	Daugava Shannon's index	Daugava Simpson 's index	Gauja Shannon' s index	Gauja Simpson' s index	Venta Shannon' s index	Venta Simpson' s index
Agricultural land	-0.54	-0.49	-0.33	-0.07	-0.66	-0.52
max depth	0.20	0.15	0.42	0.34	-0.66	-0.78
velocity	0.69	0.71	-0.05	-0.05	-0.08	-0.14
discharge	0.46	0.44	0.36	0.17	0.65	0.66
mesolithal	-0.48	-0.53	-0.67	-0.58	-0.60	-0.60
FPOM	-0.33	-0.34	0.61	0.68	-0.12	-0.16

Table 4.2.2.5. Characteristics of multiple linear regression model with fish diversity indices (dependent variables) and significance of environmental variables (predictors)

Shannon's fish diversity index					
Daugava basin		Gauja basin		Venta basin	
Environmental variables	*Sign.of coeff.*	Environmental variables	Sign.of coeff..	Environmental variables	*Sign.of coeff.*
velocity	0.045	mesolithal	0.032	microlithal	0.013
psammal	0.140	Catchment size	0.051	Altitude	0.049

Conductivity	0.251	Depth	0.274	Chloride	0.194
Sign. of model: 0.054		*Sign. of model:* 0.053		*Sign. of model:* 0.018	
R Square: 0.76		*R Square*: 0.76		*R Square*: 0.90	
Simpson's fish diversity index					
Daugava basin		Gauja basin		Venta basin	
Environmental variables	*Sign.of coeff.*	Environmental variables	*Sign.of coeff.*	Environmental variables	*Sign.of coeff.*
Velocity	0.097	FPOM	0.066	Altitude	0.012
Conductivity	0.567	Chloride	0.179	microlithal	0.009
Psammal	0.171	*Sign. of model:* 0.057		*Sign. of model:* 0.010	
Sign. of model: 0.086		*R Square*: 0.61		*R Square*: 0.84	
R Square: 0.84					

In general, the linear regression analyses of relationships between fish diversity indices (Shannon's and Simpson's) and environmental variables didn't reveal any common relationships (Tables 4.2.2.4. and 4.2.2.5.) Significant correlation coefficients are founded for fishes and environmental parameters linked with river morphology and more expressed for the Venta basin in comparison with the Daugava and the Gauja basins. Overall, the least pronounced relationships in comparison with all BQE groups were found between fish diversity indices and environmental variables (Table 4.2.2.5.) . It was confirmed by few significant correlation coefficients as well as less significant levels of multiple regression models

4.3. Macroinvertebrates

4.3.1. Macroinvertebrate metrics

Coefficients of variations of macroinvertebrate metrics are given in the Table **4.3.1.1.**

The largest CVs of different macroinvertebrate metrics like as for macrophyte and fish metrics were on the reach scale compared to stream and river basin scales.

At the reach scale the **eutrophication** metrics BMWP was more variable than the saprobity index.

Among **diversity** metrics the most variable was abundance of macroinvertebrates, followed by number of species, evenness, number of genera and number of families. Shannon's diversity index ranged from 1.1 to 2.7 (CV = 26.2) and Simpson's diversity index from 0.4 to 0.9 (CV = 23.5).

The **EPT taxa metrics** was generally more variable than the eutrophication and diversity metrics. The percent abundance of taxonomic groups ranged from 0,002 for Nematomorpha to 54.1 for Diptera. The values of CV exceeded 100 percent for most of taxa (Turbellaria, Nematomorpha, Nematoda, Hirudinea, Megaloptera, Heteroptera, Hydracarina, Crustacea, Lepidoptera, Bivalvia, Gastropoda, Odonata, Plecoptera, Oligochaeta and Coleoptera) and the highest values were typical for taxa that were found in low numbers. More commonly distributed macroinvertebrates (Ephemeroptera, Trichoptera, Diptera) were less variable, and their CV was lower than 100 percent.

The mean **abundance of taxonomic groups** ranged from 0.1 (for Nematomorpha) to 2787.6 (for Diptera) on the reaches scale. The values of CV exceeded 100 percents for most of taxa, and the highest values were typical for taxa that were poor in number (Table 2).

The mean **number of taxa** ranged from 0.01 (for Nematomorpha) to 7.3 (for Trichoptera) on the reach scale. As for the percent abundance of **taxonomic groups**, this group of metrics was highly variable.

Among macroinvertebrate groups of metrics the most variable were those related to taxonomic composition like EPT Taxa, and especially – percent of abundance of taxonomic groups and number of taxa, in comparison with eutrophication and diversity metrics.

Significant differences among **replicate samples** using Sign Test for EPT-Taxa metrics in general were stated in 4 cases out of 27. The differences among replicates were found in two streams of the Venta basin, and one stream in the Daugava basin (Annex XIII). In 3 cases out of 27 differences were found for number of taxa, and in one case – percentage of taxonomic group.
Sign Test showed no significant differences between eutrophication metrics (Saprobic Index, BMWP, ASPT, DSFI), diversity indices (Simpson-Index, Shannon-Wiener-Index, Margalef Index and DSFI Diversity Groups), diversity metrics (Number of Families, Number of Genera, Evenness and Abundance [ind/m²]) and abundance of taxonomic groups (Annex XIII).

Regarding **stream reaches** significant differences were stated in 9 cases out of 15 between EPT-Taxa metrics. A larger difference was found between reaches of streams in the Venta basin, as well as between upper a middle parts of streams (5 cases out of 9). A difference between abundance of taxonomic groups and number of taxa was found only in one case (Annex XIV).
Sign Test showed no significant differences between stream reaches according to the eutrophication metrics, diversity indices, diversity metrics and taxonomic groups (%) (Annex XIV).

According EPT-Taxa metrics at **stream** scale significant differences were found between all streams in the Venta basin. In the Daugava basin one stream (the Mergupe) differed from the two others. In the Gauja basin 2 streams differed between each other according to abundance of individuals (Annex XV).

At **river basin** scale Venta basin differed significantly from the Daugava and the Gauja basins according to EPT-Taxa (Annex XVI). Sign Test showed that there wereno significant differences between diversity indices, eutrophication metrics, diversity metrics, abundance of taxonomic groups, number of taxa and taxonomic groups [%] among stream basins (Annex XVI).

Table 4.3.1.1. Coefficients of variation (CV) for macroinvertebrate metrics

Spatial scale	Turbellaria	Nematoda	Nemorpha	Gastropoda	Bivalvia	Oligochaeta	Hirudinea	Crustacea	Ephemeroptera	Odonata	Plecoptera	Heteroptera	Megaloptera	Trichoptera	Lepidoptera	Coleoptera	Diptera	Hydracarina
	Macroinvertebrates																	
	Taxonomic groups (%)																	
Reaches	509.9	276.0	509.9	138.3	173.2	106.7	244.7	194.2	87.8	143.1	131.2	217.7	194.9	63.8	189.0	104.1	33.1	201.6
Streams	300.0	138.6	300.0	82.7	116.2	66.4	163.4	110.8	73.0	101.4	79.5	140.6	107.6	45.5	87.9	83.1	24.2	109.1
Basins	173.2	68.1	173.2	39.7	84.2	55.4	98.9	45.1	41.4	31.0	44.1	130.0	23.5	20.8	9.3	66.2	6.8	75.8
Spatial scale	**Number of taxa**																	
Reaches	509.9	257.6	509.9	71.3	42.5	30.7	108.0	119.3	35.0	121.8	61.3	96.1	141.5	39.6	178.5	49.6	28.0	61.6
Streams	300.0	130.8	300.0	32.9	30.5	17.6	71.0	81.8	29.0	84.7	30.1	65.4	95.2	23.2	83.3	44.4	17.9	47.6
Basins	173.2	75.5	173.2	32.1	13.3	9.0	66.7	14.4	14.6	17.3	24.9	66.1	62.0	11.4	10.8	38.9	11.8	34.1
Spatial scale	**Abundance of taxonomic groups**																	
Reaches	509.9	257.6	509.9	119.5	197.1	103.7	248.3	231.8	93.1	156.5	147.3	201.7	162.1	48.6	203.6	128.9	70.0	147.9
Streams	300.0	130.8	300.0	71.9	121.5	78.0	168.2	135.5	83.9	105.7	96.6	146.9	93.2	15.2	95.2	83.7	51.4	78.2
Basins	173.2	75.5	173.2	44.6	99.3	61.9	112.5	89.3	43.4	28.3	64.7	138.9	44.0	7.0	55.3	75.8	17.6	65.3

	Macroinvertebrates												
	Eutrophication metrics		**Diversity metrics**					**EPT-taxa metrics**					
Spatial scale	**SI**	**BMWP**	**Families**	**Genera**	**Species number**	**Evenness**	**Abundance**	**EPT-taxa**	**EPT/OL**	**EPT/Diptera**	**OD/Total-taxa**	**EP-taxa**	**EPTCOB (Eph., Ple., Tri., Col., Odo., Bivalv.)**
Reaches	17.5	22.7	16.2	19.4	32.3	22.5	47.0	32.4	53.3	44.9	26.3	32.3	30.9
Streams	13.9	15.0	8.0	11.3	10.5	19.4	35.1	21.8	34.7	41.2	21.3	24.3	23.5
Basins	10.7	9.0	4.2	5.6	7.7	6.8	20.5	13.4	11.6	24.7	3.9	15.7	14.4

Among basins in general number of families were the least variable macroinvertebrate metric, it varied among the stretches of the Venta basin (CV=24.6), following by the Daugava basin (CV=12.375) and the Gauja basin (CV=11.8).The most variable metrics were percent of different taxonomic groups, abundance of taxonomic groups, and number of taxa for Turbellaria and Nematomorpha. The Simpson's diversity index was less variable than the Shannon's diversity index. The highest variation of Shannon's and Simpson's diversity indices were found for Daugava river basin stretches (CV=29.42 and CV=27.72) and lower variation for Venta (CV=27.38 and 21.42) and Gauja (CV=20.63 and CV=21.29) river basin stretches.

4.3.2. Macroinvertebrate relations with environmental metrics

For PCA analyses the set of environmental variables have been included in main matrix and biological metrics in second matrix.

PCA using first 3 axes explains 62.58 % of the total variance for 9 reaches of the **Daugava basin** streams (Table 4.3.2.1.).

Table 4.3.2.1. Variance extracted, first 3 Axes, the Daugava River basin

AXIS	Eigenvalue	% of Variance	Cum.% of Variance	Broken-stick Eigenvalue
1	9.295	25.122	25.122	4.202
2	8.587	23.208	48.330	3.202
3	5.273	14.251	62.581	2.702

Most significant negative correlation was found between 1st axis and morphometrical parameters (mean depth, maximum depth, discharge) (Annex XVII, XVIII). Less important was the correlation between 1st axis and catchments parameters). There was no correlation found between 1st axis and macroinvertebrate metrics.

The 2nd axis was most positively correlated with chemical parameters (pH, conductivity, alkalinity, total hardness, chloride) and less with macroinvertebrate metrics [Simpson Index, Ephemeroptera (%), Number of Ephemeroptera Taxa, EPT-Taxa (%), EP (%), EPind/Totalind (%)].(Annex XVII, XVIII).

Ordination graph of macroinvertebrate metrics and environmental variables in two-dimensional space is given Figure 4.3.2.1.

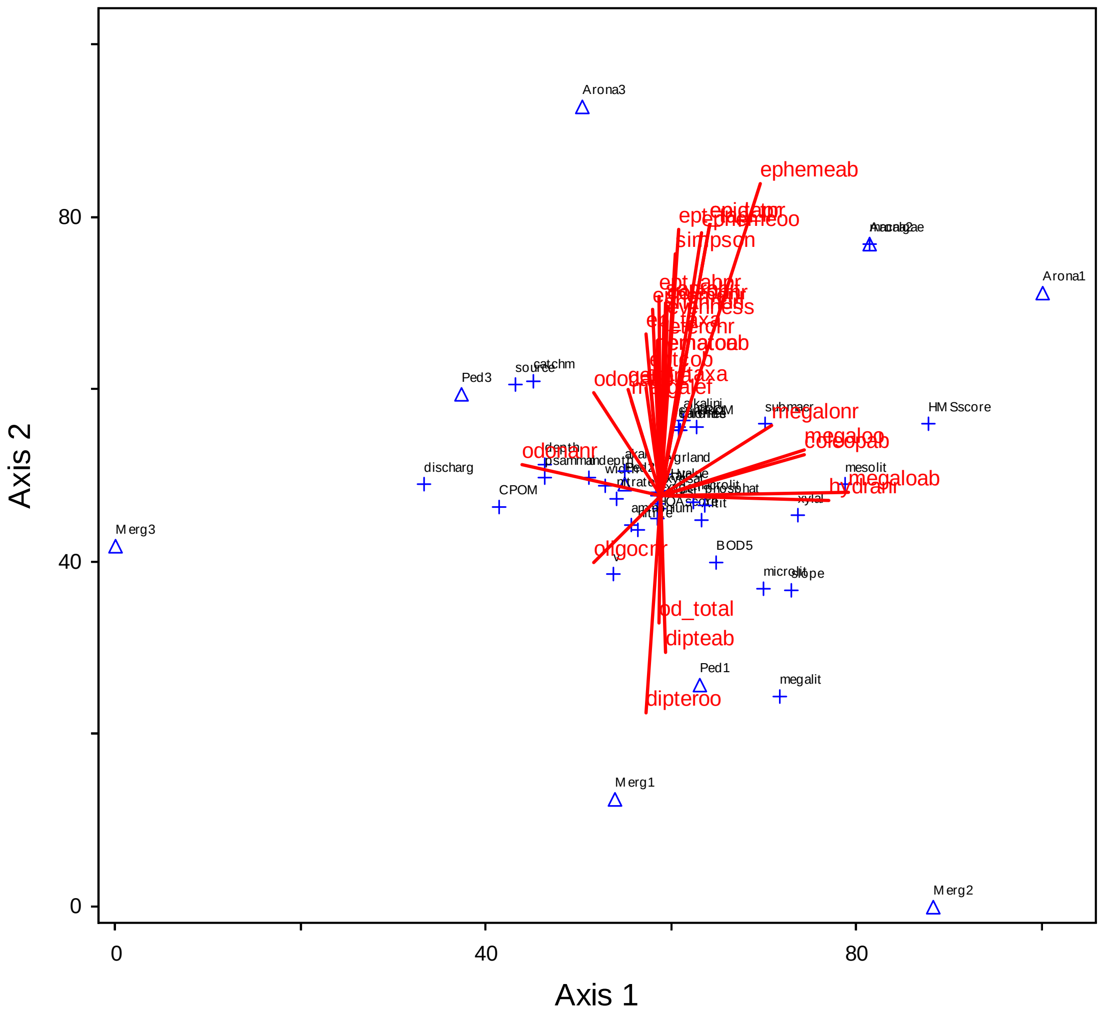


Figure 4.3.2.1. PCA Analysis of macroinvertebrate metrics and environmental variables of Daugava basin streams

For the **Gauja basin** first 3 axes explains 67.57 % of the total variance for 9 reaches of streams (Table 3.4.3.2.2.).

Table 4.3.2.2. Variance extracted, first 3 Axes, the Gauja basin.

AXIS	Eigenvalue	% of Variance	Cum.% of Variance	Broken-stick Eigenvalue
1	10.938	30.383	30.383	4.175
2	8.545	23.735	54.118	3.175
3	4.843	13.452	67.570	2.675

1st axis was positively most significant correlated with HQA score; negatively – with morphometrical parameters (mean depth, discharge), psammal/psammopelal substratum, BOD_5, and in less degree with macroinvertebrate metrics [Turbellaria (%), Number of Turbellaria Taxa, Number of Odonata Taxa, Number of Hydrachnidia Taxa and Abundance of Turbellaria] (Annex XIX, XX).

The 2^{nd} axis was most significantly positively correlated with chemical parameters (conductivity, dissolved oxygen content, alkalinity, and total hardness). Less expressed positive correlation was found with macroinvertebrate metrics [Plecoptera (Number of Taxa), Diptera (Number of Taxa), Plecoptera (Abundance), EPT/OL]. Negative correlations were less expressed than positive ones, some negative correlation was found with macroinvertebrate metrics [Bivalvia (Number of Taxa), Oligochaeta (Number of Taxa) and EPT/Diptera] (Annex XIX, XX).

Ordination graph of macroinvertebrate metrics and environmental variables in two-dimensional space is given Figure 3.4.3.2.2.

For the **Venta Basin** first 3 axes explains 70.84 % of the total variance for 8 reaches of Venta River basin streams (Table 4.4.2.3.).

Table 4.4.2.3. PCA, Variance extracted, first 3 Axes, Venta River basin.

AXIS	Eigenvalue	% of Variance	Cum.% of Variance	Broken-stick Eigenvalue
1	10.383	28.843	28.843	4.175
2	9.333	25.925	54.768	3.175
3	5.693	15.814	70.582	2.675

With 1^{st} axis positively most significant correlated with nitrate; negatively correlated with xylal microhabitat, alkalinity and total hardness (Annex XXI, XXII). There was no significant correlation with macroinvertebrate metrics.

The 2^{nd} axis was positively correlated with catchments parameters (size of catchment, distance from source), average stream width, macrolithal substratum, macroalgae, and macroinvertebrate metrics [BMWP, DSFI, Shannon-Wiener Index, Margalef index, Number of Genera, Trichoptera (%), Coleoptera (%), Number of Trichoptera Taxa, Abundance of Coleoptera, EPT-Taxa (%), EPT (%) (abundance classes), EPT-Taxa, EPTCOB]. Only one significant correlation was stated for 2^{nd} axis with psammal/psammopelal substratum (Annex XXI, XXII).

Ordination graph of macroinvertebrate metrics and environmental variables in two-dimensional space is given Figure 4.3.2.3.

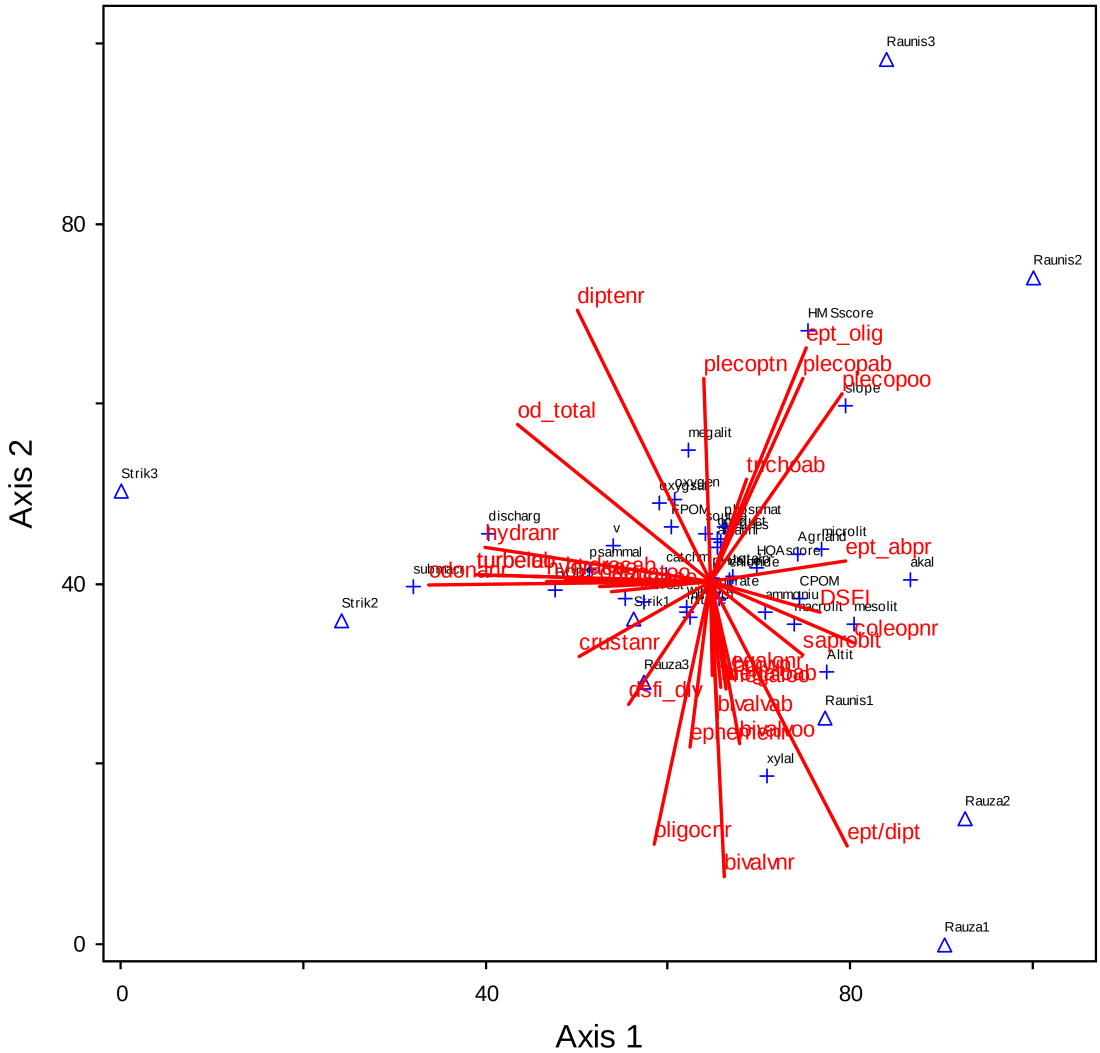


Figure 4.3.2.2. PCA Analysis of macroinvertebrate metrics and environmental variables of the Gauja basin streams

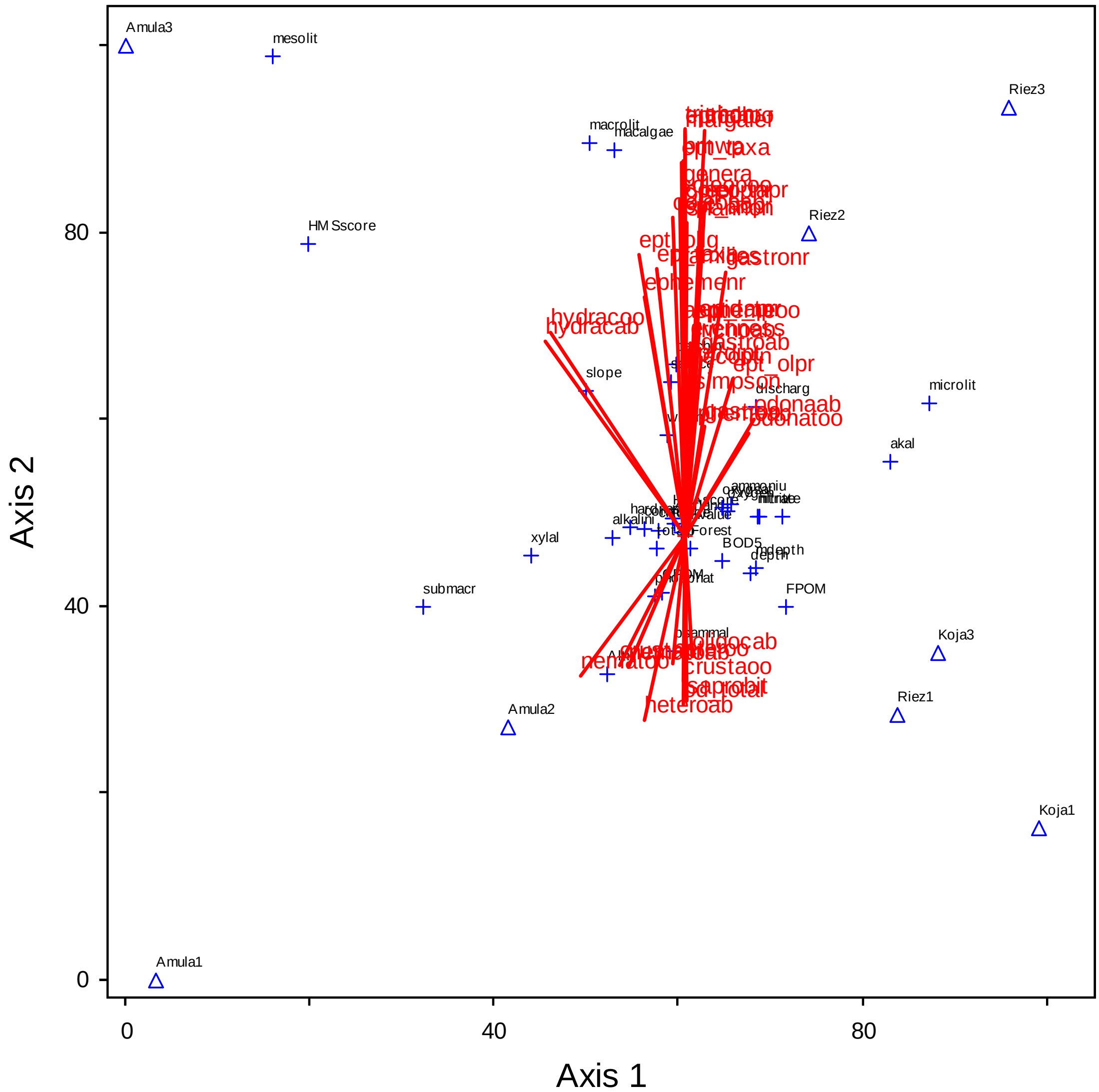


Figure 4.3.2.3. PCA Analysis of macroinvertebrate metrics and environmental variables of the Venta basin streams

Among macroinvetebrate the analysis of **EPT taxa metrics** was emphasised since there most significant disparities was found for this metric using Sign Test at all scales.

PCA analysis shows that first 3 axes explain 62.58 % of the total variance for 9 reaches of the **Daugava basin** streams (Table 4.3.2.4.).

Table 4.3.2.4. PCA, Variance extracted, first 3 Axes, Daugava River basin.

AXIS	Eigenvalue	% of Variance	Cum.% of Variance	Broken-stick Eigenvalue
1	9.295	25.122	25.122	4.202
2	8.587	23.208	48.330	3.202
3	5.273	14.251	62.581	2.702

With 1st axis significantly positive correlated mesolithal and xylal; negatively correlated with morphometrical parameters (mean depth, maximum depth, discharge) (Annexes XXIII, XXIV).

2nd axis positively was correlated with chemical parameters (pH-value, conductivity, alkalinity, total hardness, chloride), and less expressed correlation was found with EPT-Taxa [%], EP [%] and EPind/Totind [%](Annexes XXIII, XXIV).

Ordination graph of EPT-Taxa metrics and environmental variables in two-dimensional space is given Figure 4.3.2.4.

For the **Gauja Basin** first 3 axes explains 67.57 % of the total variance for 9 reaches of Gauja basin streams (Table 4.3.2.5.).

