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Ecological Quality Analysis of the Rezekne River after Zooplankton

Rasma Deksne, Margarita Božko, Jekaterina Kuzmina, Andris Linužs
Rezeknes Augstskola, Faculty of Engineering,
Address: Atbrivosanas aleja 76, Rezekne, LV-4601, Latvia

Abstract. **During seasonal studies 2012 (June/August), samples of zooplankton were collected and analyzed according standard method. Changes of quantitative and qualitative characteristics, saprobity index, species diversity (Shannon-Wiener index) and Renkonen index were employed for the analysis of zooplankton community structure in the Rezekne River. The Rezekne River saprobity varies from o – saprobity to β – mesosaprobity. The lowest ecological quality was determined in the leg of the Rezekne River in the territory of Rezekne city, which characterises with decrease in the total zooplankton abundance and species diversity according to Shannon - Wiener index, increase of saprobity.**

***Key words*: medium river, saprobity, species biological diversity, Cladocera, Copepoda, Rotifera.**

I INTRODUCTION

The Rezekne River belongs to Daugava River basin. Daugava is a significant ecosystem for the environment of Latvia and its protection and long-term usage of resources is an important objective of Latvian environment in political system [1]. A number of authors have studied the ecological situation of the Rezekne River: Jastreżemskis, [2]; Meinerte, [3]; Benislavska, [4]; Strigajeva, [5]; Strucinska, [6]; Zute, [7] – in studies it has been concluded that river water's pollution is small or average. However, none of the studies has been carried out in the whole length of river, accordingly, there has not been an opportunity to assess the ecological situation of river in general. Previous studies were carried out either using only bioindication methods or chemical. Still it is not possible to gain information about the particular substance and its total impact on hydroecosystem only with the help of chemical methods. In addition, the number of chemical compounds, which pollutes environment, is so big that it is difficult to be controlled. [8]. For that reason findings gained as a result of biomonitoring supply much more extended and precise information about the impact of polluting substance on ecosystem.

A number of authors (e.g. Bothár [9]; Mulani *et al.* [10]; Gajbhiye & Abidi [11]) are indicating to the impact of wastewater on zooplankton. The indicative role of zooplankton in the studying of pollution processes is shown in some scientific studies. Potentiality of zooplankton as bio-indicator is very high because their growth and distribution are dependent on many abiotic (e.g., temperature, salinity, stratification, pollutants) and biotic parameters (e.g., food limitation, predation, competition) [12, 13, 14].

A great number of authors are drawing attention to possibilities of the use of zooplankton for assessing the river water quality (Bakaeva & Nikanorov, [8]; Vandish, [15]; Demenik, [16]; Kutikova, [17]; Krylov, [18], [19]; Mathivanan *et al.*, [20]; Vanjare, [21]; Mulani, [10]; Marneffe *et al.*, [22]; Whitton, [23]).

The aim of this study is to assess the ecological situation of the Rezekne River after zooplankton.

II MATERIALS AND METHODS

Sampling sites

Rezekne River basin occupies 2066 km^2 (with Malta), rising in Lake Razna, the second biggest lake in Latvia, flowing into the biggest lake in Latvia – Lake Lubans. The total length of the river is 116 km. The width of the Rezekne River on average varies from 6 – 20 m, the depth – 0.8 – 2.0 m. Annual average river run-off is 0.2 km^3, run-off is also regulated by locks of Kaunata Lake at the river's source. Speed flow in the river varies from 0.2 to 0.7 m/s. Average flow rate in the Rezekne River below Rezekne City is 5.5 m^3/s. In the upper part of river basin there is a significant mouth from lakes, but in lower part – from marshes. The Rezekne River's the biggest tributaries on the left bank are Reva (9 km), Geikinu stream (12 km), Vagaļu straem (8 km), Kovšupe (10 km), Rodupe (10km), Čečora (19 km), Malta (105 km), but on the right bank - Pārtava (10 km), Ancovas stream (5 km), Križutu ditch (12 km), Taudejāņi stream (13 km), Liužanka (26 km), Sūļupe (14 km) [6].

Sampling and analysis

During the expeditions to the following Rezekne River stretches Table 1 presents GPS coordinates of the Rezekne River sampling sites and dates from the outlet from Lake Razna to the mouth in Lake Lubans (21 sampling sites) in 16 June, 30 August 2012, water samples and zooplankton were sampled at the banks.