Table 4.3.2.5. PCA, Variance extracted, first 3 Axes, Gauja River basin

AXIS	Eigenvalue	% of Variance	Cum.% of Variance	Broken-stick Eigenvalue
1	10.938	30.383	30.383	4.175
2	8.545	23.735	54.118	3.175
3	4.843	13.452	67.570	2.675

With 1st axis positively correlated HQA score; negatively correlated with morphometrical parameters (mean depth, discharge), psammal/psammopelal substratum and BOD_5 (Annexes XXV, XXVI).

2nd axis positively correlated with chemical parameters (conductivity, dissolved oxygen content, alkalinity, total hardness) and in less degree - positively with EPT/OL and negatively with EPT/Diptera (Annexes XXV, XXVI).

Ordination graph of EPT-Taxa metrics and environmental variables in two-dimensional space is given Figure 4.3.2.5.

First 3 axes explain 70.58 % of the total variance for 9 reaches in **the Venta basin** streams (Table 4.3.2.6.).

Table 4.3.2.6. Variance extracted, first 3 Axes, the Venta basin

AXIS	Eigenvalue	% of Variance	Cum.% of Variance	Broken-stick Eigenvalue
1	10.383	28.843	28.843	4.175
2	9.333	25.925	54.768	3.175
3	5.693	15.814	70.582	2.675

With 1st axis most significantly positive correlated nitrate; and negatively correlated xylal microhabitat, alkalinity and total hardness (Annexes XXVII, XXVIII).

With 2nd axis most significantly positive correlated catchments parameters (size of catchment, distance from source), average stream width, macrolithal and macroalgae, EPT-Taxa (%), EPT (%) (abundance classes), EPT-Taxa, EPTCOB. Negative correlation was stated between 2nd axis and psammal/psammopelal (Annexes XXVII, XXVIII).

Ordination graph of EPT-Taxa metrics and environmental variables in two-dimensional space is given Figure 4.3.2.6.

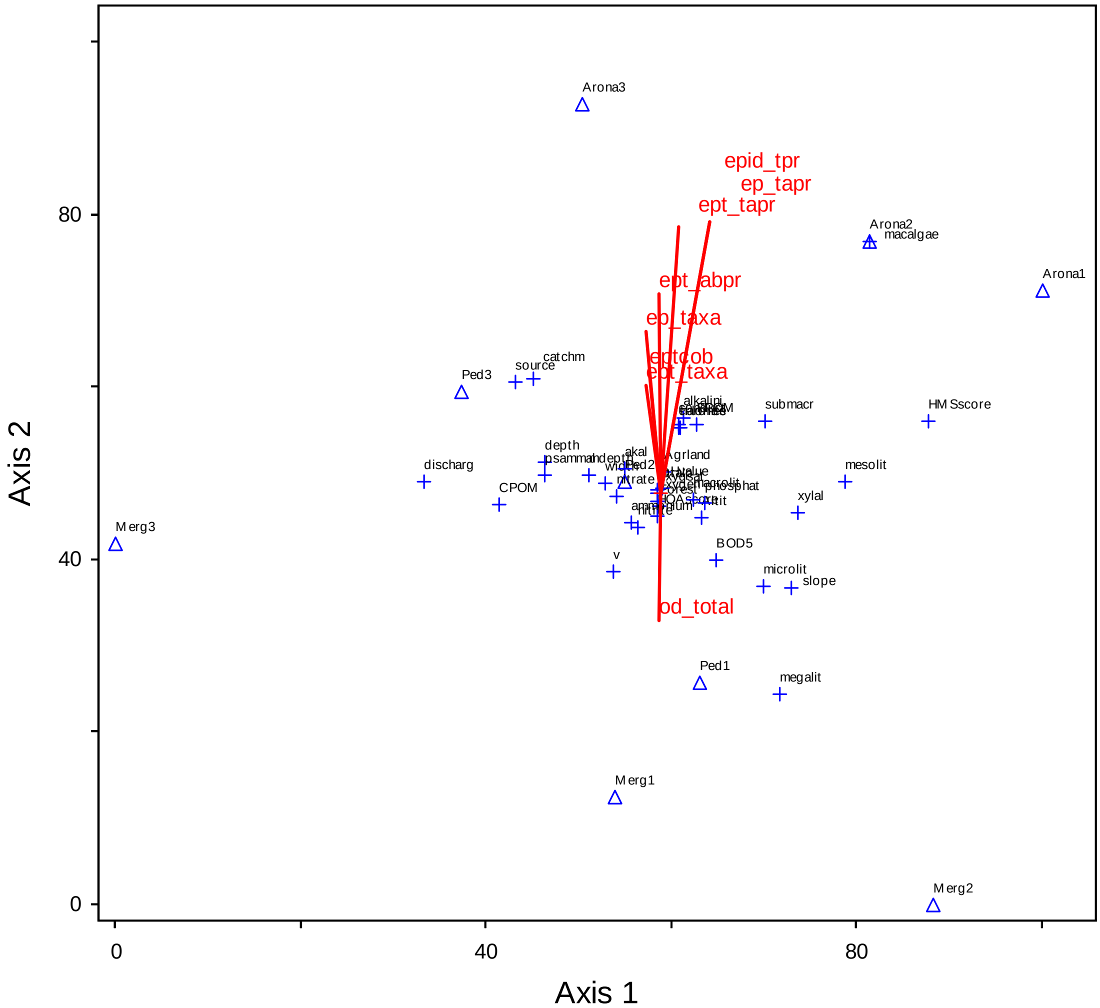


Figure 4.3.2.4. PCA Analysis of EPT metrics and environmental variables of the Daugava basin streams

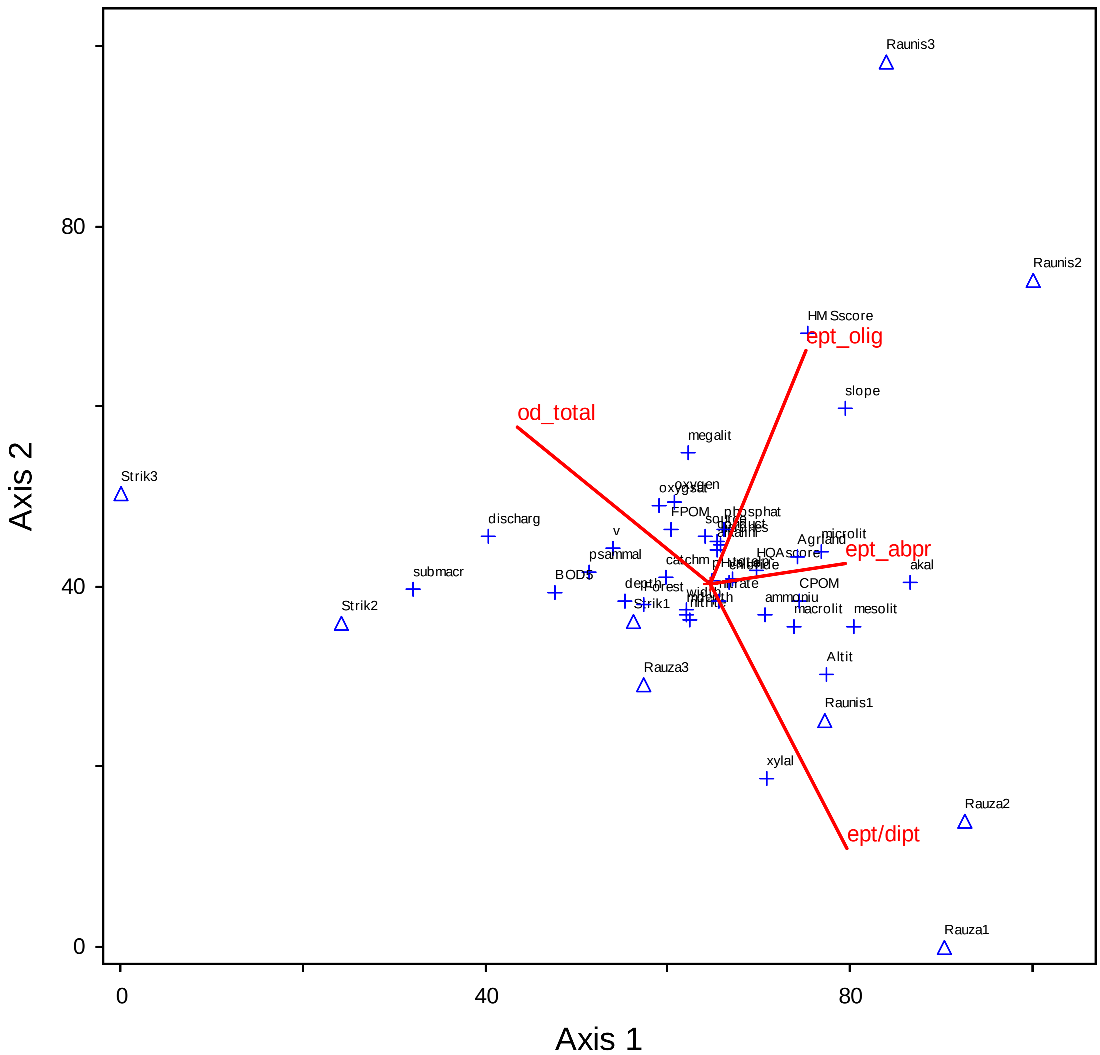


Figure 4.3.2.5. PCA Analysis of EPT metrics and environmental variables of Gauja basin streams

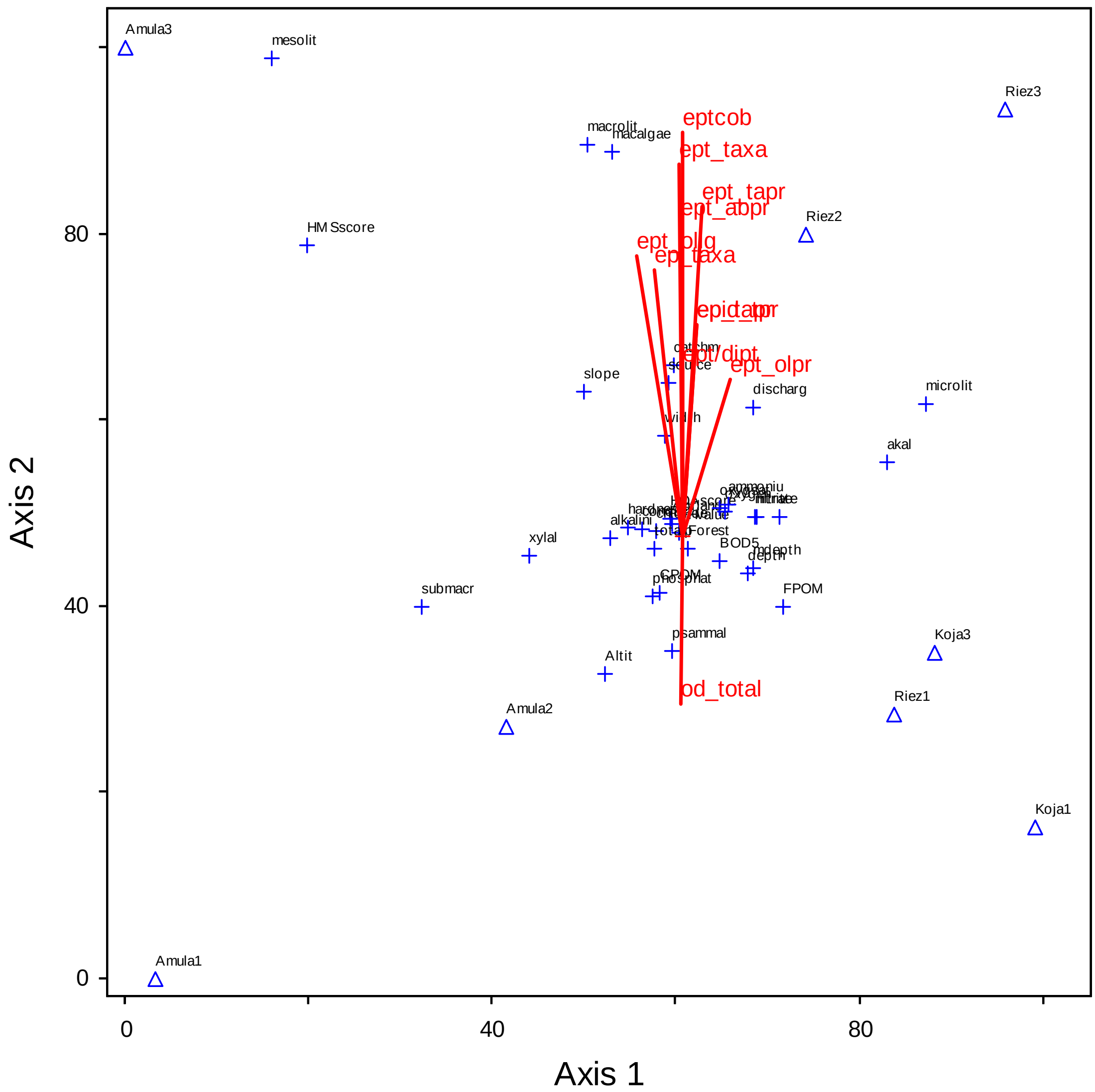


Figure 4.3.2.6. PCA Analysis of EPT metrics and environmental variables of the Venta basin streams

Table 4.3.2.7. Significant Pearson's correlation coefficients (in bold) for environmental variables and macrozoobenthos indices in the Daugava, the Gauja and the Venta basins

Parameters	Daugava Shannon's index	Daugava Simpson's index	Gauja Shannon's index	Gauja Simpson's index	Venta Shannon's index	Venta Simpson's index
HQA score	-0.75	-0.78	-0.17	-0.22	0.55	0.46
catchment's size	0.28	0.27	0.34	0.13	0.88	0.59
width	0.13	0.10	0.78	0.78	0.59	0.21
source	0.05	0.05	0.27	0.10	0.74	0.39
oxygen	-0.89	-0.90	-0.20	-0.24	0.48	0.33
alkalinity	0.57	0.68	-0.35	-0.37	0.04	-0.03
hardness	0.58	0.66	-0.29	-0.32	0.32	0.22
chloride	0.83	0.88	-0.01	0.05	0.12	0.24

BOD_5	-0.68	-0.68	-0.26	-0.25	0.16	0.20
nitrite	-0.69	-0.76	0.57	0.54	0.53	0.70

Table 4.3.2.8. Characteristics of multiple linear regression model with BQE diversity indices (dependent variables) and significance of environmental variables (predictors)

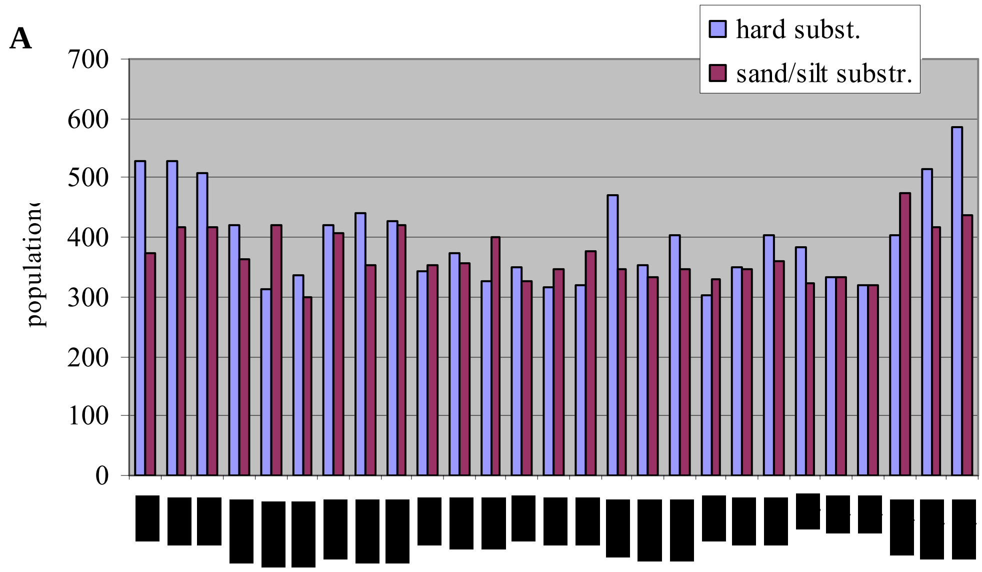
Shannon's macrozoobenthos diversity index					
Daugava basin		**Gauja basin**		**Venta basin**	
Environmental variables	*Sign.of coeff.*	Environmental variables	Sign.of coeff.	Environmental variables	*Sign.of coeff.*
Oxygen	0.004	Width	0.031	Catchment size	0.031
HQA score	0.037	Forest	0.520	macrolithal	0.598
Sign. of model: 0.001		*Sign. of model:* 0.04		*Sign. of model:* 0.022	
R Square: 0.90		*R Square:* 0.64		*R Square*: 0.78	
Simpson's macrozoobenthos diversity index					
Daugava basin		**Gauja basin**		**Venta basin**	
Environmental variables	*Sign.of coeff.*	Environmental variables	Sign.of coeff.	Environmental variables	*Sign.of coeff.*
HQA score	0.010	Width	0.040	Nitrite	0.049
Oxygen	0.001	macrolithal	0.670	Catchment size	0.098
Sign. of model: 0.00		*Sign. of model:* 0.05		*Sign. of model:* 0.04	
R Square: 0.94		*R Square:* 0.62		*R Square*: 0.72	

In most cases, the linear regression analyses of relationships between macroinvertebrate's diversity indices (Shannon's and Simpson's) and environmental variables didn't reveal identical interactions within studied river basins (Tables 4.3.2.7 and 4.3.2.8.). Significant correlation coefficients for macroinvertebrates were more expressed for the Daugava basin in comparison with the Gauja and the Venta basins. In the Daugava basin the most important environmental variables were chemical parameters linked with river basin genesis such as hardness, alkalinity, chloride, slope, stream velocity and oxygen (Table 4.3.2.7.). In this basin, the Simpson's diversity index correlated with the HQA which was not typical for any of the two other basins. Better regression model was obtained for Daugava basin using oxygen and HQA scores as predictors (Table 4.3.2.8.) In summary, the strongest correlations between diversity indices and environmental factors were found for phytobenthos followed by macroinvertebrates.

4.4. PHYTOBENTHOS

4.4.1. Phytobenthos metrics

In most cases phytobenthos population at sampling sites was higher on hard substratum (cobbles) in comparison with soft substratum (silt/sand), but the opposite was generally true for species number relationship with substratum (Fig. 4.4.1.1.)



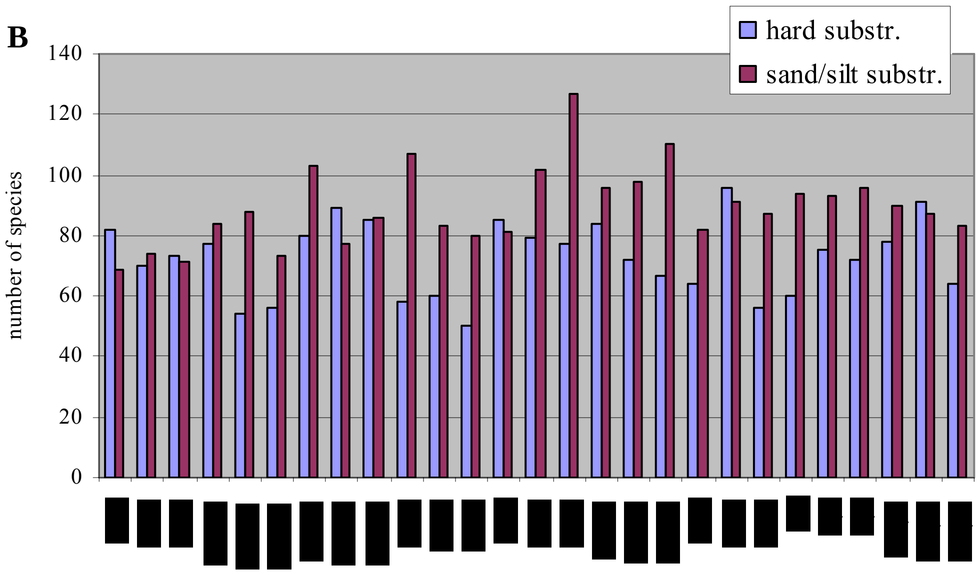


Fig. 4.4.1.1. Phytobenthos population (A) and species number (B) at sampling sites (reach scale) on hard substratum and silt/sand substratum.

Most of phytobenthos metrics from hard and soft substratum correlated on reach level (Table 4.4.1.1.)

Table 4.4.1.1. Correlation between hard substrate and soft substrate phytobenthos metrics (n = 27).

Phytobenthos Metrics	Correlation coefficient	Significance α
Population	0.519	0.01
NB species	0.048	
IPS	0.500	0.01
SLAD	0.635	0.01
DESCY	0.480	0.05
L&M	0.453	0.05
SHE	0.546	0.01
WAT	0.294	
TDI	0.439	0.05
%PT	0.470	0.05
EPI-D	0.298	
ROTT	0.606	0.01
IDG	0.394	0.05
CEE	0.431	0.05
IBD	0.635	0.01
IDAP	0.438	0.05

From these indices Specific Pollution Sensitivity Index (IPS) and Generic Diatom Index (IDG) have been found to be the best for evaluating water quality in Eastern Europe (Southern Poland) (Kwandrans et.al., 1998).

Mean values of IPS and IDG from different substrates for all investigated streams are shown in Figure 4.4.1.2. Mean values and range of IPS and IDG for reaches, streams and river basins are given in Tables 4.4.1.2.and 4.4.1.3.

Between these indices strong correlation was confirmed regarding hard substratum ($r_{0.01;\,27} = 0.870$), sand/silt substratum ($r_{0.01;\,27} = 0.755$) and in total ($r_{0.01;\,27} = 0.851$).

Nine of the indices calculated by OMNIDIA software (DESCY, L&M, SHE, SLAD, IPS, TDI, WAT, CEE and IBD) were considered as promising for an assessment of water quality in Ecoregion 15, Estonia (Vilbaste, 2004). The values of these indices are given in Annex XXIII. These indices at stream scale are shown in Figure 4.4.1.3.

For all of these indices except WAT correlation between hard and soft substratum was found.

A

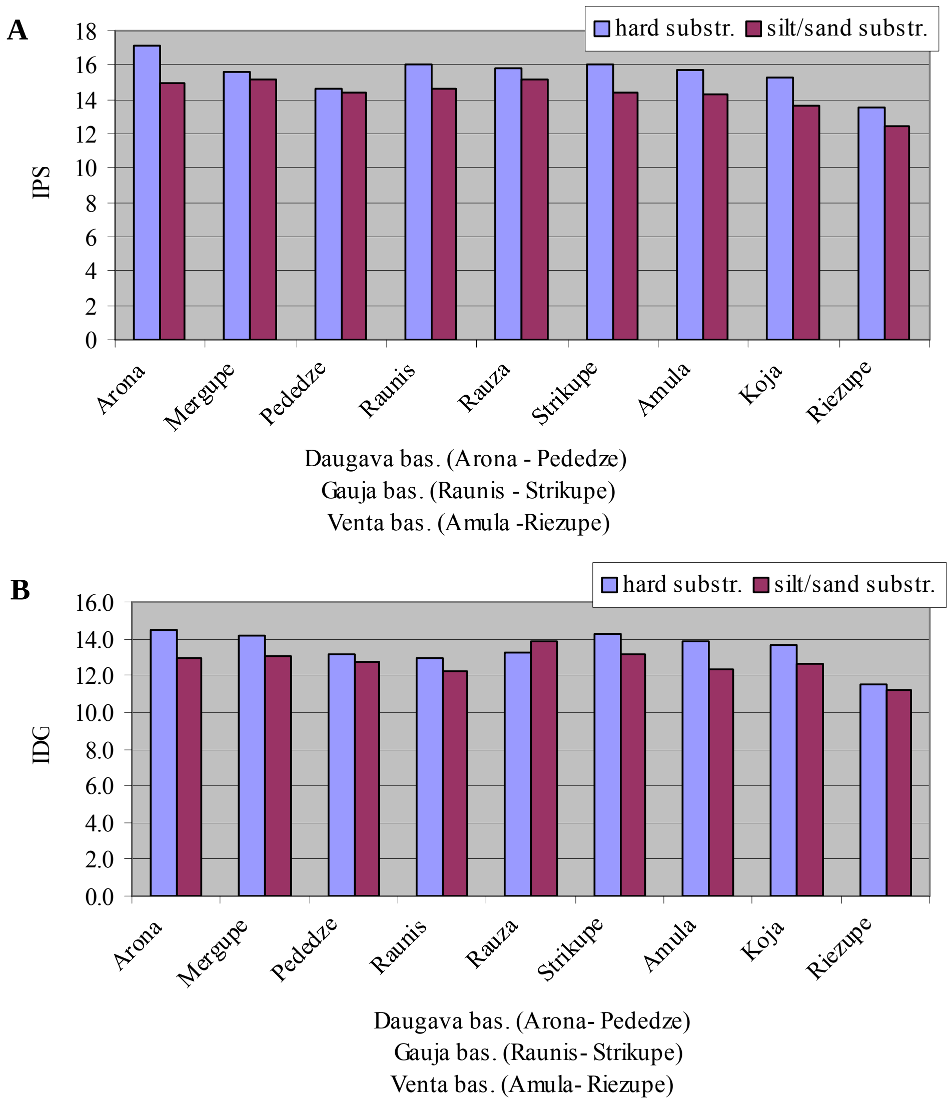


Fig. 4.4.1.2. Mean values of IPS (A) and IDG (B) from hard substratum and silt/sand substratum for streams of the Daugava, Gauja and the Venta basins.

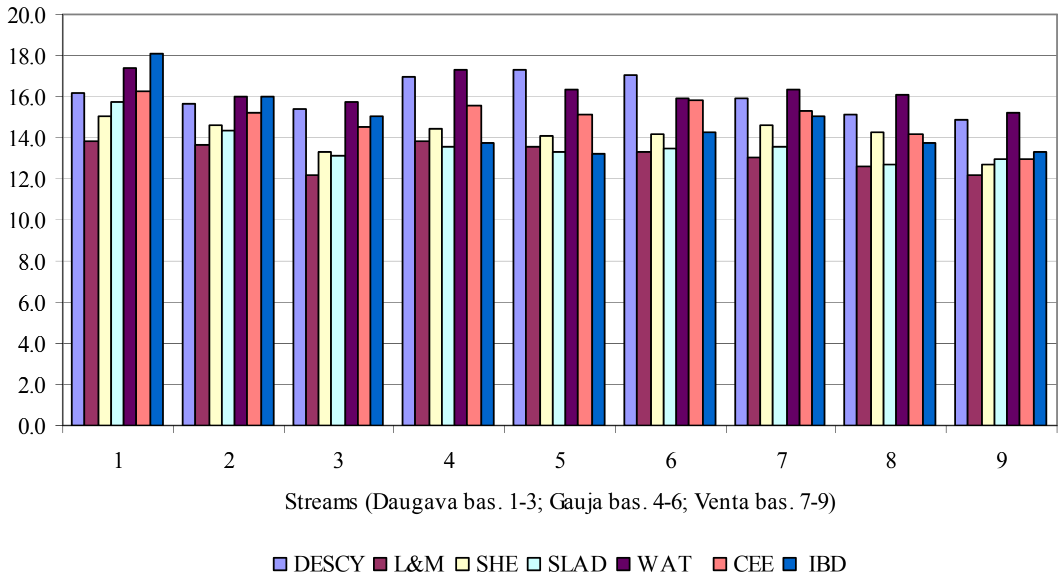


Figure 4.4.1.3. DESCY, L&M, SHE, SLAD, IPS, TDI, WAT, CEE and IBD indices per streams

In general, phytobenthos had high species number and values of Shannon's and Simpson's diversity indices (Table 4.4.1.4.).

In total, the least variable among phytobenthos metric at the reach scale was L&M, ROTT and WAT, and the most variable was %PT (Table 4.4.1.4.; 4.4.1.5.).

The ROTT metric was less diverse in reaches of the Gauja basin streams (CV = 4.2) in comparison with the reaches in the Venta (CV = 5.2) and the Daugava (CV = 5.9) basins. At the same time %PT was considerably more variable, and the largest differences among values of percent PT per reaches were observed in the Daugava basin (CV = 52.1), followed by the Venta (39.1) and the Gauja (34.7) basins.

Table 4.4.1.2. Mean values and range of Specific Pollution Sensitivity Index (IPS) for reaches, streams and river basins.

Scale	Basin	Hard substratum			Soft substratum			Hard + soft substratum		
		n	Range	Mean	n	Range	Mean	n	Range	Mean
Reaches	Daugava	9	13.3 -18.5	15.79 ± 1.69	9	13.8 -15.8	14.83 ± 0.64	18	13.3 – 18.5	15.31 ± 1.33
	Gauja	9	15.5 – 17.0	15.94 ± 0.49	9	13.2 -16.2	14.73 ± 0.91	18	13.3 – 17.0	15.34 ± 0.94
	Venta	9	12.0 – 17.2	14.82 ± 1.58	9	11.2 – 14.5	13.47 ± 1.02	18	11.2 – 17.2	14.14 ± 1.47
All reaches		27	12.0 – 18.5	15.52 ± 1.40	27	11.2 -16.2	14.34 ± 1.05	54	10.5 -18.5	14.09 ± 1.86
Streams	Daugava	3	14.6 – 17.1	15.79 ± 0.72	3	14.4 – 15.1	14.83 ± 0.38	6	14.4 – 17.1	15.31 ± 0.97
	Gauja	3	15.8 – 16.0	15.94 ± 0.15	3	14.4 – 15.2	14.73 ± 0.39	6	14.4 – 16.0	15.34 ± 0.71
	Venta	3	13.5 - 15.7	14.82 ± 1.16	3	12.5 – 14.3	13.47 ± 0.92	6	12.5 – 15.7	14.14 ± 1.20
All streams		9	13.5 – 17.1	15.52 ± 1.00	9	12.5 – 15.2	14.34 ± 0.85	18	12.5 – 17.1	14.93 ± 1.08
All basins		3	14.8 – 15.9	15.52 ± 0.61	3	13.5 – 14.8	14.34 ± 0.76	6	13.5 – 15.9	14.93 ± 0.89

Table 4.4.1.3. Mean values and range of Generic Diatom Index (IDG) for reaches, streams and river basins

Scale	Basin	Hard substratum			Soft substratum			Hard + soft substratum		
		n	Range	Mean	n	Range	Mean	n	Range	Mean
Reaches	Daugava	9	11.9 – 15.4	13.92 ± 1.36	9	12.4 – 13.5	12.87 ± 0.46	18	11.9 – 15.4	13.39 ± 1.12
	Gauja	9	11.3 – 14.3	13.50 ± 0.98	9	11.5 – 15.1	13.05 ± 1.06	18	11.3 – 15.1	13.28 ± 1.02
	Venta	9	10.3 – 15.5	13.02 ±1.62	9	10.5 – 13.2	12.05 ± 0.93	18	10.3 – 15.5	12.54 ±1.38
All reaches		27	10.3 - 15.5	13.48 ±1.35	27	10.5 -15.1	12.66 ± 0.93	54	10.3 -15.5	13.07 ± 1.22
Streams	Daugava	3	13.1 - 14.5	13.92 ± 0.73	3	12.7 - 13	12.87 ± 0.15	6	12.7 - 14.5	13.39 ± 0.75
	Gauja	3	13.0 - 14.3	13.50 ± 0.70	3	12.2 - 13.9	13.05 ± 0.83	6	12.2 – 14.3	13.28 ± 0.73
	Venta	3	11.5 - 13.9	13.02 ± 1.32	3	11.2 -12.6	12.06 ± 0.76	6	11.2 - 13.9	12.54 ± 1.10
All streams		9	11.5 - 14.5	13.48 ± 0.92	9	11.2 -13.9	12.66 ± 0.73	18	11.2 - 14.5	13.07 ± 0.91
All basins		3	13.0 - 13.9	13.48 ± 0.45	3	12.1 -13.1	12.66 ± 0.53	6	12.1 - 13.9	13.07 ± 0.63

Table 4.4.1.4. Range, mean values, standart deviations (SD) and coefficients of variations (CV) of species number, Shannon's and Simpson's diversity indices for phytobenthos

Scale	n	Species number			Shannon's diversity index			Simpson's diversity index		
		Range	Mean ± SD	CV	Range	Mean ± SD	CV	Range	Mean ± SD	
Reach	27	64.5 - 102	80.8 ± 9.2	11.4	2,77 - 3,86	3,44 ± 0,34	9.85	0,77 - 0,96	0,91 ± 0,06	6.22
Stream	9	72 - 91.8	80.8 ± 7.1	8.8	3,01 - 3,76	3,44 ± 0,25	7.19	0,86 - 0,95	0,91 ± 0,04	4.05
Basin	3	77.3 - 84.2	80.8 ± 3.5	4.3	3,33 - 3,55	3,44 ± 0,11	3.15	0,90 - 0,93	0,91 ± 0,02	1.88

Table 4.4.1.5. Coefficients of variation (CV) for phytobenthos metrics

Scale	IDG	IPS	Descy	SLAD	L&M	SHE	WAT	TDI	%PT	EPI-D	ROTT	CEE	IBD	IDAP	N_species	Popul
Reaches	7.3	7.2	5.9	6.9	5.7	6.0	5.9	15.1	48.8	6.0	5.7	7.0	10.9	8.0	11.4	14.0
Streams	5.8	5.9	4.5	5.8	4.9	4.7	4.2	9.3	41.2	5.0	5.0	6.0	8.0	6.5	8.8	13.4
Basins	3.6	4.6	4.5	4.7	3.3	1.9	3.1	8.6	28.0	3.6	3.3	4.5	6.9	2.5	4.3	6.8

Metrics among stream reaches, streams and river basins were analysed by Sign test (SPSS software).

Examination of differences between phytobenthos metrics showed that on reach scale they differed more on sand/silt substrate (8 cases out of 27) and hard/sand-silt substratum in total (8 cases out of 27) than on hard substratum (3 cases from 27). Dissimilarity among metrics was found on stream level for hard substratum (3 cases of 9) and for sand-silt substratum (5 cases of 9). The differences in phytobenthos metrics were found also on river basin scale on hard substratum (the Venta basin differed from the Daugava basin), on sand-silt substratum (the Venta basin differed from the Daugava and the Gauja basins) and hard/sand-silt substratum in total (the Venta basin differed from the Daugava and the Gauja basins) (Annex XXIV).

4.4.2. Phytobenthos metrics correlated with environmental variables

PCA Analyses were applied to the environmental variables (as main matrix) and 3 metrics of diatoms: **IPS**, **IDG** recognized as most suitable for environmental assessment in Poland (Kwandrans et.al. 1998) and promising for Estonia (Vilbaste, 2004), and **TDI** that is generally used for diatoms. Indices calculated for soft (sand-silt) and hard (cobbles) substrata (as second matrix) were analyzed.

The first PCA axis in the **Daugava basin** accounts for 25.12% of total variance (λ=9.29), the second axis – for 23.01% (λ=8.5) and third axis accounts for 14.5% (λ=5.37). In total three components explained 62.65% (Table 4.4.2.1.).
The first principal component separated the morphometrical variables and substratum, but there was no significant correlation between metrics and first component (Table 4.4.2.1., Fig. 4.4.2.1.a, 4.4.2.1.b). The 1st axis has negative relation with TDI (soft and hard substratum) and positive with IDG (soft substratum).
The second component was chemical variables of catchment's (related to basin geochemistry: hardness, alkalinity, conductivity, pH value) and stream velocity. The negative tendency with 2nd axis is for IDG (soft substratum) and positive for TDI (soft substratum) (Table 4.4.2.1., Fig. 4.4.2.1.a, 4.4.2.1.b). The 3rd axis separated substratum. There is negative correlation with IPS (soft and hard substratum) index and IDG (soft substratum) (Annex XXXI).
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Table 4.4.2.1.Extracted variances for the streams in the Daugava basin

AXIS	Eigenvalue	% of Variance	Cum.% of Var.
1	**9.295**	**25.121**	**25.121**
2	**8.514**	**23.011**	**48.131**
3	**5.373**	**14.522**	**62.653**
4	4.446	12.016	74.669
5	3.248	8.779	83.448
6	2.539	6.863	90.311
7	2.181	5.894	96.205
8	1.404	3.795	100
9	0	0	100
10	0	0	100

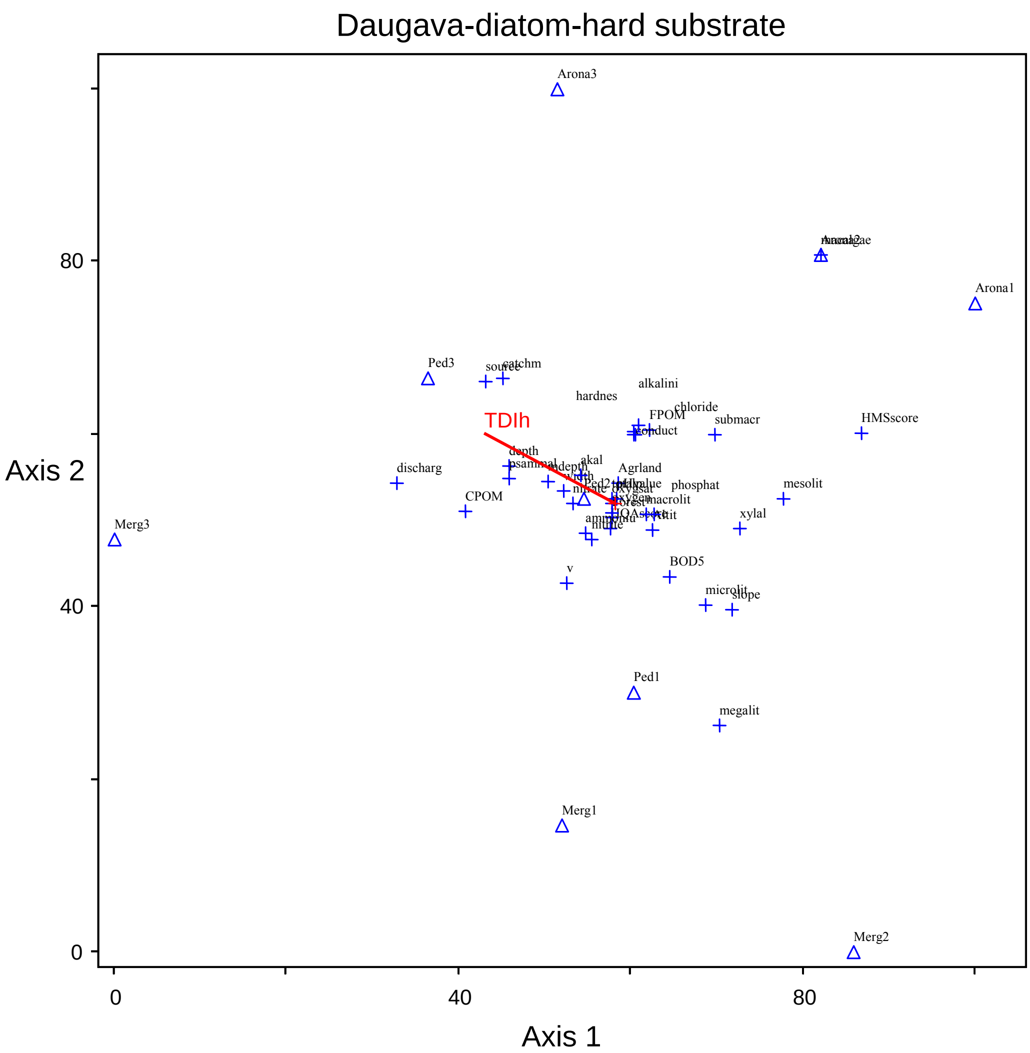

Figure 4.4.2.1.a PCA of phytobenthos metrics from hard substratum and environmental variables for the Daugava basin streams.

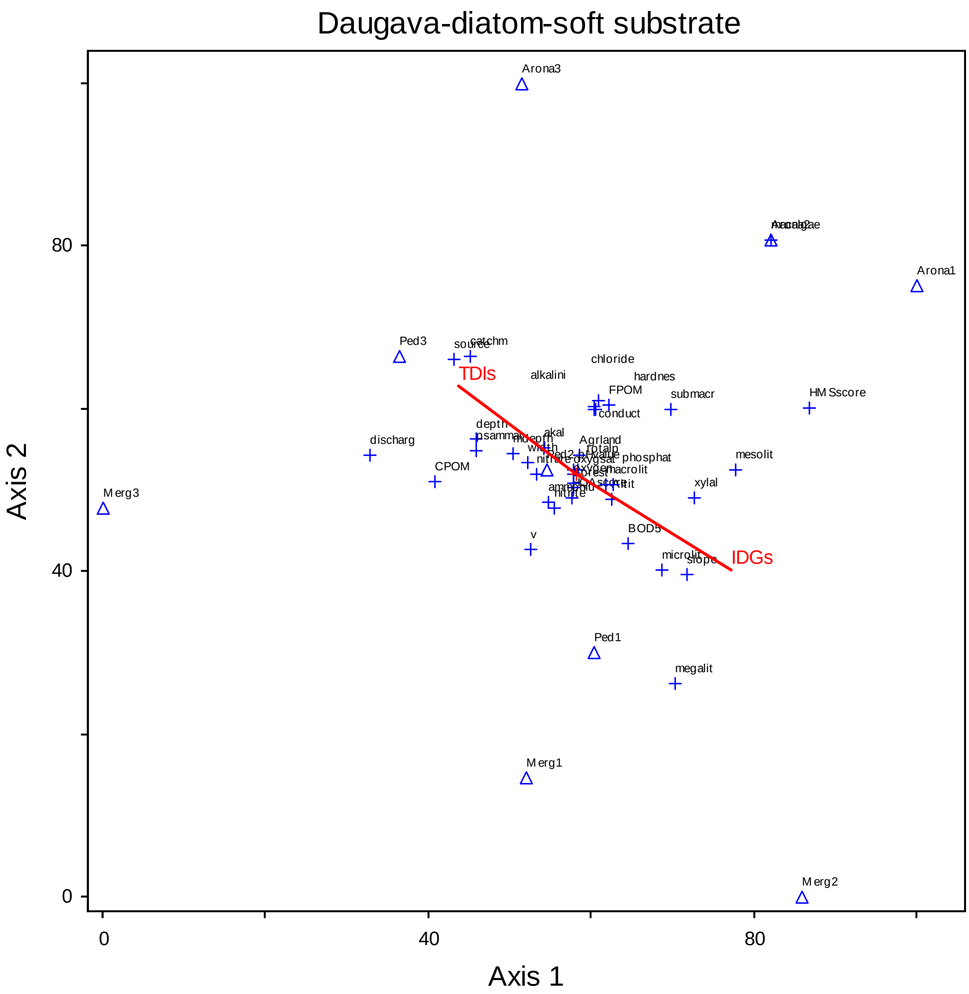

Figure 4.4.2.1.b PCA of phytobenthos metrics from sand-silt substratum and environmental variables for the Daugava basin streams.

The first PCA axis in the **Gauja basin** accounts for 30.38 % of total variance (λ=10.94), the second axis – for 23.74 % (λ=8.55), and third axis accounts for 13.45 % (λ=4,84). In total three components explained 67.57 % (Table 4.4.2.2.).

The first axis was highly correlated with local morphometrical parameters (discharge, velocity), substratum, HQA, land use (forest and agricultural lands) and chemical parameters (BOD_5, ammonium). For metrics negative correlation (-0.64) is found only for IDG from hard substratum. (Fig. 4.4.2.2.a, 4.4.2.2.b).

The second component was chemical variables (conductivity, hardness, alkalinity, alkalinity, pH value and also oxygen). There was found an association of TDI metrics with first component (Annex XXXII).

Table 4.4.2.2. Extracted variances for the streams in the Gauja basin.

AXIS	Eigenvalue	of Variance	Cum.% of Var.
1	**10.938**	**30.383**	**30.383**
2	**8.545**	**23.735**	**54.118**
3	**4.843**	**13.452**	**67.57**
4	3.804	10.567	78.137
5	2.492	6.921	85.059
6	2.07	5.751	90.81
7	1.762	4.894	95.704
8	1.547	4.296	100
9	0	0	100
10	0	0	100

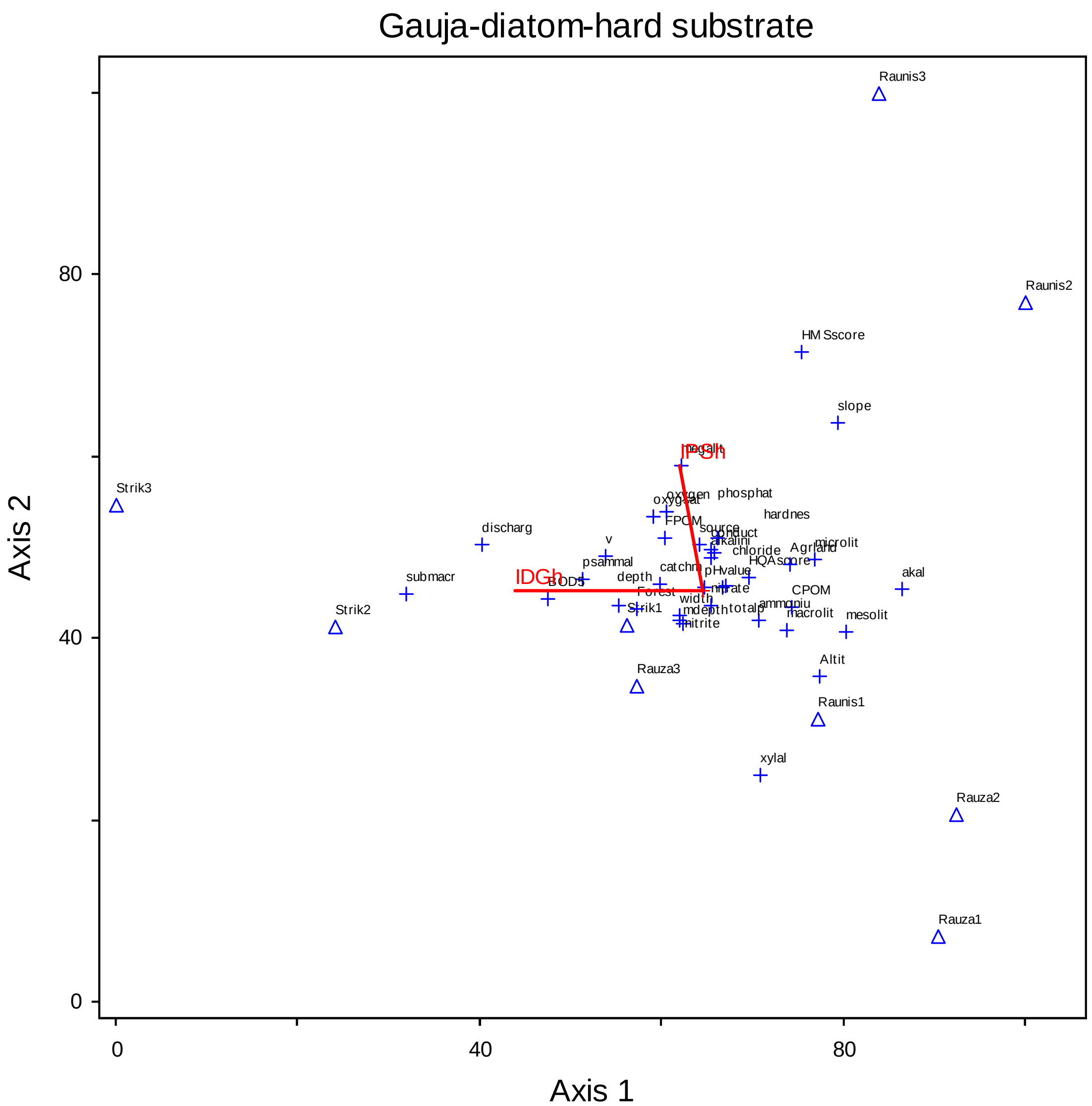

Figure 4.4.2.2.a PCA of phytobenthos metrics from hard substratum and environmental variables for the Gauja basin streams.

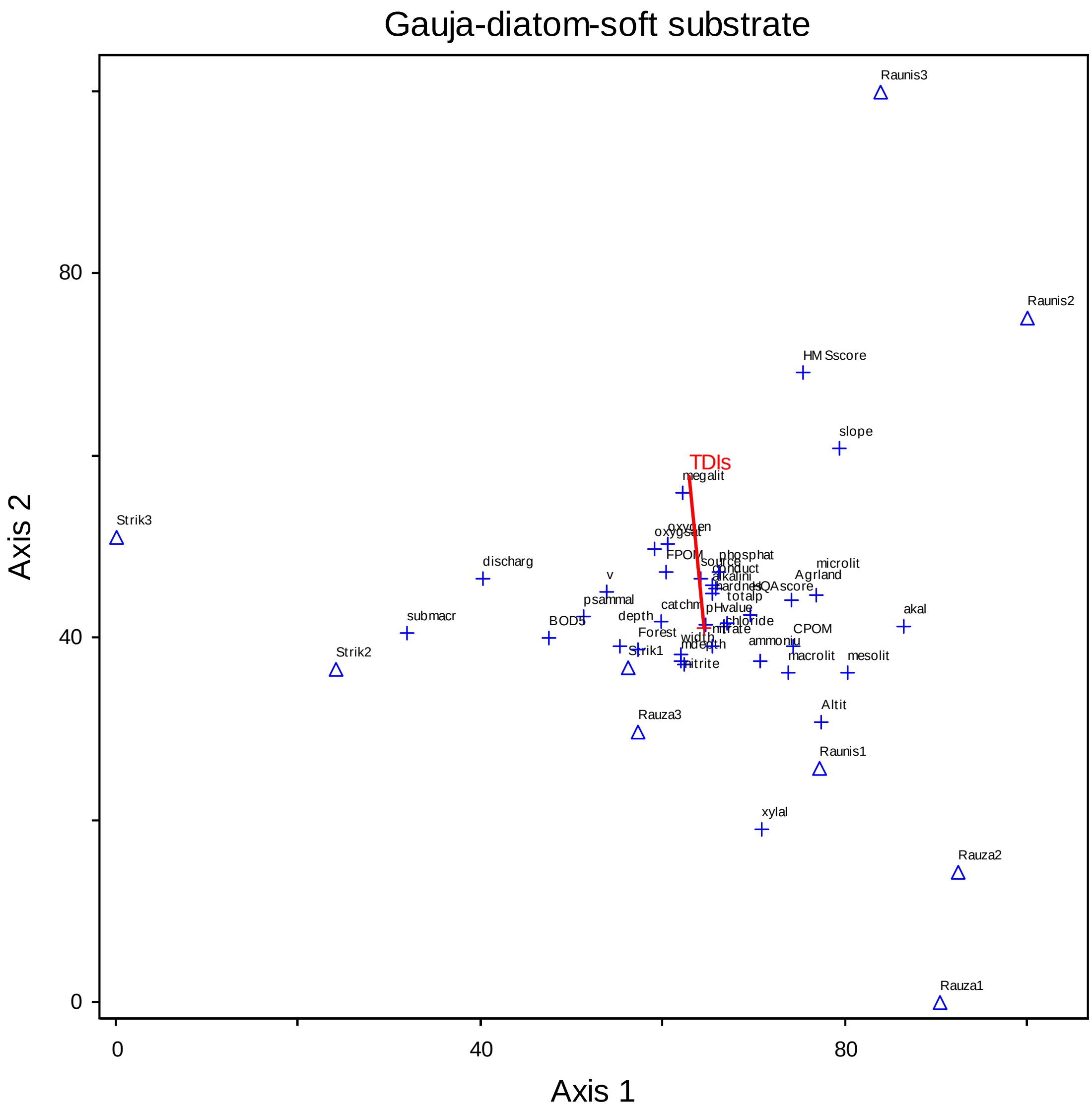

Figure 4.4.2.2.b PCA of phytobenthos metrics from soft (sand-silt) substratum and environmental variables for the Gauja basin streams.

The first axis was highly correlated with catchment parameters (altitude, distance from source, morphometrical parameters (width, depth, and discharge), substratum, HQA, land use (forest and agricultural lands) and pH value. For metrics negative correlation (-0.64) was found only for IDG (hard substratum). (Fig. 4.4.2.3.a, 4.4.2.3.b). There is not found significant correlation with diatom metrics and 1st axis, but positive relation was seen for TDI (soft substratum).

The second axis was significantantly correlated with chemical variables. There was an association with IPS (hard and soft substratum) and TDI (hard and soft substratum) (Fig. 4.4.2.3.a, 4.4.2.3.b). The 3rd axis separated substratum (CPOM, FPOM) and slope. There was a positive correlation with TDI soft substrate and third axis (Annex XXXIII).

Table 4.4.2.3. Extracted variances for the streams in the Venta basin.