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TABLE I
TYPE SIZES, SPACES AND INTERVALS

No	Sampling sites	Sampling sites coordinates
1.	Rezekne River source from Lake Kaunata	56°19'34.2"N / 27°31'14.4"E
2.	Before Spruktu reservoir	56°22'35.8"N / 27°31'36.3"E
3.	After Spruktu reservoir at Stoļerova village	56°25'37.7"N / 27°33'11.5"E
4.	Before Spruževa village at cattle farm	56°28'54.4"N / 27°26'40.2"E
5.	Hydrological station in Griškani	56°30'37.8"N / 27°26'08.5"E
6.	Before Rezekne city in Griškani	56°31'20.2"N / 27°24'21.9"E
7.	Bridge Jupatovka	56°30'58.0"N / 27°22'44.0"E
8.	Bridge at the Bowling centre	56°30'48.1"N / 27°21'07.9"E
9.	Bridge at Rezekne Hospital	56°30'25.3"N / 27°20'45.7"E
10.	Pipe before castle mound – Krasta street	56°30'07.4"N / 27°19'56.6"E
11.	A small bridge at Rimi supermarket	56°30'03.6"N / 27°19'44.5"E
12.	Bridge at Concert Hall	56°30'13.9"N / 27°19'34.2"E
13.	Railway bridge on Viļānu Street	56°30'28"N / 27°19'05.1"E
14.	Railway bridge - Makarovka	56°31'21.6"N / 27°18'40.6"E
15.	Downstream of discharge of the Rezekne city treatment plant wastewater, Greivuļi	56°32'04.2"N / 27°17'22.7"E
16.	At Sakstagals village	56°32'04.0"N / 27°15'39.6"E
17.	At Uljanovs village	56°33'48.9"N / 27°3'55.7"E
18.	At Rikava village	56°36'22.5"N / 27°1'38.1"E
19.	Before Nagļi ponds	56°40'27.9"N / 27°0'22.6"E
20.	Malta River canal inflow into Rezekne River	56°43'22.6"N / 26°59'30.6"E
21.	Rezekne River inflow into Lubans Lake	56°46'19.8"N / 26°56'12.6"E

Samples gathering and analysis were carried out according to the standartmethods [24]. Samples of zooplankton were collected from the upper water layer till 0.5 - 1 m by filtering 100 l of river water with the 65 µm mesh-sized Apshtein plankton net. Collected samples were fixed in 4 % formalin.

Nikon Eclipse E200 light microscopes were used for the analysis of zooplankton; three subsamples (2 ml each) were examined at 100 – 400 x magnification. The aim of the qualitative study was to identify Rotifera, Cladocera, and Copepoda taxa. All taxa of zooplankton were identified using keys of Kutikova [17], Borutsky [25], Manuilova [26], Segers [27], Kotov *et al.* [28], Paidere [29].

Data processing and analysis

The calculation of zooplankton abundance 1 m^3 water was defined by formula (1):

$$N = \frac{a \times b \times 1000}{c \times d} \qquad (1)$$

where: N – number of individuals (1 m^3); a - average amount of individuals in three samples; b - capacity of sample (ml); c - capacity of examined sample (2 ml); d - capacity of filtered water (100 l).

Quantitative (abundance, biomass, number of taxa), qualitative characteristics (species composition) and species diversity (Shannon - Wiener index derivative N_1 according to the number of organisms) were employed for the analysis of zooplankton community structure in the Rezekne River.

Species diversity was calculated according to the Shannon - Wiener index, by formula (2) [30, 31]:

$$H' = \sum_{i=1}^{s} (p_i)(\log_2 p_i). \qquad (2)$$

where S – the number of species; p_i – the proportion of individuals of the i^{th} species to the total number of species.

The Shannon - Wiener index expressed in units of the number of species was used in these studies was calculated using formula (3) [32]:

$$N_1 = e^{H'}. \qquad (3)$$

where e = 2; H' – Shannon - Wiener function [30]; N_1 – number of equally common species that would produce the same diversity as H'.

Hill recommends using N_1 rather than H' because units (the number of species) are more clearly understandable to ecologists [33]. Therefore N_1 is used in the present research.

Saprobity index (S) was calculated by Sladechek's method, using the created by P. Cimdiņš species - bioindicator catalogue for Latvia [35].

Hydrological data were obtained from the database of the company 'Latvian Environment, Geology and Meteorology Centre'.

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III Results and Discussion

Conditionally, after anthropogenic load, the Rezekne River has been divided into 4 stretches:

I stretch – area not so much affected by anthropogenic activity – before and after Spruktu reservoir (from the 2nd till 3rd zooplankton sampling sites);

II stretch – territory of small villages – Sprūževa village, Griškani village (from 4th till 6th site);

III stretch – territory of Rezekne city (from 7th till 15th site);

IV stretch – behind the territory of Rezekne city - at Sakstagals village, at Rikava village, at Uljanovs village (from 16th till 20th site).

Generally, the zooplankton community of the Rezekne River was dominated by Rotifers, which due to their short generation time and their high reproductive rate dominate in rivers [36]. (Fig.1.,2.) The number of taxa changed from 2 to 12 and species biological diversity according to the Shannon - Wiener index varied from 1.2 to 7.1.

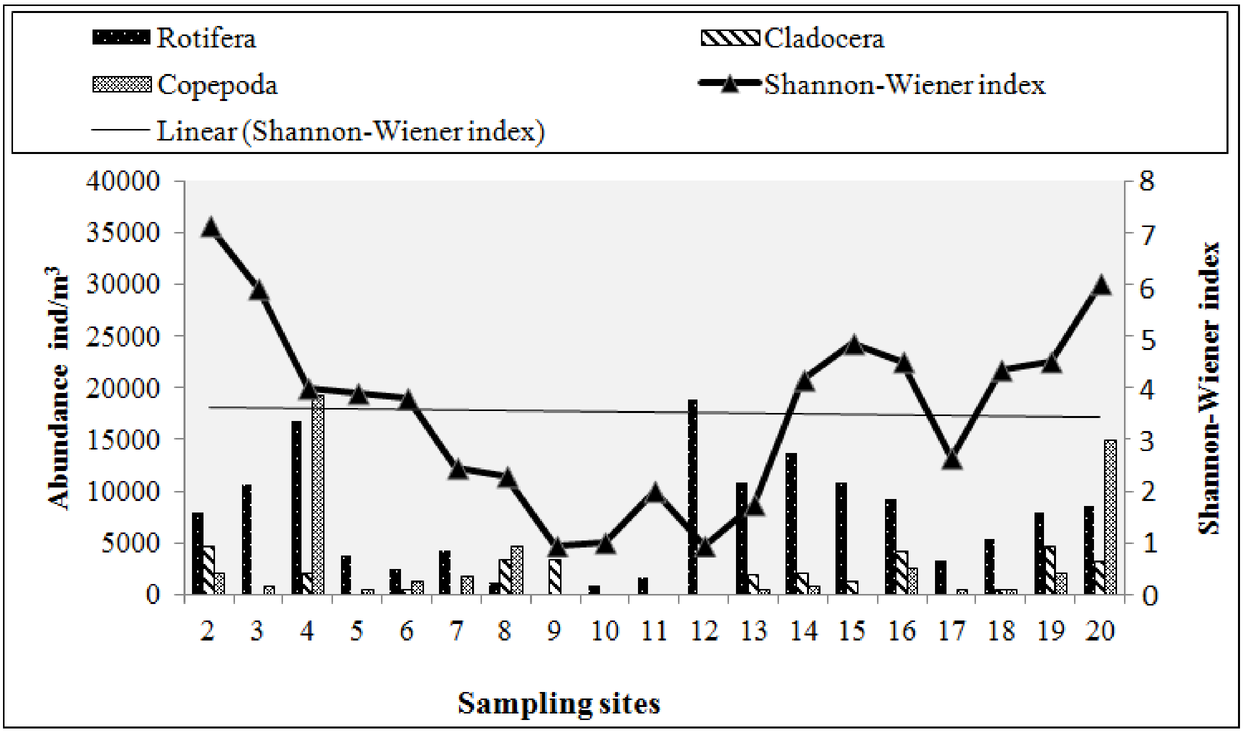

Fig. 1. Abundance of zooplankton taxonomic groups and Shannon – Wiener index in the Rezekne River in August 2012