AXIS	Eigenvalue	% of Variance	Cum.% of Var.
1	**11.152**	**30.978**	**30.978**
2	**8.455**	**23.485**	**54.464**
3	**4.84**	**13.443**	**67.907**
4	4.369	12.137	80.044
5	2.673	7.426	87.47
6	1.867	5.187	92.657
7	1.462	4.061	96.718
8	1.181	3.282	100
9	0	0	100
10	0	0	100

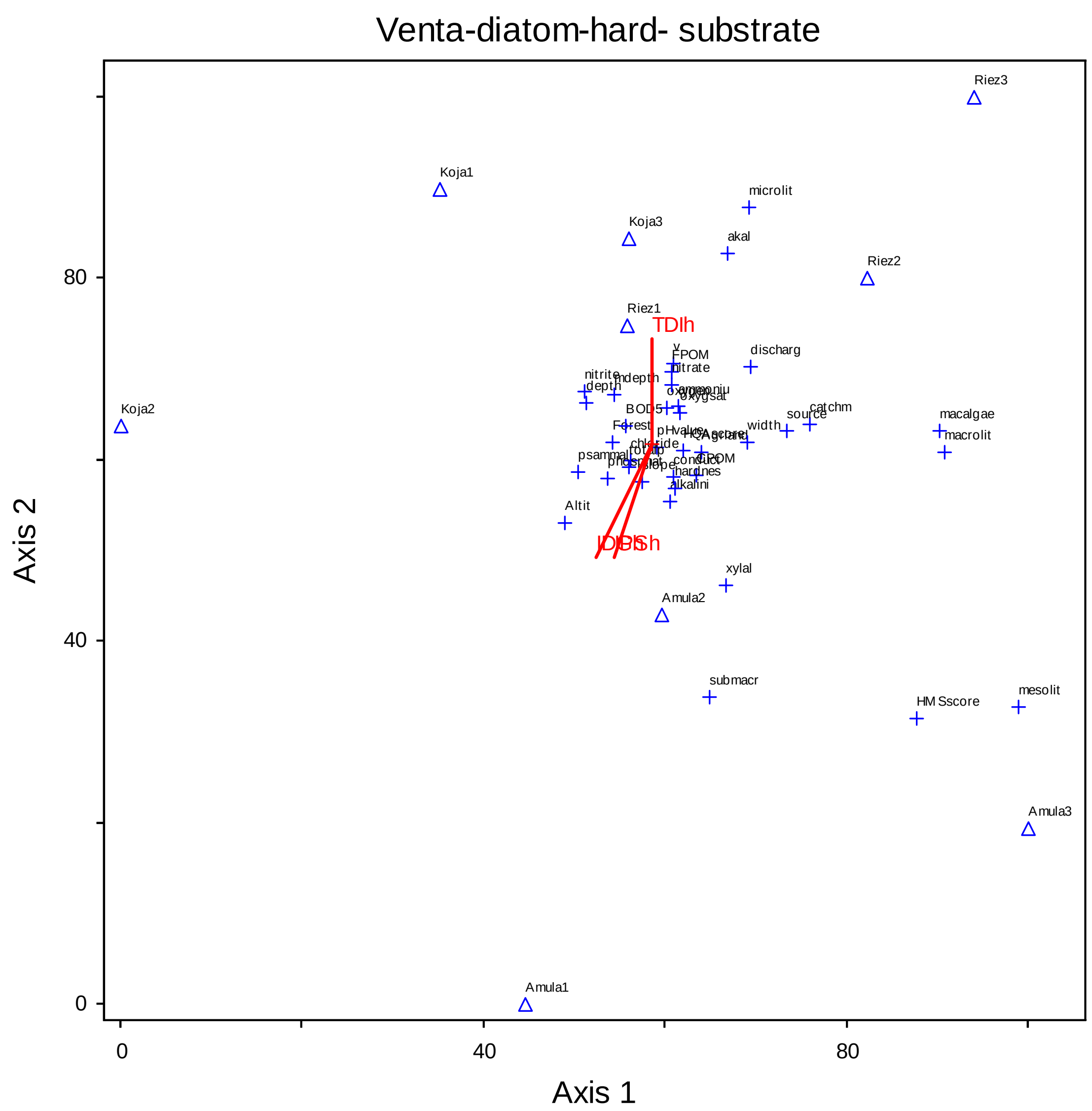

Figure 4.4.2.3.a PCA of phytobenthos metrics from hard substratum and environmental variables for the Venta basin streams.

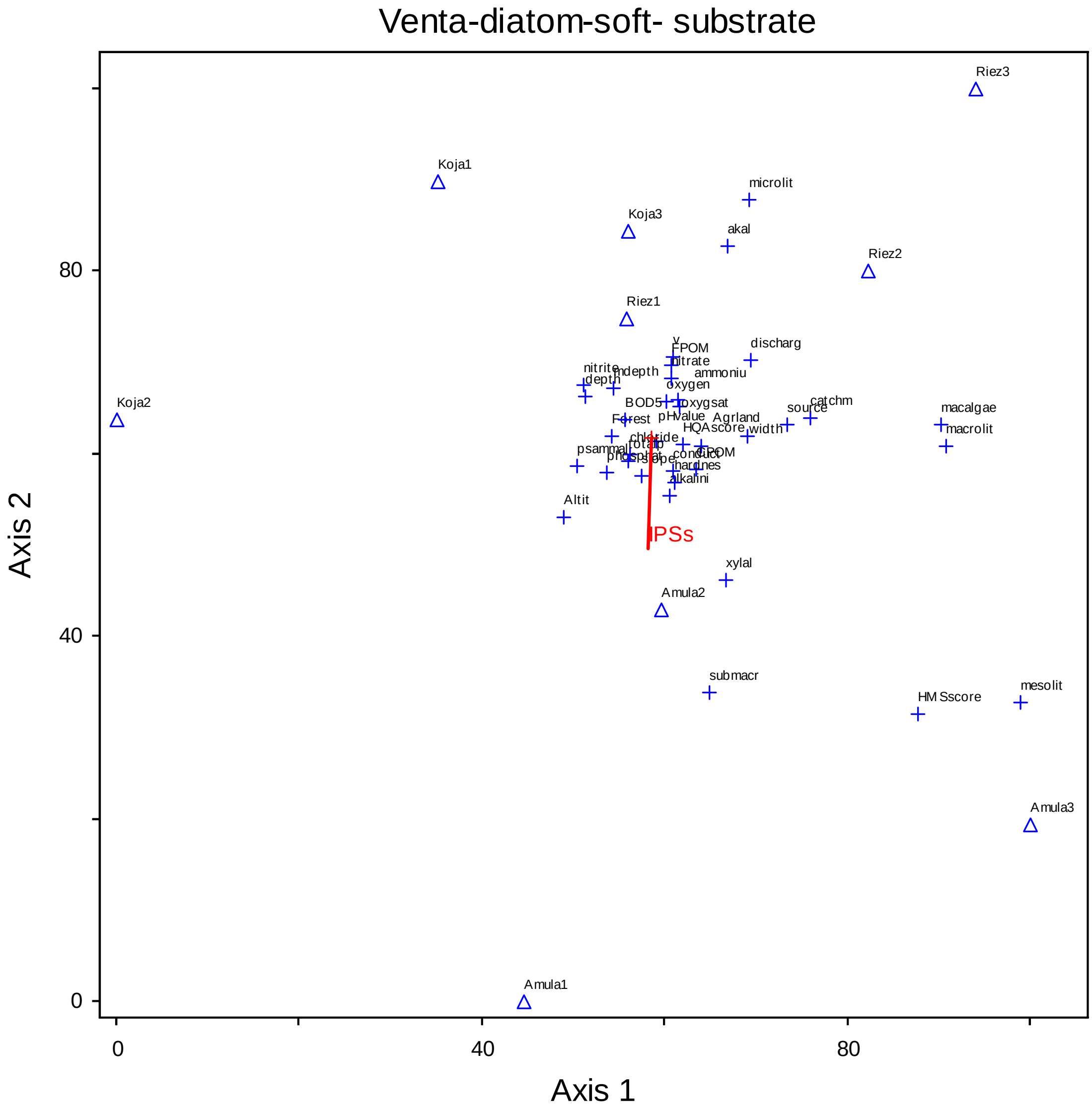

Figure 4.4.2.3.b PCA of phytobenthos metrics from soft (sand-silt) substratum and environmental variables for the Venta basin streams.

Table.4.4.2.5. Characteristics of multiply linear regression model with phytobenthos diversity indices (dependent variables) and significance of environmental variables (predictors)

Shannon's phytobenthos diversity index					
Daugava basin		**Gauja basin**		**Venta basin**	
Environmental variables	*Sign.of coeff.*	Environmental variables	***Sign.of coeff.***	Environmental variables	*Sign.of coeff.*
mesolithal	0.02	Max depth	0.03	Max depth	0.006
Ammonium	0.02	Conductivity	0.03	Xylal	0.006
Sign. of model: 0.012		*Sign. of model:* 0.003		*Sign. of model:* 0.005	
R Square: 0.77		*R Square*: 0.85		*R Square*: 0.82	
Simpson's phytobenthos diversity index					

Daugava basin		**Gauja basin**		**Venta basin**	
Environmental variables	*Sign.of coeff.*	Environmental variables	***Sign.of coeff.***	Environmental variables	*Sign.of coeff.*
mesolithal	0.038	Max depth	0.012	pH value	0.013
Hardness	0.238	Ammonium	0.050	Discharge	0.007
Sign. of model: 0.028		*Sign. of model:* 0.004		*Sign. of model:*0.008	
R Square: 0.81		*R Square: 0.83*		*R Square: 0.8*	

In the Daugava basin the most important environmental variables were chemical parameters linked with river basin genesis such as hardness, alkalinity, chloride, slope, stream velocity and oxygen. In this basin, the Simpson's diversity index correlated with the HQA which was not typical for any of the two other basins (Tables 4.4.2.4. and 4.4.2.5.). In the Venta and Gauja basins only few significant correlations were found between diversity indices and environmental variables (Table 4.4.2.4.). At the same time the best regression models were obtained for phytobenthos and environmental variables, especially using maximal depth, conductivity, ammonium and substrate characteristics (Table 4.4.2.5.). Overall, the stronger correlations between diversity indices and environmental factors were found for phytobenthos followed by macroinvertebrates, macrophytes and fish.

5. DISCUSSION

5.1. Variation in metrics and assessment systems at different spatial scales

The relative importance of the scale determining the development of biological communities is an important research topic, especially in regard to the biological quality elements prescribed by the EC Water Framework Directive (Directive 2000/60/EC…, 2000). Effects of spatial scale on ecosystem biodiversity and on relationships between biodiversity and functioning of different scale ecosystems is the object of many investigations however it is still uncertain how different organism groups are affected at different scales (local, landscape, regional) variability and what ecological scale is relevant.

Opinion exists that generally the relative variation of species richness may be expected to be greatest at small-to-intermediate spatial scales, but these biological factors should be less important as predictors of ecosystem processes at regional scales where environmental heterogeneity is larger (Loreau et.al, 2001).

A hierarchical analysis approach to biodiversity studies in natural and altered river-floodplain ecosystems will enhance our understanding of ecological phenomena operating at different scales along multidimensional environmental gradients (Ward, Tockner, 2001).

In Finland pristine or near pristine streams exhibit distinct geographical, especially north-to-south patterns in physicochemical characteristics (Heino et.al, 2002).

Spatial-scale investigations have become one research topic for macroinvertebate ecologists (Sandin, Johnson, 2000 a, Sandin, Johnson, 2000 b, Sandin, 2001), fish (Van Sickle & Hughes, 2000), aquatic macrophyte (Gantes, Caro, 2001, Mackay et.al, 2003, Vis et.al., 2003) and for studying diatom communities (Whittier et.al., 1988, Pan et.al., 1999, Soininen, 2004).

5.1.1. Macrophytes

Results of WP18 demonstrate that in general investigated river reaches were represented by 1 to 20 macrophyte species, 1 to 17 genus and 1 to 16 families that were distributed quite unevenly. Between the species number, genus number and family number was a strong correlation.

According to composition metrics, negative correlation between Shannon's and Simpson's indices was found at the reach scale, and it was more pronounced for stream scale. At stream scale also strong positive correlation between Shannon's index and evenness was found. Simpson's index was comparatively less variable in comparison with other composition metrics.

Analyses of trophic indices showed negative correlations between MTR and IBMR as well as between Ellenberg_N and hemeroby indices at stream scale. A decrease in MTR value was observed from upstream to downstream on three investigated rivers in UK reflecting the changes in nutrient load, substrate and flow (Rivers Ouse, Ure and Wharfe Macrophyte Surveys, 2001). Such pattern was not found in this study where quite uneven distribution of macrophyte metrics, including MTR, was obtained. In our research among the groups of macrophyte metrics, the most variable was composition metrics, and among them the largest variation was found for Shannon's diversity index. Simpson's index was comparatively less variable in comparison with other composition metrics, and it was least variable of all macrophyte metrics in general. Between Shannon's and Simpson's indices a negative correlation was found at the reach scale as well as at the stream scale. Within river basins Shannon's diversity index varied quite extensively, but values of Simpson's diversity index differed negligible. Groups of trophic and especially tolerance metrics (hemeroby index) which was surpising, since all sampling sites were supposedly reference sites.

Sign test for macrophyte trophic metrics (MTR, IBMR, Ellenberg_N), composition metrics (species number, genus number, family number, Shannon's diversity index, Simpson's diversity index, domination, evenness), and trophic-composition metrics among samples confirmed that in most cases there was no statistically proved dissimilarity among reaches, streams and river basins. The difference among samples was stated for composition metrics only in one case at reach scale, and one case at stream scale (Table 5.1.1.1.).

5.1.2. Fish

Our study demonstrated that fish guilds or metrics varied differently. A typical feature was that variability of fish metrics expressed by number of individuals per ha was considerably larger than corresponding metrics characterized by species number.
Fish biodiversity evaluated by Shannon's index varied largely (from 0.42 to 1.92) as well as density (n/ha) and biomass (kg/ha) at reach scale.
Density and biomass correlated between each other at reach and stream scale.

In spatial scale studies in two rivers the Murray-Darling Basin small-scale variation and short-term temporal variability was found in fish community structure. Monitoring programs intended to evaluate changes in fish communities at large spatial scales (between river basins, regions or individual rivers) need only sample at the scale immediately below the level of interest (Growns et.al., 2003).

In all river basins rheophilic species dominated in comparison with limnophilic and eurytopic ones at reach scale as well as at stream scale.
In most of the reaches and the streams percentage of water habitat species was approximately the same as that of benthic habitat species.

Analysis of reproduction metrics confirmed that lithophilic reproduction prevailed in comparison to phytophilic that means that biotops of stony rapids are typical . In general for most of reaches and streams and all three river basins long lived species prevailed in comparison with short lived ones.

Insectivorous/invertivorous fish feeding was typical for most of reaches and streams of the Daugava and the Gauja basins. On the contrary, for the Venta basin an increased role of omnivorous fish species per reaches and streams were found . Insectivorous/invertivorous fish production was typical for the Daugava basin, but omnivorous fish production was essential for two of three the Venta basin streams.

Numbers of potamodron and long distance migratory fish per hectare in reaches of the Daugava, the Gauja and the Venta river basins show great dispersion (from 0 to 1238 and from 0 to 1964, respectively).

Environmental quality assessment according to European Fish Index (EFI) sampling sites were classified from poor (one reach, value 0.22) to good (highest value 0.65), but in regard with Lithuanian fish index they corresponded with moderate to high status. It could be concluded that use of EFI is not appropriate at ecoregional scale, and local ecoregional index is more suitable. In a study of ecoregional differences among fish fauna in Western Oregon wadable streams did Van Sickle & Hughes (2000) conclude that the communities were genereally more similar within ecoregions than between ecoregions, which would also suggest that a ecoregional specific fish index will work better than one developed on the European level.

Sign Test showed that there were no significant differences among reaches, streams and river basins if number of species, biomass and density metrics were compared. Some researchers have suggested that species abundance or biomass is similar at small-scale patterns as a result of similar climate or biotic factors (Legendre, Fortin, 1989).
At the same time difference between two streams in the Venta basin was stated in relation with feeding metrics (piscivorous, insectivorous/invertivorous, omnivorous).

The largest differences was found if fish habitat metrics were compared. Disparity differences was not found for feeding metrics as well as habitat metrics on basin scale (Table 5.1.1.1.).

5.1.3. Macroinvertebrates

It is stated that biological assessment of water quality based on macroinvertebrate faunal parameters (number of taxa and biotic indices don't reveal the multiple interactions with landscape and reach properties, but large-scale factors (nutrient input, riparian cover, hydraulics) are strong predictors of functional organization (Bis et.al.i, 2000).

Our analyses of macroinvertebrate metrics representing different indicative groups demonstrated that there was a wide spectrum of variations. In WP18 macroinvertebate **replicate samples** didn't differ according to the eutrophication metrics (Saprobic Index, BMWP), diversity indices (Simpson's index, Shannon's index, Margalef index), diversity metrics (Number of families, Number of genera, Evenness and Abundance (ind/m²) and Abundance of taxonomic groups.
Some significant differences among replicate samples were stated for EPT-Taxa metrics, number of taxa, and taxonomic group percentage (Table 5.1.1.1.).

Regarding **stream reaches** significant differences were found in 9 cases out of 15 for EPT-Taxa metrics. The largest difference found was between reaches of streams in the Venta basin, as well as between upper a middle parts of streams of all basins in general.
Sign Test showed no significant differences between stream reaches according to the eutrophication metrics, diversity indices, diversity metrics and taxonomic groups (%) (Table 5.1.1.1.).

Regarding EPT-taxa metrics at **stream** scale significant differences were found between all streams in the Venta basin. In the Daugava basin one stream differed from two others. In the Gauja basin 2 streams differed between each other according abundance of taxa (Table 5.1.1.1.).

At **river basin** scale the Venta basin significantly differed from the Daugava and the Gauja basins for EPT-taxa. Sign Test showed that there are no significant differences between diversity indices, eutrophication metrics, diversity metrics, abundance of taxonomic groups, number of taxa and taxonomic groups (%) among stream basins (Table 5.1.1.1.).

Among macroinvertebrate groups of metrics more variable were those connected with taxonomic composition like as EPT taxa, and especially - taxonomic groups (%) and number of taxa, in comparison with eutrophication and diversity metrics.

In a study by Sandin & Hering (2004), they concluded that the assessment of environmental stress was well correlated with ASPT, in most stream types, but saprobic index worked clearly better than ASPT where macroinvetebrates are identified to species level (Sandin, Hering, 2004).

Our study shows that for pristine streams most sensitive to natural spatial variability are EPT-taxa metrics that differed at all spatial scales (replicates, reaches, streams, basins)..

5.1.4. Phytobenthos

Benthic diatoms are traditionally considered as being regulated more by local than larger scale factors (Pan et. al., 1999). However, it has recently been found that in fact there is no strict evidence confirming that unicellular diatoms have higher local species richness than metazoans (Hillebrand et.al., 2001). Large-scale spatial factors, such as climate, geology and vegetation also influence diatom community structure (Leland, 1995). In general, there is an opinion that spatial variation in algal communities is the result of factors prevailing at multiple scale. At the same time in Finland diatom communities exhibit a rather strong spatial component at national scale, and proportion of variation explained by spatial factors was about 25 % (Soininen, 2004). Large heterogeneity dominates among benthic diatom communities in scales from meters to tens of meters, especially in varying current regimes (Soininen, 2003). Diatoms exhibit a fairly strong spatial patterning, and some taxa exhibited regionally restricted distributions, thus contradicting the view of diatom communities having high dispersal ability (Muotka et.al., 2004).

In general, diatoms are recognized as very useful in estimating trophic status of running waters, and it is testified by establishing of a lot of diatoms' trophic indices. In Southern Poland, all diatom indices calculated using OMNIDIA software, except for the Sládeček's index, besides conductivity and most of the measured ions correlated significantly with organic load (COD) and oxygen concentration. Some indices showed a significant negative correlation with trophic level (expressed by NH_4-N and PO_4-P). In general, IPS (Specific Pollution Sensitivity Index) and GDI (Generic Diatom Index) indices gave the best results (Kwandrans et.al., 1998).

Our investigations of high quality streams demonstrated that in most cases phytobenthos abundance at sampling sites was higher on hard substratum (cobbles) in comparison with soft substratum (silt/sand), but converse tendency was found for species number relationship with substratum.
Most of phytobenthos metrics from hard and soft substratum correlated, correllation coefficients varied fromo.45 for Trophic Diatom Index to 0.84 for Steinberg & Schiefele trophic index.
Examination of differences between phytobenthos metrics showed that on reach scale they differed more on sand/silt substrate than on hard substratum. Dissimilarity among hard substratum metrics and for sand-silt substratum was found at stream level and also at river basin scale, especially for the Venta basin (Table 5.1.1.1.)

Table 5.1.1.1. Differences between biological quality metrics at different spatial scale ((D – the Daugava basin, G – the Gauja basin, V – the Venta basin)

Scale	**Macrophyte**		**Fish**		**Macroinvertebrates**		**Phytobenthos**			
							Hard substratum		Soft substratum	
	Differ. betw. metrics	total	Differ. betw. metrics	total	Differ. betw. metrics	total	Differ. betw. metrics	total	Differ. betw. metrics	total
Replicate	-	-	-	-	**4** EPT (1 **D**,1 **G**, 2 **V**)	27	-	-	-	-
					3 Number of taxa (2 **D**, 1 **V**)	27				
					1 Tax.group perc. (1 **D**)	27				
Reach	1 compostion metrics (**V**)	25	6 Habitat metrics (1 **D**, 4 **G**, 1**V**)	25	**9** EPT (3 **D**, 2 **G**, 4 **V**)	15	**3** (1 **G**, 2 **V**)	27	**8** (3 **D**,1 **G**, 4 **V**)	27
					2 Tax.gr. abund. (1 **D**, 1 **V**)	15				
					1 Numb. of taxa (**D**)	15				
Stream	1 composition metrics (**D**)	9	2 Habitat metrics (1 **G**, 1 **V**)	9	**4** EPT (1 **D**, 3 **V**)	9	**3** (2 **D**, 1 **V**)	9	**5** (2 **G**, 3 **V**)	9
					1 Tax.gr. abund. (**G**)	9				
Basin	**NO**	3	**NO**	3	**2** EPT (**V**, from D,G)	3	**1** (**V**, from D)	3	**2** (**V**, from D, G)	3

5.2. Variation in metrics and relationships between groups of biological quality elements

Studies of different organism groups showed some relationship among them. In boreal streams the spatial patterns exhibited by benthic diatoms corresponded quite closely with those of stream macroinvertebrates (Heino et.al., 2002). For example, comparison of diatom IPS and macroinvertebrate ASPT showed that the first one tended to be more variable. It may result for the fact that for ISP every species has its own sensitivity and indicator value while for ASPT only identification on family level is needed (Soininen, 2004). For diatoms, separation of community structure between sampling stations was clear, but corresponding macroinvertebrate communities were more similar to each other. Correlation between diatom and macroinvertebrate pollution indices was rather low and insignificant (r = 0.28. As a whole, variation of macroinvertebrate index values (CV = 4.7 %) among replicate samples was slightly lower than for diatom index (CV = 6.0%). On the contrary, community similarity between the replicate samples was slightly lower among macroinvertebrates (r = 0.770) due probably to their larger local scale spatial variation, sampling of more habitats and lower density compared to diatoms (r = 0.874) (Soininen, Könönen, 2004).

In this study we compared Shannon's and Simpson's diversity indices for all studied organism groups. The values of Shannon's index for reaches, streams and river basins are given in Annex XL, for Simpson's diversity index – in Annex XLI. The largest Shannon's index values were stated for diatoms from sand-silt substratum, followed by diatoms from hard substratum, macroinvertebrates, fish and macrophytes (Annex XL). According to Simpson's diversity index in most cases the largest values are typical for macrophytes followed by diatoms from hard substratum, diatoms from soft substratum, macroinvertebrates and fish (Annex XLI). In general no correlations were found for macrophytes, fish, macroinvertebrates and phytobenthos (diatom from hard and from soft substrata) of Shannon's index (Table 5.1.1.2.) as well as Simpson's index values at reach scale (Table 5.1.1.3). The only positive tie was found between macrophytes and macroinvertebrates Simpson's diversity indices (r = 0,411, α = 0.05) (Table 5.1.1.3).

Table 5.1.1.2. Correlation coefficients between Shannon's index of different organism groups

macrophyte-fish			
0,036			
macrophyte-macroinvert.	fish/macroinvert.		
-0,302	-0,017		
macrophyte-diatoms_H	fish/diatoms_H	macroinvert./diatoms_H	
-0,222	0,294	0,274	
macrophyte-diatoms_S	fish/diatoms_S	macroinvert./diatoms_S	diatoms_H/diatoms_S
0,144	0,221	-0,142	0,327

* hard substratum
**soft substratum

Table 5.1.1.2. Correlation coefficients between Simpson's diversity index values of different organism groups

macrophyte-fish			
0,026			
macrophyte-macroinvert.	fish/macroinvert.		
0,411	-0,363		
macrophyte-diatoms_H	fish/diatoms_H	macroinvert./diatoms_H	
0,090	0,386	-0,030	
macrophyte-diatoms_S	fish/diatoms_S	macroinvert./diatoms_S	diatoms_H/diatoms_S
-0,107	0,230	-0,214	0,371

***** hard substratum
******soft substratum

It is found that similarity in patterns of community structure among main biological groups is often rather low, especially at small spatial scale (within watershed scale), therefore it may be advisable to base stream biomonitoring on multiple taxonomic groups, e.g., macroinvertebrates and benthic diatoms (Soininen, Könönen, 2004) and our results confirmed this hypothesis. It could explained by the fact that different taxonomic groups showed different relationships to environmental gradients, leading to relatively low levels of concordance (Muotka et.al., 2004).

5.3. Variation in metrics and environmental relations at different spatial scale

One of the objectives within this study was to assess the importance of environmental variables to biological quality elements for different river basins.

This problem is investigated quite largely, and it is stated that the strength of observed patterns depends on the extent to which various mechanisms act in concert; clear patterns arise when several processes act in one direction, and in general observed patterns can have multiple explanations (Gaston, Blackburn, 1999). Thus the central question is not which explanation is the correct one, but what are their relative roles (Soininen, 2004).

Discharge (channel width, depth, current velocity) plays frequently an overriding role in the regulation of development of benthic organisms in general (e.g. Hart & Finelli, 1999).

The distribution of the four sample groups within the Mary River catchment was associated with two environmental gradients, the first gradient representing discharge intensity, discharge variability and total Kjeldahl nitrogen concentration and the second gradient representing discharge intensity, substrate composition, riparian canopy cover and total phosphorus concentration. Both environmental gradients were constrained by geomorphology at the catchment as well as the reach scale (Mackay et.al., 2003). Our findings confirmed the role of chemical parameters in the macrophyte biodiversity structure.

Benthic diatoms are traditionally considered as being regulated more by local than larger scale factors (Pan et. al., 1999). Large –scale spatial factors, such as climate, geology and vegetation also influence diatom community structure (Leland, 1995). In USA it was found that up to one-third of the total explainable variation in diatom species data was attributed solely to geographical factors not correlated with measured environmental characteristics (Potapova, Charles, 2002). The development of phytobenthos in streams is determined by complex of local (e.g. discharge) and larger scale regional (catchments, ecoregions) factors (e.g. geology, topography, climate), that act like as environmental filters (Poff 1997).
It is found for basin scale that ionic composition and major nutrient [i.e. nitrogen (N) and phosphorus (P)] concentration of surface waters, salinity (Na-Cl type), substratum type and physiognomic form of dominant species were primary factors contributing to variation in benthic-algal assemblages. Thus diatoms are considered to be better indicators of changes in water chemistry as macroinvertebrates due to their shorter life cycles and larger sensitivity (Steinberg, Schiefele, 1988). Conductivity was found the strongest environmental gradient explaining diatom distribution patterns in Finland, and total P and latitude was important, too (Soininen, Könönen, 2004).

Basin geology was a significant contributing factor, but the explained variance associated with this factor was less than that related to land use (Leland, 1995, Leland and Porter, 2000). Habitat characteristics strongly correlated with community structure included reach altitude, turbidity, substratum embeddedness, large woody-debris density and composition and density of the riparian vegetation (Leland, 1995).

Investigations of benthic invertebrate distributions in relation to physical and chemical factors discovered that community structure, taxa richness and EPT richness varied with dissolved-solids concentration, and that structure of invertebrate communities was a conservative measure of water quality (Leland, Fend, 1998). Species distribution of macroinvertebrates in running water of Finland was mostly related to channel width, conductivity and pH (Soininen, Könönen, 2004).

Local scale variables such as in-stream substratum, vegetation in and near the stream (riparian zone), and some chemical variables were most strongly associated with the among-site variability. Local physical (24.4 %) and chemical (20.4 %) variables explained the largest part of the among-site variability of macroinvertebrate community assemblages (Sandin & Johnson, 2004). In our study we also found relations between macroinvertebrates and chemical parameters linked with river basin genesis such as hardness, alkalinity, chloride, slope, stream velocity and oxygen, but such relationship was typical only in the Daugava basin.

Different taxonomic groups showed different relationships to environmental gradients, leading to relatively low levels of concordance (Muotka et.al., 2004).

In general, our analyses of relationships between diversity indices (Shannon's and Simpson's) of biological elements – macrophytes, fishes, macroinvertebrates and phytobenthos, and environmental variables didn't reveal didn't reveal identical interactions and differed in river basins, but it could be concluded that weak relationships of diversity indices with environmental factors were established for fishes, followed by macrophytes and macroinvertebrates, but the most evident relationships were stated for phytobenthos.

Data analyses of WP18 showed that environmental variables together with fish, macrophyte, diatoms and macroinvertebrates metrics could be valuable for assessment of environmental gradient at the different spatial scales.
Principal component analyses done for fish, macrophyte, diatoms and macroinvertebrate metrics in particular study didn't allow to differentiate among the main gradient for each metric/metric group. One of the reasons for that could be insufficient amount of streams for such statistical analyses. Probably, the set of environmental parameters selected in one matrix was too large.

6. Conclusions

A comparison of single metrics of different groups of biological quality elements demonstrated that in general they had the largest variations on the reach scale in comparison with stream and basin scales.

Variability of metrics within groups of biological quality elements:

- Among the groups of **macrophytes** the most variable were composition metrics, and trophic and especially tolerance metrics (hemeroby index) were less variable.
- Within **fish** guilds more variable were migration metrics, followed by feeding, reproduction, habitat, longevity, abundance, tolerance and composition metrics. The variability of fish metrics expressed by number of individuals per ha was considerably larger than corresponding metrics characterized by species number. The most robust indicator was EFI.
- Among **macroinvertebrate** groups of metrics more variable were those connected with taxonomic composition like as EPT Taxa, and especially - taxonomic groups (%) and number of taxa, in comparison with eutrophication and diversity metrics.
- The indices percent PT and TDI were the most variable, but ROTT, L&M and Descy - the least variable **phytobenthos** metrics.

In general, it was found, that the least variable were the large bodied organisms - macrophytes and fish, followed by the small bodied organisms - macroinvertebrates and phytobenthos.

The disparity among reaches, streams and river basins done by Sign test was evaluated using different indicative groups of the biological quality elements.

- In most cases there was no statistically proved dissimilarity among reaches, streams and river basins if **macrophyte** groups were compared.
- No significant differences among the reaches, streams and river basins were found if **fish** guilds represented by composition and abundance metrics were compared, but some difference among streams was stated in relation to feeding metrics. The largest differences were found for habitat metrics at the reach and stream scale. No differences were found for fish guilds at the basin scale.
- Comparison of groups of **macroinvertebate** metrics revealed that replicate samples differed for EPT-Taxa metrics, number of taxa and percentage of taxonomic groups. EPT-Taxa metrics differed also at the stream and basin scale.

- Comparison of all-together **phytobenthos** metrics showed that they differed at the reach scale, stream scale and also at the basin scale, especially those on a soft substratum.

For the assessment of **similarity in community structure among biological quality elements** Shannon's and Simpson's diversity indices calculated for all studied organism groups were compared and in general no correlations were found among groups of organisms.

Shannon's diversity index varied quite extensively, but values of Simpson's diversity index differed negligible. Between Shannon's and Simpson's indices a negative correlation was found.

Weak **relationships between environmental variables and diversity indices of BQE** (Shannon's and Simpson's) were established for fishes, followed by macrophytes and macroinvertebrates, but the most evident relationships were stated for phytobenthos.
These relations didn't revealed identical interactions and differed in river basins.

7. Reccomendations

The understanding of which organism group or groups are to be used at which spatial or temporal scale can be used to develop recommendations for integrated monitoring programmes and sampling networks that deliver cost-effective assessments at appropriate levels of scale and spatial resolution.
Results of this research showed that indicative groups of macrophyte and fish could be usable at river basin scale, but macroinvertebrates and phytobenthos – at smaller scale patterns.

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APPENDICES

ANNEX I Specific and mean values of macrophyte metrics per studied reaches, streams and river basins

Reach/Stream/Basin	MTR	IBMR	Ellenberg_N	Hemeroby index	Species number (S)	Genus number (G)	Family number (F)	Shannon diversity (H`)	Simpson diversity (D)	Domination (C)	Evenness (J)
Pededze 1	46,80	11,98	5,92	41,93	11	10	10	0,25	0,99	0,27	0,11
Pededze 2	46,36	11,33	5,54	40,52	6	6	6	0,07	1,00	0,32	0,04
Pededze 3	45,45	11,38	6,26	42,50	6	6	6	0,06	1,00	0,19	0,04
Pededze	**46,21**	**11,56**	**5,91**	**41,65**	**7,67**	**7,33**	**7,33**	**0,13**	**1,00**	**0,26**	**0,06**
Arona 1	43,64	11,17	6,39	44,05	16	15	15	0,19	1,00	0,19	0,07
Arona 2	49,17	11,55	6,00	43,71	11	10	10	0,09	1,00	0,24	0,04
Arona 3	34,00	9,20	6,88	44,46	10	9	9	0,11	1,00	0,40	0,05
Arona	**42,27**	**10,64**	**6,42**	**44,08**	**12,33**	**11,33**	**11,33**	**0,13**	**1,00**	**0,27**	**0,05**
Mergupe 1											
Mergupe 2	34,17	8,15	4,00	36,00	5	5	5	0,19	0,97	0,70	0,12
Mergupe 3	40,69	9,88	6,67	44,78	20	17	16	0,31	0,99	0,25	0,11
Mergupe	**37,43**	**9,02**	**5,34**	**40,39**	**12,50**	**11,00**	**10,50**	**0,25**	**0,98**	**0,48**	**0,11**
DAUGAVA BASIN	**41,97**	**10,41**	**5,89**	**42,04**	**10,83**	**9,89**	**9,72**	**0,17**	**0,99**	**0,34**	**0,07**
Rauza 1	40,00	12,11	6,00	39,07	3	3	3	0,07	1,00	0,76	0,06
Rauza 2	38,18	10,47	6,96	45,66	9	7	7	0,08	1,00	0,67	0,04
Rauza 3	40,77	10,50	6,20	43,40	10	10	10	0,07	1,00	0,35	0,03
Rauza	**39,65**	**11,03**	**6,39**	**42,71**	**7,33**	**6,67**	**6,67**	**0,07**	**1,00**	**0,59**	**0,04**
Raunis 1	56,67	13,33	6,00	39,00	3	3	3	0,02	1,00	0,73	0,01
Raunis 2	60,00	15,00			1	1	1	0,00	1,00	1,00	0,00
Raunis 3	28,33	9,47	5,21	42,33	7	6	6	0,18	0,97	0,77	0,09
Raunis	**48,33**	**12,60**	**5,61**	**40,67**	**3,67**	**3,33**	**3,33**	**0,07**	**0,99**	**0,83**	**0,04**
Strikupe 1	40,59	10,50	5,28	41,59	14	13	13	0,64	0,82	0,29	0,24
Strikupe 2	45,38	11,23	6,93	45,13	10	9	9	0,37	0,96	0,34	0,16
Strikupe 3	45,79	10,26	6,74	42,14	15	13	13	0,23	0,99	0,31	0,09
Strikupe	**43,92**	**10,67**	**6,31**	**42,95**	**13,00**	**11,67**	**11,67**	**0,42**	**0,92**	**0,31**	**0,16**
GAUJA BASIN	**43,97**	**11,43**	**6,10**	**42,11**	**8,00**	**7,22**	**7,22**	**0,18**	**0,97**	**0,58**	**0,08**
Amula 1	43,85	10,12	6,85	45,71	7	5	5	0,17	0,97	0,82	0,09
Amula 2	32,50	9,14	6,86	45,77	4	4	4	0,02	1,00	0,63	0,01
Amula 3	43,33	10,24	6,02	42,39	13	13	12	0,09	1,00	0,14	0,03
Amula	**39,89**	**9,83**	**6,58**	**44,63**	**8,00**	**7,33**	**7,00**	**0,09**	**0,99**	**0,53**	**0,05**
Riezupe 1	34,00	9,41	6,66	41,30	8	8	8	0,07	1,00	0,31	0,04
Riezupe 2	44,29	11,00	6,53	44,82	12	11	11	0,11	1,00	0,23	0,04
Riezupe 3	42,50	10,76	6,44	43,59	15	13	12	0,14	1,00	0,17	0,05
Riezupe	**40,26**	**10,39**	**6,55**	**43,24**	**11,67**	**10,67**	**10,33**	**0,11**	**1,00**	**0,24**	**0,04**
Koja 1	29,41	8,79	6,48	44,99	11	9	8	0,16	1,00	0,24	0,07
Koja 3	41,67	10,58	6,60	44,61	6	5	5	0,11	1,00	0,27	0,06
Koja	**35,54**	**9,69**	**6,54**	**44,80**	**8,50**	**7,00**	**6,50**	**0,13**	**1,00**	**0,26**	**0,06**
VENTA BASIN	**38,56**	**9,97**	**6,55**	**44,22**	**9,39**	**8,33**	**7,94**	**0,11**	**1,00**	**0,34**	**0,05**

ANNEX II
Sign test for macrophyte metrics – trophic,, composition, and trophic and composition- of samples among reaches, streams and river basins

River basin	Site name	***Exact Sig. (2-tailed)*** for 10 composition and trophic metrics	***Exact Sig. (2-tailed)*** for 3 trophic metrics	***Exact Sig. (2-tailed)*** for 7 composition metrics
Daugava River	Arona1-Arona2	0,754	1,000	0,219
	Arona1-Arona3	0,344	1,000	0,219
	Arona2-Arona3	0,754	1,000	1,000
	Mergupe2-Mergupe3	0,109	0,250	0,453
	Pededze1-Pededze2	0,109	0,250	0,453
	Pededze1-Pededze3	0,109	1,000	0,125
	Pededze2-Pededze3	1,000	1,000	0,500
Gauja River	Raunis1-Raunis2	1,000	0,500	0,219
	Raunis1-Raunis3	0,754	0,500	0,125
	Raunis2-Raunis3	1,000	0,250	0,453
	Rauza1-Rauza2	1,000	1,000	0,687
	Rauza1-Rauza3	0,344	1,000	1,000
	Rauza2-Rauza3	1,000	1,000	1,000
	Strikupe1-Strikupe2	1,000	0,250	0,453
	Strikupe1-Strikupe3	0,727	1,000	1,000
	Strikupe2-Strikupe3	1,000	1,000	1,000
Venta River	Amula1-Amula2	0,109	1,000	0,125
	Amula1-Amula3	0,754	1,000	1,000
	Amula2-Amula3	0,754	0,250	0,219
	Koja1-Koja2	1,000	0,250	0,375
	Koja1-Koja3	1,000	1,000	0,219
	Koja2-Koja3	0,344	0,250	**0,031**
	Riezupe1-Riezupe2	0,344	1,000	0,219
	Riezupe1-Riezupe3	0,344	0,250	0,375
	Riezupe2-Riezupe3	1,000	1,000	0,219

River basin	*Stream name*	***Exact Sig. (2-tailed)*** for 10 composition and trophic metrics	***Exact Sig. (2-tailed)*** for 3 trophic metrics	***Exact Sig. (2-tailed)*** for 7 composition metrics
Daugava River	Arona-Mergupe	1,000	0,250	0,109
	Mergupe-Pededze	0,210	0,250	**0,022**
	Arona-Pededze	0,021	1,000	0,070
Gauja River	Raunis-Rauza	0,077	1,000	0,109
	Rauza-Strikupe	0,454	1,000	0,388
	Raunis-Strikupe	0,454	1,000	0,267
Venta River	Koja-Amula	1,000	0,250	0,754
	Riezupe-Koja	1,000	1,000	0,549
	Amula-Riezupe	0,804	1,000	0,581

River basins	***Exact Sig. (2-tailed)*** for 10 composition and trophic metrics	***Exact Sig. (2-tailed)*** for 3 trophic metrics	***Exact Sig. (2-tailed)*** for 7 composition metrics
Daugava-Gauja	0,210	0,250	0,687
Gauja-Venta	1,000	1,000	1,000
Daugava-Venta	0,804	1,000	0,453

ANNEX III
Correlation coefficients of environmental parameters and macrophyte metrics with ordination axis of main matrix for the Daugava basin

Environmental parameters and macrophyte metrics	Pearson coefficient		
	First axis	Second axis	Third axis
HQA score	0.289	-0.689	-0.54
HMS score	-0.54	0	0.414
catchment's area	0.612	0.698	-0.107
Altitude	-0.77	-0.442	0.154
Gradient slope	-0.486	-0.572	-0.532
Distance source	0.618	0.635	-0.285
Forest	0.216	-0.684	0.467
Agricultural land	-0.252	0.716	-0.432
width	0.595	0.059	-0.094
depth	0.874	0.433	0.002
Max depth	0.795	0.338	0.274
discharge	0.925	0.166	0.058
velocity	0.678	-0.71	-0.025
megalithal	-0.066	-0.65	-0.299
macrolithal	-0.149	-0.157	-0.764
mesolithal	-0.813	-0.336	0.077
microlit	-0.31	-0.303	0.005
akal	0.069	0.212	0.746
psammal	0.602	0.407	0.044
macalgae	-0.362	0.243	-0.492
Sub.macroph.	-0.609	0.031	-0.389
xylal	-0.723	-0.237	0.023
CPOM	0.769	0.185	-0.381
FPOM	-0.339	0.464	0.688
pH value	-0.364	0.726	-0.505
conductivity	-0.468	0.856	-0.102
oxygen	0.366	-0.294	-0.67
oxygen saturation	0.197	0.203	-0.369
alkalinity	-0.503	0.844	-0.061
hardness	-0.515	0.826	-0.051
chloride	-0.424	0.669	0.466
ammonium	0.446	-0.472	0.639
nitrite	0.666	-0.367	-0.04
nitrate	0.364	0.215	0.602
phosphate	-0.452	-0.541	0.422
Tot-P	-0.028	0.282	0.297
MTR	-0.193	0.079	0.281

IBMR	-0.088	0.422	0.556
Ellenber	0.229	0.88	0.279
SpeciesN	0.236	0.388	-0.167
GenusN	0.171	0.391	-0.14
FamilyN	0.114	0.404	-0.117
Shannon	0.366	-0.311	-0.062
Simpson	-0.138	0.753	0.405
Dominat	-0.068	-0.584	-0.398
Evenness	0.232	-0.669	-0.106

ANNEX IV
Correlation coefficients of environmental parameters and macrophyte metrics with ordination axis of main matrix for the Gauja basin

Environmental parameters and macrophyte metrics	Pearson coefficient		
	First axis	Second axis	Third axis
HQAscore	0.82	0.271	-0.049
HMSscore	0.199	0.577	0.505
Catchment size	-0.332	0.059	0.6
Altitude	0.691	-0.615	0.144
Gradient slope	0.467	0.69	-0.136
Distance source	-0.03	0.372	0.584
Forest	-0.77	-0.263	0.542
Agricultural land	0.773	0.273	-0.549
width	-0.295	-0.353	0.781
depth	-0.847	-0.19	-0.191
mdepth	-0.366	-0.52	-0.468
discharge	-0.944	0.232	-0.159
velocity	-0.687	0.281	-0.262
megalithal	-0.042	0.274	0.036
macrolithal	0.42	-0.241	0.562
mesolithal	0.639	-0.218	0.48
microlithal	0.664	0.222	0.309
akal	0.694	0.005	-0.353
psammal	-0.925	0.1	-0.322
Sub-macrophytes	-0.777	-0.013	-0.366
xylal	0.181	-0.704	0.272
CPOM	0.591	-0.135	-0.652
FPOM	-0.275	0.443	-0.118
pH value	0.19	0.72	0.227
conductivity	0.144	0.928	-0.002
oxygen	-0.333	0.844	0.151
Oxygen saturation	-0.45	0.784	0.085
alkalinity	0.161	0.909	0.015
hardness	0.233	0.94	-0.003
chloride	0.539	0.064	-0.248
BOD_5	-0.89	-0.059	-0.241
ammonium	0.701	-0.45	0.23
nitrite	-0.215	-0.4	0.29
nitrate	0.259	-0.628	-0.443
phosphate	0.117	0.525	0.099
Tot-P	0.593	0.162	-0.476
MTR	0.164	-0.089	0.069
IBMR	0.38	-0.156	-0.032
Ellenber	-0.458	-0.497	-0.132
SpeciesN	-0.772	-0.024	-0.281
GenusN	-0.781	-0.043	-0.18
FamilyN	-0.781	-0.043	-0.18
Shannon	-0.506	0.057	-0.322
Simpson	0.177	-0.058	0.318
Dominat	0.836	0.251	-0.039
Evenness	-0.465	0.033	-0.281

ANNEX V
Correlation coefficients of environmental parameters and macrophyte metrics with ordination axis of main matrix for the Venta basin

Environmental variables and macrophyte metrics	Pearson coefficient		
	First axis	Second axis	Third axis
HQA score	0.824	-0.162	0.293
HMS score	0.578	-0.546	-0.403
Catchment's area	0.89	0.104	-0.234
Altitude	-0.648	-0.522	0.308
Slope gradient	-0.056	-0.191	-0.796
Distance from source	0.888	0.086	-0.329
Forest	-0.71	0.045	-0.526
Agricultural land	0.701	-0.095	0.49
width	0.887	0.025	-0.286
depth	-0.725	0.409	-0.252
Max depth	-0.262	0.307	0.006
discharge	0.654	0.478	-0.168
velocity	0.169	0.613	0.335
macrolithal	0.697	-0.017	-0.513
mesolithal	0.588	-0.385	-0.507
microlithal	0.242	0.546	-0.033
akal	0.232	0.546	0.113
psammal	-0.723	-0.235	0.407
macalgae	0.681	0.029	-0.488
submacr	0.174	-0.701	0.081
xylal	0.443	-0.783	0.282
CPOM	0.279	-0.177	0.707
FPOM	0.097	0.332	0.758
pH value	0.774	-0.444	-0.045
conduction	0.485	-0.685	0.157
oxygen	0.365	0.852	-0.068
oxygsaturation	0.624	0.687	0.09
alkalinity	0.298	-0.894	0.116
hardness	0.434	-0.759	0.063
chloride	-0.472	-0.31	-0.521
BOD5	-0.213	0.129	-0.084
ammonium	0.326	0.461	-0.14
nitrite	-0.577	0.414	-0.524
nitrate	0.289	0.86	0.15
phosphate	-0.579	-0.392	-0.006
Tot-P	-0.545	-0.498	-0.383
MTR	0.518	-0.267	-0.366
IBMR	0.035	-0.21	-0.169

Ellenber	-0.523	-0.085	0.646
SpeciesN	0.606	0.304	-0.437
GenusN	0.685	0.263	-0.494
FamilyN	0.693	0.265	-0.519
Shannon	-0.297	0.049	-0.184
Simpson	0.212	0.657	-0.279
Dominat	-0.33	-0.643	0.583
Evenness	-0.506	-0.1	-0.093

ANNEX VI

Fish metrics characterizing lithophilic and phytophilic reproduction (number of species n_sp; percentage of species perc_sp; number per ha n_ha; percentage of number per ha perc_nha, kg per ha kg_ha, percentage kg per ha perc_kg_ha) per reach, stream and river basin

Scale	Reproduction lithophilic						Reproduction phytothophilic					
	n_sp	perc_sp	n_ha	perc_nha	kg_ha	perc_kgha	n_sp	perc_sp	n_ha	perc_nha	kg_ha	perc_kgha
Arona 1	4	80	7395	98	28	99	0	0	0	0	0	0
Arona 2	4	100	1571	100	10	100	0	0	0	0	0	0
Arona 3	2	40	238	77	3	38	1	20	24	8	4	58
Arona Mean	**3.33**	**73.33**	**3068**	**91.67**	**13.67**	**79**	**0.33**	**6.67**	**8**	**2.67**	**1.33**	**19.33**
Mergupe 1	3	75	6555	99	88	100	0	0	0	0	0	0
Mergupe 2	4	100	3022	100	69	100	0	0	0	0	0	0
Mergupe 3	5	71	8082	94	39	93	0	0	0	0	0	0
Mergupe Mean	**4**	**82**	**5886.33**	**97.67**	**65.33**	**97.67**	**0**	**0**	**0**	**0**	**0**	**0**
Pededze 1	5	83	2901	94	29	89	0	0	0	0	0	0
Pededze 2	4	80	9630	99	54	99	0	0	0	0	0	0
Pededze 3	3	75	2100	88	24	85	0	0	0	0	0	0
Pededze Mean	**4**	**79.33**	**4877**	**93.67**	**35.67**	**91**	**0**	**0**	**0**	**0**	**0**	**0**
Daugava basin Mean	**3.78**	**78.22**	**4610.44**	**94.33**	**38.22**	**89.22**	**0.11**	**2.22**	**2.67**	**0.89**	**0.44**	**6.44**
Raunis 1	4	100	8048	100	18	100	0	0	0	0	0	0
Raunis 2	4	100	3750	100	35	100	0	0	0	0	0	0
Raunis 3	3	100	2500	100	25	100	0	0	0	0	0	0
Raunis Mean	**3.67**	**100**	**4766**	**100**	**26**	**100**	**0**	**0**	**0**	**0**	**0**	**0**
Rauza 1	3	60	15111	94	59	80	0	0	0	0	0	0
Rauza 2	1	33	286	58	3	43	1	33	104	21	3	37
Rauza 3	6	75	2393	88	11	72	0	0	0	0	0	0
Rauza	**3.33**	**56**	**5930**	**80**	**24.33**	**65**	**0.33**	**11**	**34.67**	**7**	**1**	**12.33**

Mean												
Strikupe 1	4	40	3776	86	32	68	3	30	102	2	3	7
Strikupe 2	4	67	1167	70	15	48	0	0	0	0	0	0
Strikupe 3	4	57	987	90	10	85	0	0	0	0	0	0
Strikupe Mean	**4**	**54.67**	**1976.67**	**82**	**19**	**67**	**1**	**10**	**34**	**0.67**	**1**	**2.33**
Gauja basin Mean	**3.67**	**70.22**	**4224.22**	**87.33**	**23.11**	**77.33**	**0.44**	**7**	**22.89**	**2.56**	**0.67**	**4.89**
Amula 1	2	40	517	81	3	29	1	20	30	5	6	55
Amula 2	4	67	542	27	5	27	0	0	0	0	0	0
Amula 3	4	67	1156	89	10	88	0	0	0	0	0	0
Amula Mean	**3.33**	**58**	**738.33**	**65.67**	**6**	**48**	**0.33**	**6.67**	**10**	**1.67**	**2**	**18.33**
Koja 1	1	25	240	4	0	8	1	25	720	12	2	66
Koja 3	6	100	1600	100	35	100	0	0	0	0	0	0
Koja Mean	**3.5**	**62.5**	**920**	**52**	**17.5**	**54**	**0.5**	**12.5**	**360**	**6**	**1**	**33**
Riezupe 1	4	80	2972	99	34	95	0	0	0	0	0	0
Riezupe 2	5	62	2290	74	18	53	1	12	483	16	3	8
Riezupe 3	3	50	2686	83	19	76	0	0	0	0	0	0
Riezupe Mean	**4**	**64**	**2649.33**	**85.33**	**23.67**	**74.67**	**0.33**	**4**	**161**	**5.33**	**1**	**2.67**
Venta basin Mean	**3.61**	**61.5**	**1435.89**	**67.67**	**15.72**	**58.89**	**0.39**	**7.72**	**177**	**4.33**	**1.33**	**18**

ANNEX VII
Fish metrics characterizing longevity (long lived, short lived) (number of species n_sp; percentage of species perc_sp; number per ha n_ha; percentage of number per ha perc_nha, kg per ha kg_ha, percentage kg per ha perc_kg_ha) per reach, stream and river basin

Scale	Long lived						Short lived					
	n_sp	perc_sp	n_ha	perc_nha	kg_ha	perc_kgha	n_sp	perc_sp	n_ha	perc_nha	kg_ha	perc_kgha
Arona 1	0	0	0	0	0	0	3	60	6723	89	19	67
Arona 2	0	0	0	0	0	0	2	50	1262	80	3	28
Arona 3	1	20	24	8	4	58	3	60	95	31	1	11
Arona Mean	**0.33**	**6.67**	**8.00**	**2.67**	**1.33**	**19.33**	**2.67**	**56.67**	**2693.33**	**66.67**	**7.67**	**35.33**
Mergupe 1	0	0	0	0	0	0	2	50	4286	65	59	67
Mergupe 2	0	0	0	0	0	0	2	50	1956	65	12	18
Mergupe 3	0	0	0	0	0	0	5	71	4959	58	7	17
Mergupe Mean	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**3.00**	**57.00**	**3733.67**	**62.67**	**26.00**	**34.00**
Pededze 1	1	17	62	2	7	22	3	50	2531	82	10	31
Pededze 2	0	0	0	0	0	0	3	60	8889	92	23	42
Pededze 3	0	0	0	0	0	0	3	75	1700	71	16	56
Pededze Mean	**0.33**	**5.67**	**20.67**	**0.67**	**2.33**	**7.33**	**3.00**	**61.67**	**4373.33**	**81.67**	**16.33**	**43.00**
Daugava basin Mean	**0.22**	**4.11**	**9.56**	**1.11**	**1.22**	**8.89**	**2.89**	**58.44**	**3600.11**	**70.33**	**16.67**	**37.44**
Raunis 1	0	0	0	0	0	0	1	25	5762	72	3	17
Raunis 2	0	0	0	0	0	0	1	25	2297	61	2	6
Raunis 3	0	0	0	0	0	0	1	33	36	1	0	1
Raunis Mean	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.00**	**27.67**	**2698.33**	**44.67**	**1.67**	**8.00**
Rauza 1	1	20	74	0	0	0	3	60	14963	94	62	85
Rauza 2	1	33	104	21	3	37	1	33	104	21	1	20
Rauza 3	1	12	18	1	3	20	4	50	2321	85	7	50
Rauza Mean	**1.00**	**21.67**	**65.33**	**7.33**	**2.00**	**19.00**	**2.67**	**47.67**	**5796.00**	**66.67**	**23.33**	**51.67**
Strikupe 1	2	20	82	2	3	6	4	40	3633	82	19	39
Strikupe 2	0	0	0	0	0	0	3	50	383	23	17	56
Strikupe 3	0	0	0	0	0	0	3	43	312	29	2	14
Strikupe Mean	**0.67**	**6.67**	**27.33**	**0.67**	**1.00**	**2.00**	**3.33**	**44.33**	**1442.67**	**44.67**	**12.67**	**36.33**
Gauja basin Mean	**0.56**	**9.44**	**30.89**	**2.67**	**1.00**	**7.00**	**2.33**	**39.89**	**3312.33**	**52.00**	**12.56**	**32.00**