The biggest zooplankton species biological diversity according to the Shannon - Wiener index was determined at river source from Razna Lake and at the mouth of Lubans Lake, which is explained by the zooplankton inflow into the river from lakes, where the amount and diversity of zooplankton is bigger. Species biological diversity decreases in II river stretch, where many villages are situated alongshore. The fastest zooplankton species biological diversity and abundance decline is observed in III river stretch in the territory of Rezekne city, where the Shannon - Wiener index decreases till 1.2. Downstream of discharge of the Rezekne city treatment plant (WTP) wastewater into the Rezekne River species biological diversity of zooplankton does not decrease, which means that WTP is not the only and main source of Rezekne River pollution. Kononova points out that too big influx of biogenic substance in the river has a negative influence on zooplankton that expresses in decreasing of species diversity and increasing of Simpson index [37]. Also Kutikova points out that abundance of zooplankton and decreasing of species sensitive to pollution is an indicator for impact of untoward environmental factors [17]. In August 2012, when water level is low (up to ~138.63 m.a.B.s.l.), negative impact of anthropogenic pollution on zooplankton (abundance and species biological diversity decline) is more marked than in June 2012 when the water level is higher (up to ~138.73 m m.a.B.s.l.) and as a result higher level of pollution concentration dilution.

Assessing after organisms abundance and the Shannon - Wiener index the most polluted river stretch is from site Nr 5 to site Nr 11, after which the abundance of zooplankton noticeably increased mainly due to breeding of *Euchlanis dilatata* o-β, *Keratella Cochlearis* β, *Lecane Luna* β, *Chydorus sphaericus* β in large quantities. In that way in Rezekne River a β – mesosaprobity zone was formed, this is characterized by intensified growth of the abundance of zooplankton and decreased species biological diversity (Fig. 3.,4.).

The zooplankton abundance decreased mainly in Cladocera and Copepoda taxa. In river researches Rundle and Hildrew mention that in the division of zooplankton crustaceans water chemical content is one of the determinative factors [38].

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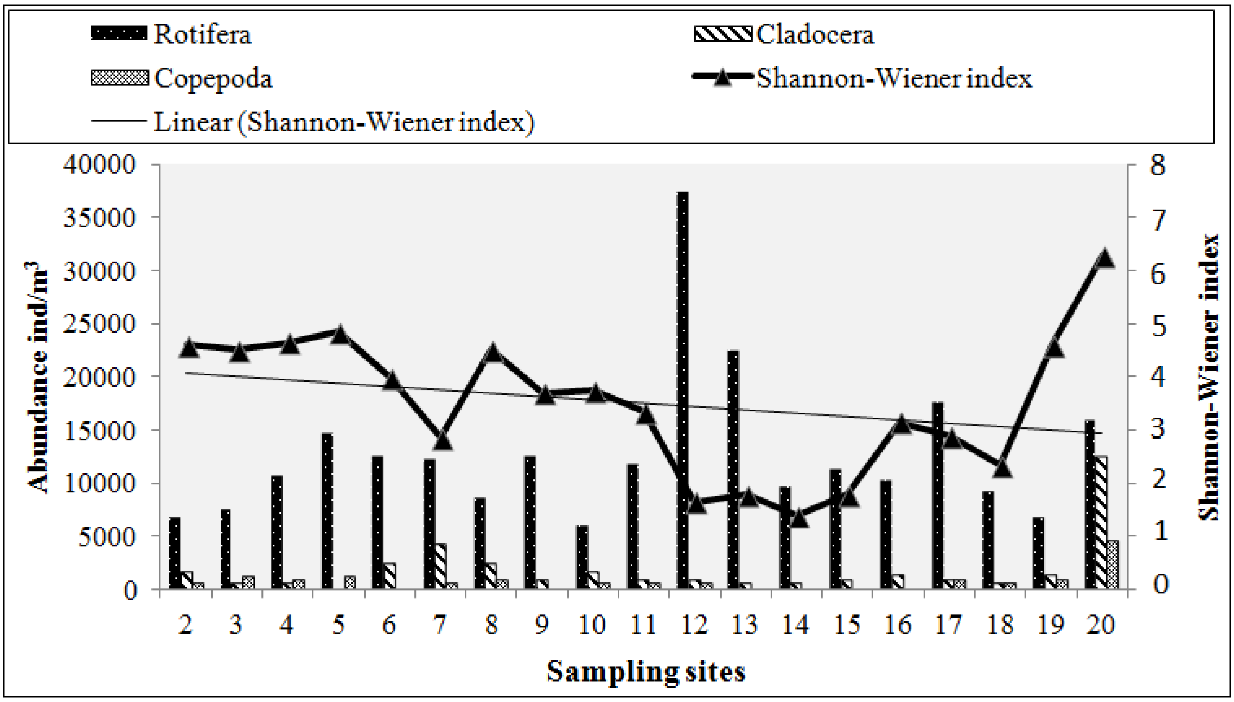