Amula 1	1	20	30	5	6	55	2	40	122	19	0	3
Amula 2	1	17	25	1	2	11	3	50	1256	61	8	42
Amula 3	1	17	181	14	1	8	3	50	272	21	1	11
Amula Mean	**1.00**	**18.00**	**78.67**	**6.67**	**3.00**	**24.67**	**2.67**	**46.67**	**550.00**	**33.67**	**3.00**	**18.67**
Koja 1	0	0	0	0	0	0	3	75	5760	99	2	94
Koja 3	1	17	19	1	8	23	2	33	343	21	3	9
Koja Mean	**0.50**	**8.50**	**9.50**	**0.50**	**4.00**	**11.50**	**2.50**	**54.00**	**3051.50**	**60.00**	**2.50**	**51.50**
Riezupe 1	0	0	0	0	0	0	2	40	1020	34	8	23
Riezupe 2	1	12	84	3	0	1	4	50	987	32	7	21
Riezupe 3	0	0	0	0	0	0	4	67	1143	35	10	42
Riezupe Mean	**0.33**	**4.00**	**28.00**	**1.00**	**0.00**	**0.33**	**3.33**	**52.33**	**1050.00**	**33.67**	**8.33**	**28.67**
Venta basin Mean	**0.61**	**10.17**	**38.72**	**2.72**	**2.33**	**12.17**	**2.83**	**51.00**	**1550.50**	**42.44**	**4.61**	**32.94**

ANNEX VIII
Percentage of fish species by feeding (piscivorous perc_sp_ Fe_pisc, insectivorous/invertivorous perc_sp_Fe_insev, omnivorous perc_sp_Fe_omni)

Scale	Feeding		
	perc_sp_ Fe_pisc	perc_sp_Fe_insev	perc_sp_Fe_omni
Arona 1	0	40	20
Arona 2	0	50	0
Arona 3	20	20	20
Arona Mean	**6.67**	**36.67**	**13.33**
Mergupe 1	0	25	25
Mergupe 2	0	50	0
Mergupe 3	0	43	14
Mergupe Mean	**0.00**	**39.33**	**13.00**
Pededze 1	17	33	0
Pededze 2	0	40	0
Pededze 3	0	25	0
Pededze Mean	**5.67**	**32.67**	**0.00**
Daugava basin Mean	**4.11**	**36.22**	**8.78**
Raunis 1	0	50	0
Raunis 2	0	50	0
Raunis 3	0	67	0
Raunis Mean	**0.00**	**55.67**	**0.00**
Rauza 1	0	0	40
Rauza 2	33	0	0
Rauza 3	12	38	0
Rauza Mean	**15.00**	**12.67**	**13.33**
Strikupe 1	10	20	20
Strikupe 2	0	50	0
Strikupe 3	0	43	14
Strikupe Mean	**3.33**	**37.67**	**11.33**
Gauja basin Mean	**6.11**	**35.33**	**8.22**
Amula 1	20	20	20
Amula 2	0	17	33
Amula 3	0	17	50
Amula Mean	**6.67**	**18.00**	**34.33**
Koja 1	0	25	50
Koja 3	0	50	17
Koja Mean	**0.00**	**37.50**	**33.50**
Riezupe 1	0	40	0
Riezupe 2	0	25	12
Riezupe 3	0	17	33
Riezupe Mean	**0.00**	**27.33**	**15.00**
Venta basin Mean	**2.22**	**27.61**	**27.61**

ANNEX IX
Test Statistics using Sign Test for comparison of fish metrics sampled populations showed that there were not significant differences

Site name	***Exact Sig. (2-tailed)*** Species number, biomass, density	***Exact Sig. (2-tailed)*** Habitat metrics	***Exact Sig. (2-tailed)*** Feeding metrics
Arona1-Arona2	1,250	**0,004**	0,125
Arona1-Arona3	0,500	0,146	1,000
Arona2-Arona3	1,000	0,754	0,727
Mergupe1-Mergupe2	0,500	0,065	1,000
Mergupe1-Mergupe3	1,000	1,000	0,625
Mergupe2-Mergupe3	1,000	0,065	1,000
Pededze1-Pededze2	0,250	1,000	1,000
Pededze1-Pededze3	0,250	0,146	0,219
Pededze2-Pededze3	1,000	0,289	0,250
Raunis1-Raunis2	1,000	1,000	1,000
Raunis1-Raunis3	1,000	0,508	0,500
Raunis2-Raunis3	0,250	0,180	1,000
Rauza1-Rauza2	0,250	**0,021**	1,000
Rauza1-Rauza3	1,000	0,774	0,508
Rauza2-Rauza3	0,250	**0,006**	0,625
Strikupe1-Strikupe2	0,250	**0,013**	0,180
Strikupe1-Strikupe3	0,250	**0,003**	0,180
Strikupe2-Strikupe3	1,000	0,754	1,000
Amula1-Amula2	0,250	**0,021**	1,000
Amula1-Amula3	0,250	0,227	0,727
Amula2-Amula3	0,500	0,065	1,000
Koja1-Koja3	1,000	0,791	0,688
Riezupe1-Riezupe2	1,000	0,388	0,625
Riezupe1-Riezupe3	1,000	1,000	1,000
Riezupe2-Riezupe3	1,000	0,791	1,000

Stream name			
Arona-Mergupe	0,250	0,180	1,000
Mergupe-Pededze	0,500	0,791	0,727
Arona-Pededze	0,250	0,146	0,688
Raunis-Rauza	0,250	**0,000**	0,508
Rauza-Strikupe	1,000	0,607	1,000
Raunis-Strikupe	1,000	0,118	0,180
Koja-Amula	1,000	1,000	1,000
Riezupe-Koja	1,000	0,607	**0,031**
Amula-Riezupe	0,250	**0,003**	0,508

River basin			
Daugava-Gauja	1,000	1,000	0,180
Gauja-Venta	1,000	1,000	0,508
Daugava-Venta	1,000	1,000	0,508

ANNEX X
Correlation coefficients with of environmental parameters and fish metrics ordination axis of main matrix for the Daugava basin

Environmental parameters and fish metrics	Pearson coefficient		
	First axis	Second axis	Third axis
HQA score	-0.507	0.271	0.745
HMS score	0.6	-0.086	-0.522
catchment’s area	-0.655	-0.736	0.143
Altitude	0.767	0.401	-0.247
Gradient slope	0.401	0.377	0.713
Distance source	-0.778	-0.567	0.226
Forest	-0.048	0.485	0.029
Agricultural land	0.056	-0.501	-0.172
width	-0.568	-0.427	0.406
depth	-0.909	-0.279	-0.099
Max depth	-0.723	-0.353	-0.472
discharge	-0.904	-0.294	-0.104
velocity	-0.659	0.578	0.326
megalithal	0.058	0.23	0.806
macrolithal	0.017	-0.735	0.614
mesolithal	0.873	-0.22	0.065
microlit	0.235	0.255	-0.241
akal	0.111	0.355	-0.505
psammal	-0.762	0.199	-0.27
macalgae	0.524	-0.384	0.618
Sub.macroph.	0.743	0.302	0.153
xylal	-0.86	-0.353	-0.103
CPOM	0.459	0.252	-0.7
FPOM	0.312	-0.832	0.335
pH value	0.419	-0.87	-0.112
conductivity	-0.566	0.287	0.208
oxygen	-0.411	-0.294	-0.409
oxygen saturation	0.472	-0.842	-0.161
alkalinity	0.469	-0.828	-0.12
hardness	0.664	-0.459	-0.319
chloride	0.247	0.513	0.383
ammonium	-0.285	0.435	-0.169
nitrite	-0.652	0.53	-0.287
nitrate	-0.311	0.014	-0.86
phosphate	0.591	0.214	0.193
Tot-P	0.179	-0.004	-0.517
Nspall	-0.605	-0.199	-0.394
Biomsp	-0.29	0.736	0.193
Denssp	-0.395	-0.191	-0.195
EFI	-0.442	0.005	0.234

ANNEX XI
Correlation coefficients of environmental parameters and fish metrics with ordination axis of main matrix for the Gauja basin

Environmental parameters and fish metrics	Pearson coefficient		
	First axis	Second axis	Third axis
HQA score	-0.865	0.054	0.02
HMS score	-0.385	0.365	0.765
catchment's area	0.281	0.039	0.783
Altitude	-0.473	-0.805	0.033
Gradient slope	-0.673	0.515	-0.22
Distance source	-0.072	0.281	0.869
Forest	0.811	-0.226	0.477
Agricultural land	-0.82	0.253	-0.458
width	0.317	-0.649	0.332
depth	0.902	0.152	0.095
Max depth	0.83	-0.111	-0.047
discharge	0.849	0.491	-0.098
velocity	0.58	0.464	-0.208
megalithal	-0.091	0.2	-0.364
macrolithal	-0.542	-0.747	0.104
mesolithal	-0.565	-0.51	0.399
microlit	-0.717	-0.057	0.156
akal	-0.814	0.138	-0.031
psammal	0.86	0.409	-0.224
macalgae	0.732	0.225	-0.46
Sub.macroph.	0.061	-0.702	0.365
xylal	-0.71	0.148	-0.373
CPOM	0.099	0.464	-0.404
FPOM	-0.427	0.512	0.125
pH value	-0.431	0.82	0.208
conductivity	0.044	0.861	0.389
oxygen	0.187	0.852	0.335
oxygen saturation	-0.434	0.793	0.231
alkalinity	-0.5	0.817	0.218
hardness	-0.55	-0.04	-0.302
chloride	0.88	0.243	-0.106
ammonium	-0.534	-0.653	0.126
nitrite	0.332	-0.362	0.061
nitrate	0.075	-0.585	-0.426
phosphate	-0.407	0.353	-0.292
Tot-P	-0.598	0.236	-0.148
Nspall	0.58	-0.141	-0.041
Biomsp	-0.337	-0.485	-0.483
Denssp	-0.35	-0.778	-0.236
EFI	-0.09	0.175	0.235

ANNEX XII
Correlation coefficients of environmental parameters and fish metrics with ordination axis of main matrix for the Venta basin

Environmental variables and fish metrics	Pearson coefficient		
	First axis	Second axis	Third axis
HQA score	-0.639	0.212	0.645
HMS score	-0.871	0.094	0.154
catchment's area	-0.723	-0.607	0.126
Altitude	0.3	0.921	-0.106
Gradient slope	-0.787	0.397	0.259
Distance source	-0.782	-0.607	-0.001
Forest	0.304	-0.323	-0.269
Agricultural land	-0.352	0.398	0.307
width	-0.789	-0.539	-0.095
depth	0.692	0.01	0.401
Max depth	0.379	0.441	0.501
discharge	-0.286	-0.755	0.101
velocity	0.382	-0.11	0.672
megalithal	-0.713	-0.269	0.315
macrolithal	-0.873	0.159	0.075
mesolithal	0.214	-0.169	0.718
microlit	0.288	0.101	0.703
akal	0.56	0.132	-0.716
psammal	-0.659	-0.308	0.334
macalgae	-0.585	-0.49	-0.321
Sub.macroph.	-0.716	0.275	-0.527
xylal	0.112	0.219	-0.742
CPOM	0.55	0.342	0.024
FPOM	-0.889	0.32	0.075
pH value	-0.802	-0.172	-0.01
conductivity	0.253	-0.771	0.367
oxygen	0.095	-0.907	0.222
oxygen saturation	-0.875	0.264	-0.152
alkalinity	-0.837	-0.082	-0.133
hardness	-0.485	0.8	0.153
chloride	0.176	-0.536	-0.547
ammonium	0.053	-0.774	-0.116
nitrite	0.406	-0.333	0.49
nitrate	0.539	-0.767	0.251
phosphate	0.403	-0.511	-0.607
Tot-P	-0.297	-0.163	-0.462
Nspall	-0.475	-0.388	0.059
Biomsp	0.126	-0.776	-0.407
Denssp	0.628	0.102	0.495
EFI	0.202	-0.678	0.11

ANNEX XIII
Sign Test statistics (Exact Sig. (2-tailed) for macroinvertebrate metrics of replicate samples*

Compared replicates of streams	EPT-metrics	Diversity indices		Diversity metrics	Taxonomic group (abundance)	Taxonomic group (number of taxa)	Taxonomic group (%)
VENTA BASIN							
Amula 3							
Amula R1 - Amula R2	,754(a)	,250(a)	1(a)	1,000(a)	,344(a)	1,000(a)	,804(a)
Amula R1 - Amula R3	,065(a)	,625(a)	0,5(a)	,625(a)	1,000(a)	1,000(a)	,815(a)
Amula R2 - Amula R3	,109(a)	,625(a)	1(a)	,625(a)	,774(a)	,804(a)	,481(a)
Koja 3							
Koja R1 – Koja R2	**,012(a)**	,625(a)	0,5(a)	,625(a)	1,000(a)	,454(a)	,143(a)
Koja R1 – Koja R3	**,021(a)**	,250(a)	0,5(a)	,625(a)	,344(a)	,057(a)	,629(a)
Koja R2 - Koja R3	,227(a)	1,000(a)	1(a)	,625(a)	,581(a)	**,022(a)**	,815(a)
Riezupe 3							
Riezupe R1 - Riezupe R2	,109(a)	1,000(a)	0,5(a)	,625(a)	1,000(a)	,344(a)	,629(a)
Riezupe R1 - Riezupe R3	**,012(a)**	,250(a)	0,5(a)	,625(a)	,774(a)	,092(a)	,049(a)
Riezupe R2 - Riezupe R3	,549(a)	,125(a)	1(a)	1,000(a)	,549(a)	,065(a)	1,000(a)
DAUGAVA BASIN							
Arona 3			0,5(a)				
Arona R1 - Arona R2	,227(a)	1,000(a)	0,5(a)	1,000(a)	,549(a)	,581(a)	,167(a)
Arona R1 - Arona R3	1,000(a)	,625(a)	1(a)	,625(a)	,581(a)	,388(a)	,481(a)
Arona R2 - Arona R3	1,000(a)	,125(a)		,625(a)	1,000(a)	,057(a)	,359(a)
Mergupe 3			0,5(a)				
Mergupe R1 - Mergupe R2	,344(a)	,125(a)	0,5(a)	,125(a)	,146(a)	,302(a)	,238(a)
Mergupe R1 – Mergupe R3	1,000(a)	1,000(a)	0,5(a)	,625(a)	,057(a)	,167(a)	,648(a)
Mergupe R2 - Mergupe R3	1,000(a)	,250(a)		1,000(a)	,791(a)	,629(a)	,648(a)
Pededze 3			1(a)				
Pededze R1 - Pededze R2	1,000(a)	,625(a)	0,5(a)	,625(a)	1,000(a)	**,035(a)**	,359(a)
Pededze R1 - Pededze R3	,344(a)	,125(a)	1(a)	,625(a)	,549(a)	,791(a)	**,021(a)**
Pededze R2 - Pededze R3	**,012(a)**	,125(a)	1(a)	,625(a)	,581(a)	**,013(a)**	,238(a)

* Significant differences marked in bold

Continued

GAUJA BASIN							
Raunis 3							
Raunis R1 - Raunis R2	,065(a)	,125(a)	1(a)	1,000(a)	1,000(a)	,267(a)	,057(a)
Raunis R1 - Raunis R3	1,000(a)	,125(a)	1(a)	1,000(a)	1,000(a)	,754(a)	,057(a)
Raunis R2 - Raunis R3	,549(a)	,250(a)	1(a)	,625(a)	1,000(a)	,424(a)	,302(a)
Rauza 3							
Rauza R1 - Rauza R2	,549(a)	,250(a)	0,5(a)	,625(a)	,774(a)	1,000(a)	,629(a)
Rauza R1 - Rauza R3	,227(a)	,250(a)	0,5(a)	,625(a)	1,000(a)	,267(a)	,359(a)
Rauza R2 - Rauza R3	,289(a)	,250(a)	0,5(a)	,625(a)	,607(a)	1,000(a)	,503(a)
Strikupe 3							
Strikupe R1 - Strikupe R2	,065(a)	1,000(a)	0,5(a)	1,000(a)	,388(a)	,629(a)	,332(a)
Strikupe R1 - Strikupe R3	,754(a)	,625(a)	1(a)	,125(a)	,092(a)	,774(a)	,815(a)
Strikupe R2 - Strikupe R3	,065(a)	1,000(a)	0,5(a)	1,000(a)	1,000(a)	1,000(a)	1,000(a)

* Significant differences marked in bold

ANNEX XIV
Sign Test statistics (Exact Sig. (2-tailed) for macroinvertebrate metrics of stream reaches*

Reach	Eutrophication metrics	Diversity indices	Diversity metrics	EPT-Taxa	Taxonomic group (%)	Taxonomic group (number of taxa)	Taxonomic group (abundance)
VENTA BASIN							
AMULA 1 - AMULA 2	0,5(a)	0,125	0,125	**0,021**	0,302	0,092	**0,035**
AMULA 1 - AMULA 3	1(a)	0,125	0,125	**0,012**	0,791	0,180	0,791
AMULA 2 - AMULA 3	1(a)	0,625	0,625	**0,012**	0,607	0,607	0,791
KOJA 1 - KOJA 3	1(a)	0,625	0,625	0,065	0,791	0,180	0,424
RIEZUPE 1 - RIEZUPE 2	1(a)	0,125	0,625	**0,012**	0,791	1,000	0,424
RIEZUPE 1 - RIEZUPE 3	1(a)	0,125	0,125	0,065	0,791	0,549	0,791
RIEZUPE 2 - RIEZUPE 3	0,5(a)	0,125	0,125	1,000	1,000	0,774	0,581
DAUGAVA BASIN							
ARONA 1 - ARONA 2	1(a)	1	0,125	1,000	0,581	0,180	0,146
ARONA 1 - ARONA 3	*	0,625	0,625	0,344	0,791	0,227	1,000
ARONA 2 - ARONA 3	0,5(a)	0,625	0,125	0,549	0,302	0,180	0,180
MERGUPE 1 - MERGUPE 2	1(a)	0,625	0,625	**0,012**	0,549	0,727	0,549
MERGUPE 1 - MERGUPE 3	0,5(a)	0,125	0,125	0,227	0,118	0,118	**0,035**
MERGUPE 2 - MERGUPE 3	0,5(a)	0,625	0,625	1,000	0,607	**0,013**	0,607
PEDEDZE 1 - PEDEDZE 2	1(a)	0,125	1	**0,012**	0,424	1,000	0,424
PEDEDZE 1 - PEDEDZE 3	0,5(a)	1	1	**0,001**	0,607	0,791	1,000
PEDEDZE 2 - PEDEDZE 3	1(a)	0,625	0,625	0,549	0,607	0,424	1,000
GAUJA BASIN							
RAUNIS 1 - RAUNIS 2	1(a)	1	1	1,000	1,000	1,000	1,000
RAUNIS 1 - RAUNIS 3	1(a)	0,125	0,625	0,065	0,754	1,000	0,344
RAUNIS 2 - RAUNIS 3	0,5(a)	0,625	0,625	0,065	1,000	1,000	0,227
RAUZA 1 - RAUZA 2	1(a)	0,125	0,625	0,227	1,000	0,754	1,000
RAUZA 1 - RAUZA 3	1(a)	1	0,125	0,065	0,210	0,057	0,210
RAUZA 2 - RAUZA 3	1(a)	0,25	0,625	0,227	0,210	0,791	0,454
STRIKUPE 1 - STRIKUPE 2	1(a)	0,125	0,625	**0,001**	1,000	0,754	1,000
STRIKUPE 1 - STRIKUPE 3	0,5(a)	1	0,625	0,549	0,804	0,424	0,454
STRIKUPE 2 - STRIKUPE 3	1(a)	0,125	0,125	**0,012**	1,000	0,180	1,000

Significant differences marked in bold

ANNEX XV
Sign Test statistics (Exact Sig. (2-tailed) for macroinvertebrate metrics of streams of the Daugava, the Gauja and the Venta basins *

RIVER REACHES COMPARED	Metrics						
	Eutrophication metrics	**Diversity indices**	**Diversity metrics**	**Taxonomic group (%)**	**Taxonomic group (number of taxa)**	**Taxonomic group (abundance)**	**EPT-Taxa**
VENTA BASIN							
KOJA - AMULA	1(a)	0,125	0,125	0,424	0,607	1,000	**0,012**
RIEZUPE - AMULA	1(a)	0,625	0,625	0,804	1,000	0,454	**0,012**
RIEZUPE - KOJA	1(a)	0,625	0,625	0,804	0,302	1,000	**0,012**
DAUGAVA BASIN							
MERGUPE - ARONA	0,5(a)	0,625	0,625	0,454	0,210	0,607	**0,012**
PEDEDZE - ARONA	1(a)	0,125	0,625	0,804	1,000	0,454	0,549
PEDEDZE - MERGUPE	0,5(a)	0,625	0,625	0,607	0,302	1,000	**0,012**
GAUJA BASIN							
RAUZA - RAUNIS	0,5(a)	0,125	0,125	0,049	0,077	0,049	1,000
STRIKUPE - RAUNIS	1(a)	1,000	0,625	0,607	0,077	**0,021**	0,065
STRIKUPE - RAUZA	0,5(a)	0,625	1,000	0,481	0,607	0,815	0,227

* Significant differences marked in bold

ANNEX XVI
Sign Test statistics (Exact Sig. (2-tailed) for macroinvertebrate metrics of the Daugava, the Gauja and the Venta basins*

Metrics	RIVER BASINS COMPARED		
	DAUGAVA - VENTA	**GAUJA - VENTA**	**GAUJA - DAUGAVA**
Eutrophication metrics	1	1	1
Diversity indices	0,125	0,250	0,125
Diversity metrics	0,625	0,625	0,125
Taxonomic group (%)	1,000	0,629	0,804
Taxonomic group (number of taxa)	1,000	0,815	1,000
Taxonomic group (abundance)	0,804	0,815	0,481
EPT-Taxa	**0,012**	**0,012**	0,754

* Significant differences marked in bold

ANNEX XVII
Pearson's correlations with ordination axes of main data matrix for environmental variables of the Daugava basin streams ($r_{0.05;9}$=0.666)*

Metric	Axis 1	Axis 2
HQA score	-0,095	**-0,731**
HMS score	0,514	0,143
Size of catchment	**-0,666**	0,624
Altitude	**0,689**	-0,41
Gradient of slope	**0,646**	-0,489
Distance from source	**-0,669**	0,527
Forest %	-0,04	-0,443
Agricultural land %	0,051	0,438
Average stream width (m)	-0,573	0,111
Mean depth of water body (m)	**-0,906**	0,258
Maximum depth of water body (m)	**-0,851**	0,22
Estimated discharge (l/s)	**-0,908**	0,043
Mean current velocity (m/s)	-0,464	**-0,782**
Megalithal >40cm	0,243	-0,427
Macrolithal >20cm to 40cm	0,2	-0,038
Mesolithal >6cm to 20cm	**0,808**	0,049
Microlithal >2cm to 6cm	0,316	-0,296
Akal >0.2cm to 2cm	-0,186	0,131
Psammal/psammopelal	-0,647	0,106
Macro-algae	0,283	0,354
Submerged macrophytes	0,538	0,386
Xylal	**0,79**	-0,113
CPOM	**-0,772**	-0,059
FPOM	0,172	0,341
pH-value	0,202	**0,81**
Conductivity (µS/cm)	0,228	**0,92**
Dissolved oxygen content (mg/l)	-0,23	-0,561
Oxygen saturation (%)	-0,225	0,006
Alkalinity (mmol/l)	0,263	**0,929**
Total hardness (mmol/l)	0,269	**0,903**
Chloride (mg/l)	0,222	**0,831**
BOD5 (mg/l)	0,453	-0,569
Ammonium (mg/l)	-0,347	-0,371
Nitrite (mg/l)	-0,442	**-0,67**
Nitrate (mg/l)	-0,453	-0,026
Ortho-phosphate (µg/l)	0,528	-0,126
Total phosphate (µg/l)	-0,059	0,076

* Significant correlations marked in bold

ANNEX XVIII
Pearson's correlations with ordination axes of second data matrix for macroinvertebrate metrics of the Daugava basin streams ($r_{0.05;9}$=0.666)*

Metric	Axis 1	Axis 2
Saprobic Index (Zelinka & Marvan)	0,1	0,644
Biological Monitoring Working Party (BMWP)	-0,054	0,385
Diversity (Simpson-Index)	0,174	**0,721**
Diversity (Shannon-Wiener-Index)	0,092	0,623
Diversity (Margalef Index)	-0,252	0,451
DSFI Diversity Groups	0,198	-0,382
Number of Families	-0,133	0,313
Number of Genera	-0,267	0,479
Evenness	0,121	0,613
Abundance (ind/m²)	0,352	-0,224
- Nematoda (%)	-0,107	0,548
- Gastropoda (%)	-0,379	-0,232
- Bivalvia (%)	-0,33	0,293
- Oligochaeta (%)	-0,279	-0,352
- Hirudinea (%)	-0,045	-0,139
- Crustacea (%)	0,044	-0,246
- Ephemeroptera (%)	0,297	**0,754**
- Odonata (%)	-0,433	0,262
- Plecoptera (%)	0,199	-0,123
- Heteroptera (%)	-0,079	-0,172
- Megaloptera (%)	0,557	0,312
- Trichoptera (%)	-0,38	0,107
- Lepidoptera (%)	-0,314	-0,252
- Coleoptera (%)	0,292	0,345
- Diptera (%)	-0,182	**-0,685**
- Hydrachnidia (%)	0,153	-0,183
- Nematoda (Number of Taxa)	-0,107	0,548
- Gastropoda (Number of Taxa)	-0,068	-0,097
- Bivalvia (Number of Taxa)	-0,29	-0,347
- Oligochaeta (Number of Taxa)	-0,378	-0,378
- Hirudinea (Number of Taxa)	-0,031	0,27
- Crustacea (Number of Taxa)	-0,138	0,038
- Ephemeroptera (Number of Taxa)	-0,133	0,634
- Odonata (Number of Taxa)	-0,546	0,257
- Plecoptera (Number of Taxa)	-0,134	-0,183
- Heteroptera (Number of Taxa)	-0,088	0,579
- Megaloptera (Number of Taxa)	0,49	0,391
- Trichoptera (Number of Taxa)	-0,132	0,19
- Lepidoptera (Number of Taxa)	-0,279	-0,239
- Coleoptera (Number of Taxa)	0,117	0,638
- Diptera (Number of Taxa)	-0,125	0,103
- Hydrachnidia (Number of Taxa)	0,602	-0,102
- Nematoda (Abundance)	-0,107	0,548
- Gastropoda (Abundance)	-0,145	-0,282

* Significant correlations marked in bold

Continued

Metric	**Axis 1**	**Axis 2**
- Bivalvia (Abundance)	-0,191	0,352
- Oligochaeta (Abundance)	-0,212	-0,314
- Hirudinea (Abundance)	-0,135	-0,009
- Crustacea (Abundance)	-0,026	-0,227
- Ephemeroptera	0,463	**0,82**
- Odonata (Abundance)	-0,381	0,472
- Plecoptera (Abundance)	0,322	-0,152
- Heteroptera (Abundance)	-0,301	0,023
- Megaloptera (Abundance)	0,636	0,08
- Trichoptera (Abundance)	-0,249	-0,055
- Lepidoptera (Abundance)	-0,4	-0,227
- Coleoptera (Abundance)	0,556	0,296
- Diptera (Abundance)	0,094	-0,583
- Hydrachnidia (Abundance)	0,363	-0,057
- EPT-Taxa (%)	0,193	**0,758**
- EPT/OL (%)	0,186	0,403
- EP (%)	0,323	**0,766**
- EPind/Totind (%)	0,323	**0,766**
- EPT (%) (abundance classes)	-0,07	0,655
- EPT-Taxa	-0,178	0,48
- EPT/OL	-0,005	0,395
- EPT/Diptera	-0,078	0,293
- OD/Total-Taxa	-0,053	-0,525
- EP-Taxa	-0,179	0,591
- EPTCOB (Eph., Ple., Tri., Col., Odo., Bivalv.)	-0,161	0,514

* Significant correlations marked in bold

ANNEX XIX
Pearson's correlations with ordination axes of main data matrix for environmental variables of the Gauja basin streams ($r_{0.05;9}$=0.666)*

Metric	Axis 1	Axis 2
HQA score	**0,82**	0,271
HMS score	0,199	0,577
Size of catchment	-0,332	0,059
Altitude	**0,691**	-0,615
Gradient of slope	0,467	**0,69**
Distance from source	-0,03	0,372
Forest %	**-0,77**	-0,263
Agricultural land %	**0,773**	0,273
Average stream width (m)	-0,295	-0,353
Mean depth of water body (m)	**-0,847**	-0,19
Maximum depth of water body (m)	-0,366	-0,52
Estimated discharge (l/s)	**-0,944**	0,232
Mean current velocity (m/s)	**-0,687**	0,281
Megalithal >40cm	-0,042	0,274
Macrolithal >20cm to 40cm	0,42	-0,241
Mesolithal >6cm to 20cm	0,639	-0,218
Microlithal >2cm to 6cm	0,664	0,222
Akal >0.2cm to 2cm	0,694	0,005
Psammal/psammopelal	**-0,925**	0,1
Submerged macrophytes	**-0,777**	-0,013
Xylal	0,181	**-0,704**
CPOM	0,591	-0,135
FPOM	-0,275	0,443
pH-value	0,19	**0,72**
Conductivity (µS/cm)	0,144	**0,928**
Dissolved oxygen content (mg/l)	-0,333	**0,844**
Oxygen saturation (%)	-0,45	**0,784**
Alkalinity (mmol/l)	0,161	**0,909**
Total hardness (mmol/l)	0,233	**0,94**
Chloride (mg/l)	0,539	0,064
BOD5 (mg/l)	**-0,89**	-0,059
Ammonium (mg/l)	**0,701**	-0,45
Nitrite (mg/l)	-0,215	-0,4
Nitrate (mg/l)	0,259	-0,628
Ortho-phosphate (µg/l)	0,117	0,525
Total phosphate (µg/l)	0,593	0,162

* Significant correlations marked in bold

ANNEX XX
Pearson's correlations with ordination axes of second data matrix for macroinvertebrate metrics of the Gauja basin streams ($r_{0.05;9}$=0.666)*

Metric	Axis 1	Axis 2
Saprobic Index (Zelinka & Marvan)	0,451	-0,402
Biological Monitoring Working Party (BMWP)	0,224	-0,461
Diversity (Simpson-Index)	0,123	-0,281
Diversity (Shannon-Wiener-Index)	0,08	-0,236
Diversity (Margalef Index)	0,012	-0,345
DSFI Diversity Groups	-0,423	-0,518
Number of Families	-0,143	-0,291
Number of Genera	-0,099	-0,367
Evenness	0,109	-0,192
Abundance (ind/m²)	-0,109	0,187
- Turbellaria (%)	**-0,716**	0,123
- Nematoda (%)	0,309	-0,326
- Nematomorpha (%)	-0,081	-0,14
- Gastropoda (%)	0,033	-0,243
- Bivalvia (%)	0,256	-0,597
- Oligochaeta (%)	0,27	-0,279
- Hirudinea (%)	0,245	-0,341
- Crustacea (%)	-0,466	-0,153
- Ephemeroptera (%)	-0,07	-0,347
- Odonata (%)	-0,492	-0,101
- Plecoptera (%)	0,536	0,643
- Heteroptera (%)	-0,09	-0,088
- Megaloptera (%)	0,185	-0,488
- Trichoptera (%)	0,391	0,321
- Lepidoptera (%)	0,225	0,387
- Coleoptera (%)	-0,022	-0,181
- Diptera (%)	-0,234	0,366
- Hydrachnidia (%)	-0,6	0,039
- Turbellaria (Number of Taxa)	**-0,716**	0,123
- Nematoda (Number of Taxa)	0,309	-0,326
- Nematomorpha (Number of Taxa)	-0,081	-0,14
- Gastropoda (Number of Taxa)	-0,068	-0,173
- Bivalvia (Number of Taxa)	0,169	**-0,806**
- Oligochaeta (Number of Taxa)	-0,353	**-0,759**
- Hirudinea (Number of Taxa)	0,126	-0,346
- Crustacea (Number of Taxa)	-0,538	-0,404
- Ephemeroptera (Number of Taxa)	-0,212	-0,602
- Odonata (Number of Taxa)	**-0,787**	-0,086
- Plecoptera (Number of Taxa)	-0,115	**0,668**
- Heteroptera (Number of Taxa)	0,141	-0,191
- Megaloptera (Number of Taxa)	0,046	-0,454
- Trichoptera (Number of Taxa)	0,322	-0,027
- Lepidoptera (Number of Taxa)	0,125	0,406
- Coleoptera (Number of Taxa)	0,562	-0,365
- Diptera (Number of Taxa)	-0,539	**0,773**

* Significant correlations marked in bold

Continued

Metric	**Axis 1**	**Axis 2**
- Hydrachnidia (Number of Taxa)	**-0,704**	0,274
- Turbellaria (Abundance)	**-0,716**	0,123
- Nematoda (Abundance)	0,309	-0,326
- Nematomorpha (Abundance)	-0,081	-0,14
- Gastropoda (Abundance)	0,011	-0,193
- Bivalvia (Abundance)	0,119	-0,546
- Oligochaeta (Abundance)	0,207	-0,207
- Hirudinea (Abundance)	0,252	-0,338
- Crustacea (Abundance)	-0,337	-0,111
- Ephemeroptera (Abundance)	-0,193	-0,313
- Odonata (Abundance)	-0,402	-0,082
- Plecoptera (Abundance)	0,448	**0,667**
- Heteroptera (Abundance)	-0,09	-0,087
- Megaloptera (Abundance)	0,149	-0,48
- Trichoptera (Abundance)	0,283	0,475
- Lepidoptera (Abundance)	0,09	0,327
- Coleoptera (Abundance)	-0,125	-0,199
- Diptera (Abundance)	-0,095	0,311
- Hydrachnidia (Abundance)	-0,563	0,046
- EPT-Taxa (%)	0,142	-0,116
- EPT/OL (%)	0	-0,172
- EP (%)	-0,029	-0,307
- EPind/Totind (%)	-0,029	-0,307
- EPT (%) (abundance classes)	0,542	0,21
- EPT-Taxa	0,19	-0,158
- EPT/OL	0,457	**0,716**
- EPT/Diptera	0,549	**-0,761**
- OD/Total-Taxa	-0,65	0,588
- EP-Taxa	-0,247	-0,35
- EPTCOB (Eph., Ple., Tri., Col., Odo., Bivalv.)	0,298	-0,372

* Significant correlations marked in bold

ANNEX XXI
Pearson's correlations with ordination axes of main data matrix for environmental variables of the Venta basin streams ($r_{0.05;8}$=0.707)*

Metric	Axis 1	Axis 2
HQA score	-0,372	0,589
HMS score	-0,679	0,553
Size of catchment	-0,044	**0,882**
Altitude	-0,405	**-0,756**
Gradient of slope	-0,422	0,652
Distance from source	-0,075	**0,903**
Forest %	0,134	-0,28
Agricultural land %	-0,233	0,271
Average stream width (m)	-0,137	**0,863**
Mean depth of water body (m)	0,589	-0,351
Maximum depth of water body (m)	0,341	-0,16
Estimated discharge (l/s)	0,363	0,706
Mean current velocity (m/s)	0,606	0,13
Macrolithal >20cm to 40cm	-0,191	**0,819**
Mesolithal >6cm to 20cm	-0,539	0,662
Microlithal >2cm to 6cm	0,513	0,293
Akal >0.2cm to 2cm	0,537	0,207
Psammal/psammopelal	-0,075	**-0,851**
Macro-algae	-0,139	**0,802**
Submerged macrophytes	-0,668	-0,191
Xylal	**-0,924**	-0,125
CPOM	-0,146	-0,381
FPOM	0,462	-0,343
pH-value	-0,672	0,571
Conductivity (µS/cm)	**-0,753**	0,122
Dissolved oxygen content (mg/l)	**0,782**	0,499
Oxygen saturation (%)	0,692	0,559
Alkalinity (mmol/l)	**-0,926**	-0,019
Total hardness (mmol/l)	**-0,813**	0,142
Chloride (mg/l)	-0,565	0,113
BOD5 (mg/l)	0,2	-0,141
Ammonium (mg/l)	0,446	0,332
Nitrite (mg/l)	**0,712**	0,197
Nitrate (mg/l)	**0,891**	0,247
Ortho-phosphate (µg/l)	-0,289	-0,595
Total phosphate (µg/l)	-0,611	-0,297

* Significant correlations marked in bold

ANNEX XXII

Pearson's correlations with ordination axes of second data matrix for macroinvertebrate metrics of Venta basin streams ($r_{0.05;8}$=0.707)*

Metric	Axis 1	Axis 2
Saprobic Index (Zelinka & Marvan)	0,062	-0,595
Biological Monitoring Working Party (BMWP)	-0,056	**0,897**
Diversity (Simpson-Index)	0,14	0,548
Diversity (Shannon-Wiener-Index)	0,065	**0,818**
Diversity (Margalef Index)	0,009	**0,928**
DSFI Diversity Groups	-0,313	0,308
Number of Families	-0,066	**0,753**
Number of Genera	-0,058	**0,861**
Evenness	0,107	0,642
Abundance (ind/m²)	-0,144	-0,294
- Nematoda (%)	-0,475	-0,546
- Gastropoda (%)	0,205	0,487
- Bivalvia (%)	0,33	-0,381
- Oligochaeta (%)	0,198	-0,373
- Hirudinea (%)	0,314	-0,25
- Crustacea (%)	-0,049	-0,558
- Ephemeroptera (%)	0,144	0,672
- Odonata (%)	0,369	0,469
- Plecoptera (%)	0,379	-0,175
- Heteroptera (%)	-0,157	-0,521
- Megaloptera (%)	0,238	-0,067
- Trichoptera (%)	0,207	**0,932**
- Lepidoptera (%)	0,147	-0,286
- Coleoptera (%)	-0,111	**0,848**
- Diptera (%)	-0,378	-0,273
- Hydrachnidia (%)	-0,535	0,659
- Nematoda (Number of Taxa)	-0,349	-0,531
- Gastropoda (Number of Taxa)	0,295	**0,752**
- Bivalvia (Number of Taxa)	0,018	-0,014
- Oligochaeta (Number of Taxa)	0,241	0,02
- Hirudinea (Number of Taxa)	0,06	0,012
- Crustacea (Number of Taxa)	-0,373	-0,524
- Ephemeroptera (Number of Taxa)	-0,296	**0,716**
- Odonata (Number of Taxa)	0,38	0,346
- Plecoptera (Number of Taxa)	0,036	0,595
- Heteroptera (Number of Taxa)	0,085	-0,17
- Megaloptera (Number of Taxa)	-0,009	-0,137
- Trichoptera (Number of Taxa)	0,04	**0,933**
- Lepidoptera (Number of Taxa)	0,029	-0,322
- Coleoptera (Number of Taxa)	-0,004	**0,841**
- Diptera (Number of Taxa)	-0,054	0,374
- Hydrachnidia (Number of Taxa)	-0,328	-0,125
- Nematoda (Abundance)	-0,349	-0,531
- Gastropoda (Abundance)	0,187	0,619
- Bivalvia (Abundance)	0,158	-0,427

* Significant correlations marked in bold

Continued

Metric	Axis 1	Axis 2
- Oligochaeta (Abundance)	0,116	-0,509
- Hirudinea (Abundance)	0,277	-0,27
- Crustacea (Abundance)	-0,137	-0,409
- Ephemeroptera (Abundance)	-0,034	0,48
- Odonata (Abundance)	0,384	0,5
- Plecoptera (Abundance)	0,383	-0,237
- Heteroptera (Abundance)	-0,297	-0,627
- Megaloptera (Abundance)	0,085	-0,22
- Trichoptera (Abundance)	0,131	0,64
- Lepidoptera (Abundance)	-0,016	-0,319
- Coleoptera (Abundance)	-0,168	**0,826**
- Diptera (Abundance)	-0,194	-0,314
- Hydrachnidia (Abundance)	-0,546	0,646
- EPT-Taxa (%)	0,202	**0,842**
- EPT/OL (%)	0,319	0,582
- EP (%)	0,171	0,675
- EPind/Totind (%)	0,171	0,675
- EPT (%) (abundance classes)	-0,046	**0,82**
- EPT-Taxa	-0,079	**0,893**
- EPT/OL	-0,316	**0,777**
- EPT/Diptera	0,033	0,601
- OD/Total-Taxa	-0,058	-0,598
- EP-Taxa	-0,245	**0,757**
- EPTCOB (Eph., Ple., Tri., Col., Odo., Bivalv.)	-0,04	**0,93**

* Significant correlations marked in bold

ANNEX XXIII
Pearson's correlations with ordination axes of main data matrix for environmental variables of the Daugava basin streams ($r_{0.05;9}$=0.666)*

Metric	Axis 1	Axis 2
HQA score	-0,095	**-0,731**
HMS score	0,514	0,143
Size of catchment	**-0,666**	0,624
Altitude	**0,689**	-0,41
Gradient of slope	0,646	-0,489
Distance from source	**-0,669**	0,527
Forest %	-0,04	-0,443
Agricultural land %	0,051	0,438
Average stream width (m)	-0,573	0,111
Mean depth of water body (m)	**-0,906**	0,258
Maximum depth of water body (m)	**-0,851**	0,22
Estimated discharge (l/s)	**-0,908**	0,043
Mean current velocity (m/s)	-0,464	**-0,782**
Megalithal >40cm	0,243	-0,427
Macrolithal >20cm to 40cm	0,2	-0,038
Mesolithal >6cm to 20cm	**0,808**	0,049
Microlithal >2cm to 6cm	0,316	-0,296
Akal >0.2cm to 2cm	-0,186	0,131
Psammal/psammopelal	-0,647	0,106
Macro-algae	0,283	0,354
Submerged macrophytes	0,538	0,386
Xylal	**0,79**	-0,113
CPOM	**-0,772**	-0,059
FPOM	0,172	0,341
pH-value	0,202	**0,81**
Conductivity (µS/cm)	0,228	**0,92**
Dissolved oxygen content (mg/l)	-0,23	-0,561
Oxygen saturation (%)	-0,225	0,006
Alkalinity (mmol/l)	0,263	**0,929**
Total hardness (mmol/l)	0,269	**0,903**
Chloride (mg/l)	0,222	**0,831**
BOD5 (mg/l)	0,453	-0,569
Ammonium (mg/l)	-0,347	-0,371
Nitrite (mg/l)	-0,442	-0,67
Nitrate (mg/l)	-0,453	-0,026
Ortho-phosphate (µg/l)	0,528	-0,126
Total phosphate (µg/l)	-0,059	0,076

* Significant correlations marked in bold

ANNEX XXIV
Pearson's correlations with ordination axes of second data matrix for EPT-Taxa metrics of the Daugava basin streams ($r_{0.05;9}$=0.666)*

Metric	**Axis 1**	**Axis 2**
EPT-Taxa (%)	0,193	**0,758**
EPT/OL (%)	0,186	0,403
EP (%)	0,323	**0,766**
EPind/Totind (%)	0,323	**0,766**
EPT (%) (abundance classes)	-0,07	0,655
EPT-Taxa	-0,178	0,48
EPT/OL	-0,005	0,395
EPT/Diptera	-0,078	0,293
OD/Total-Taxa	-0,053	-0,525
EP-Taxa	-0,179	0,591
EPTCOB (Eph., Ple., Tri., Col., Odo., Bivalv.)	-0,161	0,514

* Significant correlations marked in bold

ANNEX XXV

Pearson's correlations with ordination axes of main data matrix for environmental variables of the Gauja basin streams ($r_{0.05;9}$=0.666)*

Metric	Axis 1	Axis 2
HQA score	**0,82**	0,271
HMS score	0,199	0,577
Size of catchment	-0,332	0,059
Altitude	**0,691**	-0,615
Gradient of slope	0,467	**0,69**
Distance from source	-0,03	0,372
Forest %	**-0,77**	-0,263
Agricultural land %	**0,773**	0,273
Average stream width (m)	-0,295	-0,353
Mean depth of water body (m)	**-0,847**	-0,19
Maximum depth of water body (m)	-0,366	-0,52
Estimated discharge (l/s)	**-0,944**	0,232
Mean current velocity (m/s)	**-0,687**	0,281
Megalithal >40cm	-0,042	0,274
Macrolithal >20cm to 40cm	0,42	-0,241
Mesolithal >6cm to 20cm	0,639	-0,218
Microlithal >2cm to 6cm	0,664	0,222
Akal >0.2cm to 2cm	**0,694**	0,005
Psammal/psammopelal	**-0,925**	0,1
Submerged macrophytes	**-0,777**	-0,013
Xylal	0,181	**-0,704**
CPOM	0,591	-0,135
FPOM	-0,275	0,443
pH-value	0,19	**0,72**
Conductivity (µS/cm)	0,144	**0,928**
Dissolved oxygen content (mg/l)	-0,333	**0,844**
Oxygen saturation (%)	-0,45	**0,784**
Alkalinity (mmol/l)	0,161	**0,909**
Total hardness (mmol/l)	0,233	**0,94**
Chloride (mg/l)	0,539	0,064
BOD5 (mg/l)	**-0,89**	-0,059
Ammonium (mg/l)	**0,701**	-0,45
Nitrite (mg/l)	-0,215	-0,4
Nitrate (mg/l)	0,259	-0,628
Ortho-phosphate (µg/l)	0,117	0,525
Total phosphate (µg/l)	0,593	0,162

* Significant correlations marked in bold

ANNEX XXVI
Pearson's correlations with ordination axes of second data matrix for EPT-Taxa metrics of Gauja basin streams ($r_{0.05;9}$=0.666)*

Metric	Axis 1	Axis 2
EPT-Taxa (%)	0,142	-0,116
EPT/OL (%)	0	-0,172
EP (%)	-0,029	-0,307
EPind/Totind (%)	-0,029	-0,307
EPT (%) (abundance classes)	0,542	0,21
EPT-Taxa	0,19	-0,158
EPT/OL	0,457	**0,716**
EPT/Diptera	0,549	**-0,761**
OD/Total-Taxa	-0,65	0,588
EP-Taxa	-0,247	-0,35
EPTCOB (Eph., Ple., Tri., Col., Odo., Bivalv.)	0,298	-0,372

* Significant correlations marked in bold

ANNEX XXVII
Pearson's correlations with ordination axes of main data matrix for environmental variables of the Venta basin streams ($r_{0.05;8}$=0.707)*

Metric	Axis 1	Axis 2
HQA score	-0,372	0,589
HMS score	-0,679	0,553
Size of catchment	-0,044	**0,882**
Altitude	-0,405	**-0,756**
Gradient of slope	-0,422	0,652
Distance from source	-0,075	**0,903**
Forest %	0,134	-0,28
Agricultural land %	-0,233	0,271
Average stream width (m)	-0,137	**0,863**
Mean depth of water body (m)	0,589	-0,351
Maximum depth of water body (m)	0,341	-0,16
Estimated discharge (l/s)	0,363	0,706
Mean current velocity (m/s)	0,606	0,13
Macrolithal >20cm to 40cm	-0,191	**0,819**
Mesolithal >6cm to 20cm	-0,539	0,662
Microlithal >2cm to 6cm	0,513	0,293
Akal >0.2cm to 2cm	0,537	0,207
Psammal/psammopelal	-0,075	**-0,851**
Macro-algae	-0,139	**0,802**
Submerged macrophytes	-0,668	-0,191
Xylal	**-0,924**	-0,125
CPOM	-0,146	-0,381
FPOM	0,462	-0,343
pH-value	-0,672	0,571
Conductivity (µS/cm)	**-0,753**	0,122
Dissolved oxygen content (mg/l)	**0,782**	0,499
Oxygen saturation (%)	0,692	0,559
Alkalinity (mmol/l)	**-0,926**	-0,019
Total hardness (mmol/l)	**-0,813**	0,142
Chloride (mg/l)	-0,565	0,113
BOD5 (mg/l)	0,2	-0,141
Ammonium (mg/l)	0,446	0,332
Nitrite (mg/l)	**0,712**	0,197
Nitrate (mg/l)	**0,891**	0,247
Ortho-phosphate (µg/l)	-0,289	-0,595
Total phosphate (µg/l)	-0,611	-0,297

* Significant correlations marked in bold

ANNEX XXVIII
Pearson's correlations with ordination axes of second data matrix for EPT-Taxa metrics of the Venta basin streams ($r_{0.05;8}$=0.707)*

Metric	Axis 1	Axis 2
EPT-Taxa (%)	0,202	**0,842**
EPT/OL (%)	0,319	0,582
EP (%)	0,171	0,675
EPind/Totind (%)	0,171	0,675
EPT (%) (abundance classes)	-0,046	**0,82**
EPT-Taxa	-0,079	**0,893**
EPT/OL	-0,316	**0,777**
EPT/Diptera	0,033	0,601
OD/Total-Taxa	-0,058	-0,598
EP-Taxa	-0,245	**0,757**
EPTCOB (Eph., Ple., Tri., Col., Odo., Bivalv.)	-0,04	**0,93**

* Significant correlations marked in bold

ANNEX XXIX
Values of DESCY, L&M, SHE, SLAD, TDI, WAT, CEE and IBD Indices

		SLAD		DESCY		L&M		SHE		WAT		TDI		CEE		IBD	
River basin	Stream name	H	S	H	S	H	S	H	S	H	S	H	S	H	S	H	S
	Arona 1	16.3	14.4	14.5	14.6	13.4	12.3	15.6	13.7	17.5	16.3	31.6	48.1	16.4	14.3	20	17.4
	Arona 2	16.6	13.8	16.4	16.3	14.4	12.6	15.9	13.7	18.7	16.3	40.7	58.8	17.2	15.3	20	15.3
	Arona 3	14.2	12	17.7	15.9	13.7	11.6	13.7	12.1	16	14.6	66.3	76.8	15.1	13.5	14.2	11.9
	Arona	**15.7**	**13.4**	**16.2**	**15.6**	**13.8**	**12.2**	**15.1**	**13.2**	**17.4**	**15.7**	**46.2**	**61.2**	**16.2**	**14.4**	**18.1**	**14.9**
	Mergupe 1	13.3	13.3	14	16.9	12.1	13.1	13.4	13.0	13.8	14.6	52.7	53.6	14.1	14.5	15.1	14.3
	Mergupe 2	15.1	13.2	16.1	17	14.8	12.9	15.9	13.4	17.5	14.8	25.9	56.9	15.1	14.5	16.4	14
	Mergupe 3	14.6	13.6	16.9	17.7	14	14.1	14.6	13.7	16.6	15	45.5	65.3	16.4	15.1	16.6	13.5
	Mergupe	**14.3**	**13.4**	**15.7**	**17.2**	**13.6**	**13.4**	**14.6**	**13.4**	**16.0**	**14.8**	**41.4**	**58.6**	**15.2**	**14.7**	**16.0**	**13.9**
	Pededze 1	13.6	12.7	15.3	15.8	12.6	12.2	13.4	12.4	16.7	14.3	48.7	52.5	15.1	13.5	16	14
	Pededze 2	12.3	11.3	14.9	15.5	11.6	11	12.4	11.5	14.8	14.4	60.4	70.8	13.5	12.6	13.7	12.7
	Pededze 3	13.6	13	15.9	17.1	12.3	12.7	14	13.4	15.7	15.3	58.6	67.4	14.9	14.7	15.5	12.6
	Pededze	**13.2**	**12.3**	**15.4**	**16.1**	**12.2**	**12.0**	**13.3**	**12.4**	**15.7**	**14.7**	**55.9**	**63.6**	**14.5**	**13.6**	**15.1**	**13.1**
Daugava		**14.0**	**12.7**	**15.6**	**16.0**	**12.7**	**12.0**	**13.9**	**12.7**	**16.3**	**15.0**	**52.7**	**62.8**	**15.1**	**13.9**	**16.1**	**13.7**
	Raunis 1	13.1	12.3	16.5	15.5	13.5	12.1	14	12.4	17.6	13.8	64	67.7	15.3	12.6	13.5	13.4
	Raunis 2	13.3	12.6	17.3	16.6	13.4	12.3	14	13	16.6	14.7	76.8	71.8	14.7	13.7	12.9	13.1
	Raunis 3	14.3	13.1	17.2	16.4	14.5	12.9	15.3	13.7	17.6	15.7	54.4	64.9	16.6	14.7	14.7	13.4
	Raunis	**13.6**	**12.7**	**17.0**	**16.2**	**13.8**	**12.4**	**14.4**	**13.0**	**17.3**	**14.7**	**65.1**	**68.1**	**15.5**	**13.7**	**13.7**	**13.3**
	Rauza 1	13.5	13.6	17.9	17.4	13.9	13.4	14	14.3	17.2	16.4	67.6	51.4	15.1	14.7	13.1	14.4
	Rauza 2	12.9	12.1	16.5	16	12.9	12.3	14	12.7	16.1	14.1	64.4	64.4	14.9	13.7	13.3	13.6
	Rauza 3	13.5	12.6	17.4	16.8	14	12.7	14.3	13.7	15.8	14.5	63.9	60.4	15.4	14.5	13.3	14.2
	Rauza	**13.3**	**12.8**	**17.3**	**16.7**	**13.6**	**12.8**	**14.1**	**13.6**	**16.4**	**15.0**	**65.3**	**58.7**	**15.1**	**14.3**	**13.2**	**14.1**