Fig. 2. Abundance of zooplankton taxonomic groups and Shannon – Wiener index in the Rezekne River in June 2012

Zooplankton abundance and numbers of taxa increased downstream from the territory of Rezekne city (Fig. 1.,2). Increase of zooplankton abundance and growth of biological diversity of species can be explained by the river self-purification processes, in this stretch of the river favourable wastewater dilution area is built up with richly developed bacteria plankton, which is very good feeding base for the development of zooplankton. A number of authors are also reporting the importance of zooplankton in effectiveness of self-purification process (Kutikova, [17]; Bakaeva and Nikonorov, [8]). In the whole length of the Rezekne River from the source till the mouth Shannon - Wiener index decreases, which points out to the negative impact of anthropogenic pollution on river zooplankton and ecosystem in general.

63% of the species found on the examined stretch of the Rezekne River were indicator species of saprobity, which is a sufficient amount to consider the river pollution level according to zooplankton. Kutikova indicates that it is difficult to consider the river saprobity if there are few indicator species of saprobity in the river [17].

In August and June 2012 saprobity changed from oligosaprobity (S=0.83), which describes clean or very slight pollution (water quality class I) in the I stretch of the Rezekne River to the β - mezosaprobity (S=1.80), which describes moderate pollution (water quality class II) behind Rezekne city WTP wastewater influx site (Figure 3.,4.), which means that also Rezekne city WTP is one of the important river pollution sources. Only in I stretch of the river dominate o-o-β oligosaprobity species, in other river stretches dominate β-α mezosaprobity species (Fig. 3.,4.).

In general saprobity increases in the whole length of the Rezekne River and β-α mezosaprobity species dominate (Fig. 3.,4.), which points out to river is not able to make self-purification and pollution flows into Lubans Lake. It has also been reported about insufficient river's self-purification abilities in the Daugava River basin region management plan 2010 – 2015 [39].

Species biological diversity decreases and saprobity increases beginning with II river stretch, which means that this river stretch is already influenced by anthropogenic impact.

Decrease in zooplankton abundance III river stretch occurred not only on account of predominant species, but also on account of decreasing of oligosaprobes or even total extinction thereof, not a single oligosaprobity species was found (Figure 3). Only such species as *Euchlanis dilatata* o-β, *Keratella Cochlearis* β, *Lecane Luna* β, *Chydorus sphaericus* β, *Asplancha priodonta* β, *Pompholux sulcata* β, *Brachionus angularis* β–α, *Trichocerca cylindrica* α as well as Bdelloida increased in numbers. Ferdous and Muktadir [14] in their studies mention that species variation of these order deceased in polluted water. Some species were not found in some highly polluted area through these species have high tolerance level. Gulyas points out that species such as *Asplanchna priodonta, Brachionus angularis, B. calyciflorus, B. leydigi, B. quadridentatus, Euchlanis dilatata, Keratella cochlearis, K. quadrata, Polyarthra vulgaris* have all been recorded below the mouths of polluted tributaries [41]. The increasing of the pollution level causes decrease in numbers of the above predominant species, β and α-β saprobity species are developing [8].

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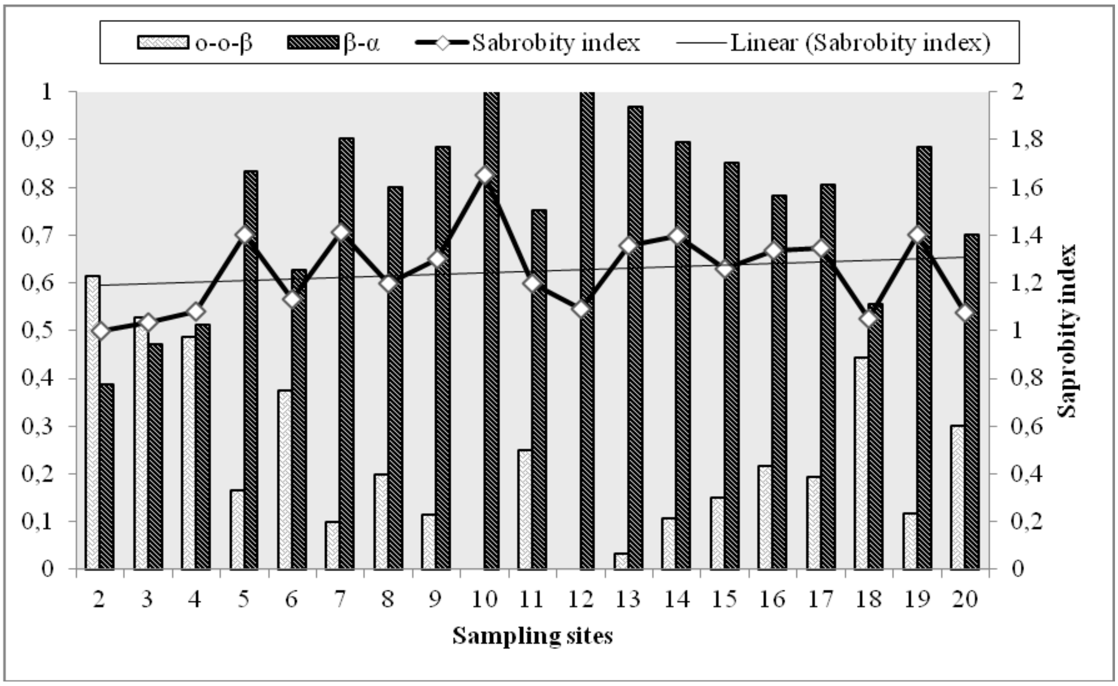