	Strikupe 1	13.6	12	15.4	16.3	13.1	11.5	14.6	12.4	16.6	14.2	50.2	67.6	15.8	11.8	15.9	12.8
	Strikupe 2	13.8	12.1	17	16.5	13.7	11.9	14.3	13	15.6	14.7	51.2	65.2	16	13.9	14.6	13.4
	Strikupe 3	13	11.5	18.7	15.8	13.1	11.4	13.7	12.7	15.5	13.8	66.5	68.1	15.6	13	12.2	11.9
	Strikupe	**13.5**	**11.9**	**17.0**	**16.2**	**13.3**	**11.6**	**14.2**	**12.7**	**15.9**	**14.2**	**56.0**	**67.0**	**15.8**	**12.9**	**14.2**	**12.7**
Gauja		**13.4**	**12.4**	**17.1**	**16.4**	**13.6**	**12.3**	**14.2**	**13.1**	**16.5**	**14.7**	**62.1**	**64.6**	**15.5**	**13.6**	**13.7**	**13.4**
	Amula 1	13.6	11.4	14.7	15.5	12.8	11.9	14.9	12.4	16.3	13	40.1	68.3	16	13.4	16.3	12.8
	Amula 2	13.4	12.7	17.4	16.2	13.4	12.7	13.7	13	15.1	13.7	67.8	73.4	14.5	13.5	12.9	13.9
	Amula 3	13.8	12.9	15.6	16	13	12.5	15.3	14	17.6	15.9	47.9	60.7	15.4	14.9	15.9	14.5
	Amula	**13.6**	**12.3**	**15.9**	**15.9**	**13.1**	**12.4**	**14.6**	**13.1**	**16.3**	**14.2**	**51.9**	**67.5**	**15.3**	**13.9**	**15.0**	**13.7**
	Koja 1	14.2	11.7	14.9	15	13.5	11	15.3	12.1	18.0	12.2	38.6	66.5	15.8	12	16.9	13
	Koja 2	11.8	12.5	15.2	15.3	12.1	12.2	13.7	13.4	15.1	15.0	76.5	56.2	13.4	13.7	12	13.2
	Koja 3	12.2	11.8	15.2	15.9	12.2	12.2	13.7	13.4	15.1	14.1	76	71.3	13.4	13.9	12.2	12.5
	Koja	**12.7**	**12.0**	**15.1**	**15.4**	**12.6**	**11.8**	**14.2**	**13.0**	**16.1**	**13.8**	**63.7**	**64.7**	**14.2**	**13.2**	**13.7**	**12.9**
	Riezupe 1	13.7	11	15.6	14.6	13	10.8	14	11.5	16.1	12.9	57.1	68.2	14.1	11.8	14.7	12.7
	Riezupe 2	12.8	11	14.4	13.5	11.9	10.5	12.7	11.1	15.3	12.9	61.8	69	13	10.7	13.3	11.4
	Riezupe 3	12.4	11.7	14.5	15.9	11.6	11.7	11.5	12.1	14.3	14.5	75.5	70.2	11.8	13	12	11.9
	Riezupe	**13.0**	**11.2**	**14.8**	**14.7**	**12.2**	**11.0**	**12.7**	**11.6**	**15.2**	**13.4**	**64.8**	**69.1**	**13.0**	**11.8**	**13.3**	**12.0**
Venta		**17.4**	**15.6**	**20.2**	**20.2**	**16.7**	**15.4**	**18.1**	**16.4**	**21.0**	**18.3**	**81.7**	**90.1**	**18.5**	**16.9**	**18.5**	**16.9**

ANNEX XXX

Sign Test for phytobenthos metrics on hard substratum, sand/silt substratum, and hard + sand/silt substratum

Site name	***Exact Sig. (2-tailed) Hard substrate***	***Exact Sig. (2-tailed) Sand/silt substrate***	***Exact Sig. (2-tailed) Hard + sand/silt substrate***
Arona1-Arona2	0.302	0.424	0.454
Arona2-Arona3	0.077	**0.013**	**0.035**
Arona1-Arona3	0.077	0.210	0.077
Mergupe1-Mergupe2	0.077	**0.035**	0.077
Mergupe2-Mergupe3	1.000	0.804	0.454
Mergupe1-Mergupe3	0.077	0.302	**0.021**
Pededze1-Pededze2	0.077	**0.021**	**0.004**
Pededze2-Pededze3	0.077	0.077	**0.004**
Pededze1-Pededze3	0.791	0.424	1.000
Raunis1-Raunis2	0.791	0.210	0.804
Raunis2-Raunis3	0.210	0.118	0.210
Raunis1-Raunis3	0.118	0.118	**0.021**
Rauza1-Rauza2	**0.013**	0.077	**0.021**
Rauza2-Rauza3	0.424	**0.004**	**0.007**
Rauza1-Rauza3	1.000	0.210	0.607
Strikupe1-Strikupe2	1.000	0.057	1.000
Strikupe2-Strikupe3	0.607	0.077	0.302
Strikupe1-Strikupe3	0.424	0.302	0.210
Amula1-Amula2	0.210	**0.007**	0.454
Amula2-Amula3	0.424	0.210	0.454
Amula1-Amula3	0.424	**0.007**	**0.021**
Koja1-Koja2	0.077	**0.021**	0.077
Koja2-Koja3	1.000	0.791	1.000
Koja1-Koja3	0.077	0.077	0.210
Riezupe1-Riezupe2	0.077	0.267	0.210
Riezupe2-Riezupe3	**0.021**	**0.004**	0.454
Riezupe1-Riezupe3	**0.021**	0.077	0.077

Stream name	***Exact Sig. (2-tailed) Hard substrate***	***Exact Sig. (2-tailed) Sand/silt substrate***	***Exact Sig. (2-tailed) Hard + sand/silt substrate***
Arona-Mergupe	**0.021**	0.804	0.210
Mergupe-Pededze	0.077	0.077	0.077
Arona-Pededze	**0.021**	0.454	0.077
Raunis-Rauza	0.454	**0.021**	0.454
Rauza-Strikupe	0.210	**0.004**	0.210
Raunis-Strikupe	0.607	0.077	0.454
Koja-Amula	**0.004**	**0.021**	0.077
Riezupe-Koja	0.454	**0.021**	0.077
Amula-Riezupe	0.077	**0.035**	0.077

River basin	***Exact Sig. (2-tailed) Hard substrate***	***Exact Sig. (2-tailed) Sand/silt substrate***	***Exact Sig. (2-tailed) Hard + sand/silt substrate***
Daugava-Gauja	1.000	0.607	0.607
Gauja-Venta	0.077	**0.021**	**0.021**
Daugava-Venta	**0.004**	**0.021**	**0.021**

ANNEX XXXI
Correlation coefficients of environmental parameters and phytobenthos metrics with ordination axis of main matrix for the Daugava basin

Environmental parameters and diatom metrics	1st axis	2nd axis	3rd axis
HQA score	-0.12	**-0.74**	-0.49
HMS score	0.51	0.13	0.39
catchment	-0.64	**0.65**	-0.21
Altitude	**0.67**	-0.44	0.24
Gradient slope	0.63	-0.52	-0.48
Dist from source	-0.64	0.55	-0.38
Forest	-0.07	-0.43	0.45
Agricultural land	0.08	0.42	-0.39
width	-0.57	0.13	-0.13
depth	**-0.89**	0.30	-0.12
Max depth	**-0.85**	0.26	0.20
discharge	**-0.91**	0.08	-0.03
velocity	-0.50	**-0.76**	-0.04
megalithal	0.23	-0.45	-0.26
macrolithal	0.21	-0.06	**-0.72**
mesolithal	**0.81**	0.02	0.09
microlit	0.30	-0.31	0.12
akal	-0.19	0.15	**0.75**
psammal	-0.64	0.14	-0.05
macro-algae	0.30	0.33	-0.43
submerged macrophy.	0.56	0.35	-0.31
xylal	**0.78**	-0.14	0.03
CPOM	**-0.77**	-0.03	-0.44
FPOM	0.18	0.35	**0.65**
pH value	0.24	**0.79**	-0.51
conductivity	0.27	**0.91**	-0.15
oxygen content	-0.24	-0.56	-0.59
oxygen saturation	-0.22	0.01	-0.37
alkalinity	0.30	**0.92**	-0.11
hardness	0.31	**0.89**	-0.11
chloride	0.25	**0.83**	0.38
BOD_5	0.44	-0.52	-0.41
ammonium	-0.38	-0.34	0.63
nitrite	-0.47	**-0.65**	-0.01
nitrate	-0.46	0.00	0.59
phosphate	0.51	-0.13	0.31
total-phosphorus	-0.06	0.09	0.25
IPS hard	0.21	0.37	-0.51
IDG hard	0.33	-0.03	-0.45
TDI hard	-0.55	0.41	0.43
IPS-soft	0.10	-0.08	-0.58
IDG-soft	0.62	-0.49	-0.17
TDI-soft	-0.54	0.47	-0.13

ANNEX XXXII
Correlation coefficients of environmental parameters and phytobenthos metrics with ordination axis of main matrix for the Gauja basin

Environmental parameters and diatom metrics	1st axis	2nd axis	3rd axis
HQA score	**0.82**	0.27	-0.05
HMS score	0.20	0.58	0.51
catchment	-0.33	0.06	0.60
Altitude	**0.69**	-0.62	0.14
Gradient slope	0.47	**0.69**	-0.14
Dist from source	-0.03	0.37	0.58
Forest	**-0.77**	-0.26	0.54
Agricultural land	**0.77**	0.27	-0.55
width	-0.30	-0.35	**0.78**
depth	**-0.85**	-0.19	-0.19
Max depth	-0.37	-0.52	-0.47
discharge	**-0.94**	0.23	-0.16
velocity	**-0.69**	0.28	-0.26
macrolithal	-0.04	0.27	0.04
mesolithal	0.42	-0.24	0.56
microlithal	0.64	-0.22	0.48
akal	**0.66**	0.22	0.31
psammal	**0.69**	0.01	-0.35
macro-algae	**-0.93**	0.10	-0.32
submerged macrophy.	**-0.78**	-0.01	-0.37
xylal	0.18	**-0.70**	0.27
CPOM	0.59	-0.14	**-0.65**
FPOM	-0.28	0.44	-0.12
pHvalue	0.19	**0.72**	0.23
conduc	0.14	**0.93**	0.00
oxygen content	-0.33	**0.84**	0.15
oxygen saturation	-0.45	**0.78**	0.09
alkalinity	0.16	**0.91**	0.02
hardness	0.23	**0.94**	0.00
chloride	0.54	0.06	-0.25
BOD_5	**-0.89**	-0.06	-0.24
ammonium	**0.70**	-0.45	0.23
nitrite	-0.22	-0.40	0.29
nitrate	0.26	-0.63	-0.44
phosphate	0.12	0.53	0.10
total-phosphorus	0.59	0.16	-0.48
IPS hard	-0.23	0.53	0.02
IDG hard	-0.64	-0.01	-0.04
TDI hard	0.36	-0.07	-0.02
IPS-soft	0.40	0.05	0.24
IDG-soft	-0.01	-0.37	0.10
TDI-soft	-0.18	0.58	-0.33

ANNEX XXXII
Correlation coefficients of environmental parameters and phytobenthos metrics with ordination axis of main matrix for the Gauja basin

Environmental parameters and diatom metrics	1st axis	2nd axis	3rd axis
HQA score	**0.82**	-0.16	0.29
HMS score	0.58	-0.55	-0.40
catchment	**0.89**	0.10	-0.23
Altitude	**-0.65**	-0.52	0.31
Gradient slope	-0.06	-0.19	**-0.80**
Dist from source	**0.89**	0.09	-0.33
Forest	**-0.71**	0.05	-0.53
Agricultural land	**0.70**	-0.10	0.49
width	**0.89**	0.03	-0.29
depth	**-0.73**	0.41	-0.25
Max depth	-0.26	0.31	0.01
discharge	**0.65**	0.48	-0.17
velocity	0.17	0.61	0.34
macrolithal	**0.70**	-0.02	-0.51
mesolithal	0.59	-0.39	-0.51
microlithal	0.24	0.55	-0.03
akal	0.23	0.55	0.11
psammal	**-0.72**	-0.24	0.41
macro-algae	**0.68**	0.03	-0.49
submerged macrophy.	0.17	**-0.70**	0.08
xylal	0.44	**-0.78**	0.28
CPOM	0.28	-0.18	**0.71**
FPOM	0.10	0.33	**0.76**
pH value	**0.77**	-0.44	-0.05
conductivity	0.49	**-0.69**	0.16
oxygen content	0.37	**0.85**	-0.07
oxygen saturation	0.62	**0.69**	0.09
alkalinity	0.30	**-0.89**	0.12
hardness	0.43	**-0.76**	0.06
chloride	-0.47	-0.31	-0.52
BOD_5	-0.21	0.13	-0.08
ammonium	0.33	0.46	-0.14
nitrite	-0.58	0.41	-0.52
nitrate	0.29	**0.86**	0.15
phosphate	-0.58	-0.39	-0.01
total-phosphorus	-0.55	-0.50	-0.38
IPS hard	-0.29	-0.50	0.09
IDG hard	-0.35	-0.50	-0.01
TDI hard	-0.03	0.48	-0.21
IPS-soft	-0.09	-0.49	0.09
IDG-soft	-0.34	-0.26	-0.26
TDI-soft	0.39	0.21	**0.85**

ANNEX XXXIX HQA and HMS scores for the reashes, streams and river basin RHS results

Stream_Name	HQA arising from Flow Types	HQA arising from Channel Substrates	HQA arising from Channel Features	HQA arising from Bank Features	HQA arising from Bank Vegetation	HQA arising from Point bars	HQA arising from In-stream Channel Vegetation	HQA arising from within Land-use 50m	HQA arising from Trees & Associated Features	HQA arising from Special Features	HQA score	HMS arising from Modifications at spot checks	HMS arising from Modifications not at spot checks	HMS score
Arona 1	9	5	2	2	11	0	8	2	10	0	49	4	0	4
Arona 2	6	3	4	5	11	1	6	4	11	0	51	0	0	0
Arona 3	6	3	0	1	7	0	12	3	11	0	43	0	0	0
Arona	**7.0**	**3.7**	**2.0**	**2.7**	**9.7**	**0.3**	**8.7**	**3.0**	**10.7**	**0.0**	**47.7**	**1.3**	**0.0**	**1.3**
Mergupe 1	5	7	3	4	12	2	0	4	15	5	57	0	0	0
Mergupe 2	9	8	3	3	12	1	5	4	15	5	65	0	0	0
Mergupe 3	6	4	1	3	12	0	12	2	15	5	60	0	0	0
Mergupe	**6.7**	**6.3**	**2.3**	**3.3**	**12.0**	**1.0**	**5.7**	**3.3**	**15.0**	**5.0**	**60.7**	**0.0**	**0.0**	**0.0**
Pededze 1	6	4	2	3	11	1	6	2	9	5	49	2	0	2
Pededze 2	10	8	2	4	11	1	11	4	10	0	61	0	0	0
Pededze 3	8	6	2	2	12	0	4	4	11	0	49	0	0	0
Pededze	**8.0**	**6.0**	**2.0**	**3.0**	**11.3**	**0.7**	**7.0**	**3.3**	**10.0**	**1.7**	**53.0**	**0.7**	**0.0**	**0.7**
Daugava basin mean	**7.2**	**5.3**	**2.1**	**3.0**	**11.0**	**0.7**	**7.1**	**3.2**	**11.9**	**2.2**	**53.8**	**0.7**	**0.0**	**0.7**
Daugava basin max	**10.0**	**8.0**	**4.0**	**5.0**	**12.0**	**2.0**	**12.0**	**4.0**	**15.0**	**5.0**	**65.0**	**4.0**	**0.0**	**4.0**
Daugava basin min	**5.0**	**3.0**	**0.0**	**1.0**	**7.0**	**0.0**	**0.0**	**2.0**	**9.0**	**0.0**	**43.0**	**0.0**	**0.0**	**0.0**
Raunis 1	7	6	3	6	12	1	1	4	16	0	56	0	0	1
Raunis 2	8	8	2	10	11	1	2	4	17	5	68	0	0	0
Raunis 3	12	8	3	5	11	1	5	4	15	0	64	3	1	4
Raunis	**9.0**	**7.3**	**2.7**	**7.0**	**11.3**	**1.0**	**2.7**	**4.0**	**16.0**	**1.7**	**62.7**	**1.0**	**0.3**	**1.7**
Rauza 1	6	5	2	5	12	1	5	4	15	0	55	0	0	0
Rauza 2	5	6	4	5	12	1	7	2	16	0	58	0	0	0
Rauza 3	7	6	2	9	11	0	4	2	16	0	57	2	0	2
Rauza	**6.0**	**5.7**	**2.7**	**6.3**	**11.7**	**0.7**	**5.3**	**2.7**	**15.7**	**0.0**	**56.7**	**0.7**	**0.0**	**0.7**

Strikupe 1	6	7	4	2	12	0	12	5	11	5	64	0	0	0
Strikupe 2	3	3	1	3	12	1	12	0	0	0	35	0	0	0
Strikupe 3	6	3	1	5	0	1	7	2	9	5	39	0	0	0
Strikupe	**5.0**	**4.3**	**2.0**	**3.3**	**8.0**	**0.7**	**10.3**	**2.3**	**6.7**	**3.3**	**46.0**	**0.0**	**0.0**	**0.0**
Gauja basin mean	**6.7**	**5.8**	**2.4**	**5.6**	**10.3**	**0.8**	**6.1**	**3.0**	**12.8**	**1.7**	**55.1**	**0.6**	**0.1**	**0.8**
Gauja basin max	**12.0**	**8.0**	**4.0**	**10.0**	**12.0**	**1.0**	**12.0**	**5.0**	**17.0**	**5.0**	**68.0**	**3.0**	**1.0**	**4.0**
Gauja basin min	**3.0**	**3.0**	**1.0**	**2.0**	**0.0**	**0.0**	**1.0**	**0.0**	**0.0**	**0.0**	**35.0**	**0.0**	**0.0**	**0.0**
Amula 1	8	3	1	4	8	1	8	4	14	5	56	2	0	2
Amula 2	6	3	2	4	11	1	8	4	14	5	58	0	0	0
Amula 3	7	4	0	7	11	1	9	3	14	5	61	6	0	6
Amula	**7.0**	**3.3**	**1.0**	**5.0**	**10.0**	**1.0**	**8.3**	**3.7**	**14.0**	**5.0**	**58.3**	**2.7**	**0.0**	**2.7**
Koja 1	8	5	1	2	11	0	10	3	9	5	54	0	0	0
Koja 2	5	4	1	1	4	0	7	3	7	5	37	0	0	0
Koja 3	6	3	2	3	12	0	6	4	10	5	51	0	0	0
Koja	**6.3**	**4.0**	**1.3**	**2.0**	**9.0**	**0.0**	**7.7**	**3.3**	**8.7**	**5.0**	**47.3**	**0.0**	**0.0**	**0.0**
Riezupe 1	7	3	0	5	12	1	7	3	7	0	45	0	0	0
Riezupe 2	10	7	4	4	12	2	4	4	10	0	57	0	0	0
Riezupe 3	11	5	2	7	10	1	8	3	10	5	62	0	2	2
Riezupe	**9.3**	**5.0**	**2.0**	**5.3**	**11.3**	**1.3**	**6.3**	**3.3**	**9.0**	**1.7**	**54.7**	**0.0**	**0.7**	**0.7**
Venta basin mean	**7.6**	**4.1**	**1.4**	**4.1**	**10.1**	**0.8**	**7.4**	**3.4**	**10.6**	**3.9**	**53.4**	**0.9**	**0.2**	**1.1**
Venta basin max	**11.0**	**7.0**	**4.0**	**7.0**	**12.0**	**2.0**	**10.0**	**4.0**	**14.0**	**5.0**	**62.0**	**6.0**	**2.0**	**6.0**
Venta basin min	**5.0**	**3.0**	**0.0**	**1.0**	**4.0**	**0.0**	**4.0**	**3.0**	**7.0**	**0.0**	**37.0**	**0.0**	**0.0**	**0.0**

ANNEX XL
Values of Shannon's index for reaches, streams and river basins

Reach **Stream** **River basin**	**SHANNON'S INDEX**				
	MACROPHYTES	FISH	MACROINVERTEBRATES	DIATOMS-H	DIATOMS-S
Pededze 1	0,25	0,92	2,71	3,05	3,99
Pededze 2	0,07	0,42	2,27	3,75	3,72
Pededze 3	0,06	1,17	2,73	3,59	3,69
Pededze	**0,13**	**0,84**	**2,57**	**3,47**	**3,80**
Arona 1	0,19	0,46	2,29	2,34	3,21
Arona 2	0,09	0,56	2,16	2,11	3,44
Arona 3	0,11	1,05	2,46	3,42	3,55
Arona	**0,13**	**0,69**	**2,30**	**2,62**	**3,40**
Mergupe 1	-	0,69	1,21	3,48	3,70
Mergupe 2	0,19	1,26	1,24	2,48	3,76
Mergupe 3	0,31	1,22	1,42	3,08	3,64
Mergupe	**0,25**	**1,05**	**1,29**	**3,02**	**3,70**
Daugava basin	**0,17**	**0,86**	**2,06**	**3,04**	**3,63**
Rauza 1	0,07	0,49	2,06	3,49	3,61
Rauza 2	0,08	0,97	1,44	3,62	4,11
Rauza 3	0,07	1,24	2,30	3,45	4,28
Rauza	**0,07**	**0,90**	**1,93**	**3,52**	**4,00**
Raunis 1	0,02	0,82	1,92	3,08	4,08
Raunis 2	0,00	1,07	2,07	3,23	3,70
Raunis 3	0,18	0,61	1,48	2,46	3,58
Raunis	**0,07**	**0,83**	**1,83**	**2,93**	**3,79**
Strikupe 1	0,64	1,03	1,37	3,10	3,88
Strikupe 2	0,37	1,20	2,22	2,84	4,05
Strikupe 3	0,23	0,93	1,44	3,189	4,16
Strikupe	**0,42**	**1,05**	**1,68**	**3,04**	**4,03**

Gauja basin	**0,18**	**0,93**	**1,81**	**3,16**	**3,94**
Amula 1	0,17	0,98	1,31	2,55	3,70
Amula 2	0,02	1,22	1,69	3,60	3,54
Amula 3	0,09	1,29	2,14	2,17	3,34
Amula	**0,09**	**1,16**	**1,72**	**2,78**	**3,53**
Riezupe 1	0,07	1,75	1,81	3,48	3,87
Riezupe 2	0,11	0,98	2,10	3,68	3,9
Riezupe 3	0,14	1,33	2,56	3,44	3,76
Riezupe	**0,11**	**1,35**	**2,16**	**3,54**	**3,84**
Koja 1	0,16	0,55	1,52	1,88	3,96
Koja 2	0,11	-	-	3,56	3,74
Koja 3	-	1,92	1,06	3,50	4,08
Koja	**0,13**	**1,23**	**1,29**	**2,98**	**3,93**
Venta basin	**0,11**	**1,25**	**1,72**	**3,10**	**3,77**

ANNEX XLI
Values of Simpson's diversity index for reaches, streams and river basins

Reach **Stream** **River basin**	**SIMPSON'S DIVERSITY**				
	MACROPHYTES	FISH	MACROINVERTEBRATES	DIATOMS-H	DIATOMS-S
Pededze 1	0,99	0,45	0,86	0,85	0,97
Pededze 2	1,00	0,19	0,79	0,96	0,95
Pededze 3	1,00	0,64	0,88	0,95	0,96
Pededze	**1,00**	**0,43**	**0,84**	**0,92**	**0,96**
Arona 1	1,00	0,21	0,80	0,71	0,91
Arona 2	1,00	0,29	0,81	0,68	0,94
Arona 3	1,00	0,52	0,85	0,95	0,95
Arona	**1,00**	**0,34**	**0,82**	**0,78**	**0,93**
Mergupe 1	-	0,43	0,46	0,95	0,96
Mergupe 2	0,97	0,68	0,42	0,82	0,96
Mergupe 3	0,99	0,64	0,47	0,91	0,96
Mergupe	**0,98**	**0,58**	**0,45**	**0,89**	**0,96**
Daugava basin	**0,99**	**0,45**	**0,71**	**0,86**	**0,95**
Rauza 1	1,00	0,22	0,78	0,94	0,95
Rauza 2	1,00	0,58	0,50	0,95	0,97
Rauza 3	1,00	0,57	0,75	0,93	0,98
Rauza	**1,00**	**0,46**	**0,68**	**0,94**	**0,97**
Raunis 1	1,00	0,45	0,74	0,92	0,97
Raunis 2	1,00	0,59	0,71	0,93	0,96
Raunis 3	0,97	0,39	0,53	0,80	0,95
Raunis	**0,99**	**0,48**	**0,66**	**0,88**	**0,96**
Strikupe 1	0,82	0,46	0,45	0,86	0,96
Strikupe 2	0,96	0,61	0,78	0,83	0,97
Strikupe 3	0,99	0,45	0,52	0,93	0,97
Strikupe	**0,92**	**0,51**	**0,58**	**0,87**	**0,97**
Gauja basin	**0,97**	**0,48**	**0,64**	**0,90**	**0,97**

Amula 1	0,97	0,51	0,55	0,75	0,96
Amula 2	1,00	0,63	0,64	0,94	0,93
Amula 3	1,00	0,62	0,71	0,69	0,90
Amula	**0,99**	**0,59**	**0,63**	**0,79**	**0,93**
Riezupe 1	1,00	0,79	0,68	0,93	0,96
Riezupe 2	1,00	0,54	0,71	0,95	0,97
Riezupe 3	1,00	0,61	0,84	0,95	0,96
Riezupe	**1,00**	**0,65**	**0,74**	**0,95**	**0,96**
Koja 1	1,00	0,28	0,71	0,57	0,97
Koja 2	-	-	-	0,94	0,94
Koja 3	1,00	0,82	0,38	0,95	0,97
Koja	**1,00**	**0,55**	**0,54**	**0,82**	**0,96**
Venta basin	**1,00**	**0,60**	**0,64**	**0,85**	**0,95**