Fig. 3. Percentage distribution of the zooplankton abundance according to saprobity and saprobity index in August 2012.

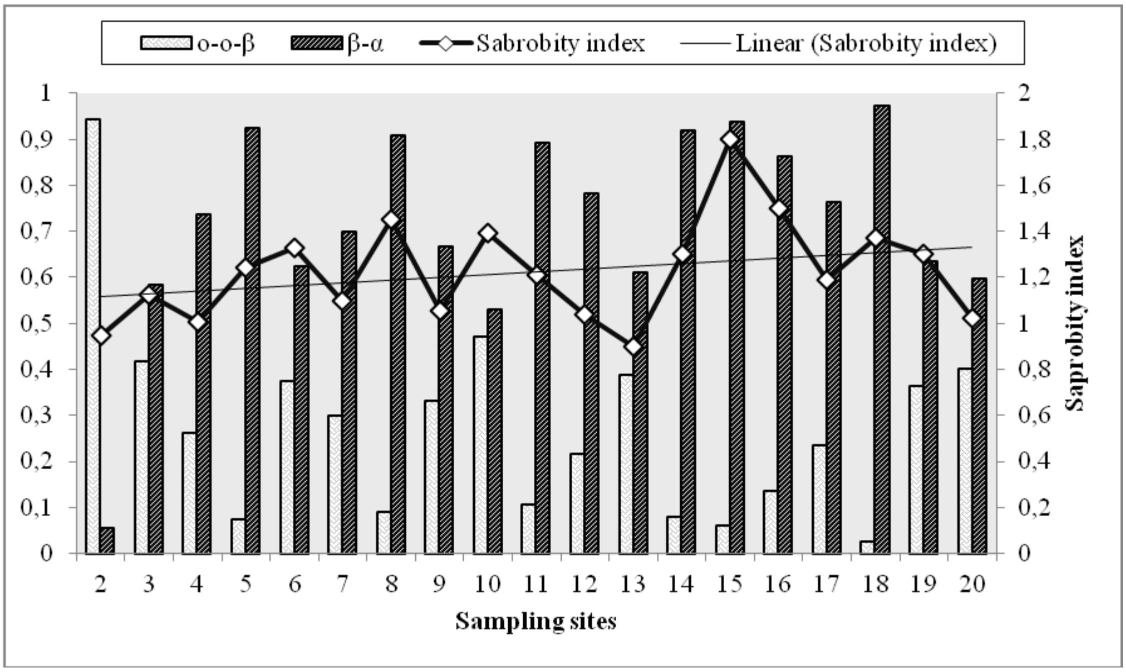

Fig. 4. Percentage distribution of the zooplankton abundance according to saprobity and saprobity index in June 2012.

IV Conclusion

The Rezekne River saprobity varies from o – saprobity to β – mesosaprobity, which points out that river water is evaluated as slightly polluted to moderately polluted.

The lowest ecological quality has the river stretch in the territory of Rezekne city, which is characterised by decrease in the total zooplankton abundance and species diversity according to Shannon - Wiener index, increase of saprobity.

Rezekne city treatment plant is not the only source of the Rezekne River pollution; it is influenced by anthropogenic impact in the whole river length.

Saprobity increases from the Rezekne River source till the river mouth, in its turn biological diversity decreases, which points out to the river's inability self-purification and pollution flows into Lubans Lake.

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