Use of Softwer Applications in Water Quality Assesment

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***Abstract*- Nowadays, we have many specific programs (software packages) which are used for statistic analysis of water quality in aquatic ecosystems. Selected parameters used in this paper are physico-chemical and biological, and are valorized on the example of the river Spreča analysis. Researches have show that there is a correlation between the physico-chemical value and biological indicators related to the assessment of the water quality of river Spreča. The composition of the zoobenthos community of river Spreča shows β-mesosaprobic character in the upper course of the river, while, according to the researches, the lower part of the watercourse shows polysaproby character. Similarity of ichthyopopulation on localities of research is tested by the Bray – Curtis similarity cluster analyses, which have shown that the greatest degree of similarity is visible in localities 1. and 3. In a special group are separated samples from the site 4. and 5. with a degree of similarity of 93,86%. Shanon-Waever's diversity index was calculated for all 6 sites researches.**

***Keywords*: Spreča, BioDiversity Pro 2.0, zoobenhtos, ichthypopulation, water quality.**

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1. Introduction

Biological research of the world, including Bosnia and Hercegovina in recent years has taken on the character of complexity, which is among other things reflected in the use of various softwer applications and tools in order to reach the best possible and reliable results. Application of modern methods in the analysis of biological material has contributed to the actualization of computer application softwer and that lead to the establishment of a separate discipline, bioinformatics. This discipline, except from information science and biology, includes mathematical knowledge, on which basis changes and events in the living are presented through mathematical forms. The application of softwer is particulary important in numerous cases where life and life occurances shall be "translated" into numbers. It is generally known that the quantitive and qualitative characteristics can be presented numerically. One of the first computer applications that is used in biological research is Microsoft Office Excel. This program still represents the basis of any biological research in which are usually processed the basic computational steps such as the medium, minimal and maximum value of a parameter, standard deviation, the median or even more complex tasks after a certain programing formula for calculating the same. Its particular importance is reflected in the possibility that certain biological parameters can be presented in tables and charts. Because of these features and capabilities, *Microsoft Office Excel* has a wide application in the bilogical researches today. Softwer called *BioDiversity Pro* 2.0 also found a wide application in biological researches(McAleece, et all. 1997**).** [1]
It can be said that this program has a primary use in the biological research and that it is made for this purpose. This statistical package enables the

assesment and calculation of the diversity by species or samples. The graphical representation helps descriptive statistics in many ways, and it is possible to correlate different factors. Water is a priceless gift of nature for man as well as for the rest of the world. Water from the seas and oceans has a huge importance to the humans. One way of successful ecosystem management and rational use of marine ecosystems represent mathematical modeling (Fulton et al. 2011). [2]

The use of spatial planning for multi-use zoning of marine areas is growing in both developed and developing countries. Comprehensive maps of marine resources, including those important for the management of local fisheries and the conservation of biological diversity, provide a key foundation of information for the planning process. Using a combination of field and high resolution satellite spatial data, using an empirical method for creating bathymetry map (RMSE 1.76 m) based on objectiv image analysis to produce precision MAPAZ geomorphological classification of benthic coral (Kappa values of 0.80 and 0.63, 9:33 pm, respectively) traditionally covers a large (> 260 km2) area of fisheries on the islands of Fiji. From these charts we derive information about the wealth of habitats, structural complexity, coral cover and its distance from the mainland, for which the use of this variable as input to models for predicting fish species wealth, diversity and biomass (Knudby et al. 2011). [3]

However, the available quantities of quality drinking water, in the nature and in the economy are insufficient. Nowadays, we have a growing problem of providing clean, drinking water as well as clean water for the economy. The possible solution, with a schematic plan of usage for development and protection of water, and water purification with the particular emphasis on the permanent monitoring of water quality is the continuous monitoring of water. The status of water in Bosnia and Herzegovina is such that measures as the one on the global level must be taken. In the area of Tuzla region, supply of drinking water is not on the statisfactory level, and in some areas it takes the critical proportions. In order to improve the supply of population with drinking water and water supply for industry of Tuzla and Lukavac, upstream from the strait Modrac in the central part of the basin of the river Spreča, an artificial lake Modrac has been made and put into operation in the year of 1964 (Skenderović, 2016**).** [4]

The diversity of biological system is the best indicator of the state of the environment. The impact of man on the environment is continous and usually not in conformity with environmental laws that govern nature. Similary, the living world of Bosnia and Herzegovina has not been spared from the adverse anthropogenic influence. Evaluation of the water quality is determined by physical, chemical, biological and hydrobiological analysis (Nalić, 2013).[5]

Many informations have been taken into consideration such as: suspended solids expressed in mg/l, remainder of total evaporation in mg/l, dissolved oxygen in mg/l, biological oxygen demand during five days (BOD 5 mg/O_2/l/, saprobity level, productivity level (for lakes), maximum number of coliform bacteria in 100 ml of water, vissible matter, color, odor and pH. Water represents the most important factor for living beings but, today, the biological effects of pollution of natural waters are numerous and varied. Nowadays, limnological researches are intensified, worlwide as well as in our country, therefore biological researches are the most reliable indicator in water quality assesment. The sole purpose of biological water assesment is not only in scientific research but it also provides us with important information about the water quality. Based on the analysis of bilogical research that involves the investigation of the plant composition and animal communities, the environmental situation has been established, which also points to the biological quality of water. Biological water analysis provides important information for assessment of the intensity and the size of contamination. Biological methods are used for the valorization of water quality and through their application and explication as well as the exactness of results, informations are presented to those who are not biologist, and whose area of work is not closely connected with the problem of contamination of hydrosystem waste (Imamović, 2013). [6]

In the area of Tuzla Canton as well as in Bosnia and Herzegovina, facilities for wastewater treatment are almost non-exsistent, so that wastewaters are discharged into surface water without treatment. From a total number of 122 facilities for treatment of industrial water, fifty (50) were successful, but today few of the facilities are operative (Kupusović et all.,

2010**).** [7] By the year 1992, systematic testing of surface water quality was carried out, however, the systems of measuring stations were destroyed during the war. Today, the system of measuring stations is gradually renewed so that at certain larger watercourses the monitoring of water quality is established. (Kupusović et all., 2010**).** [7] Some authors such as Petitgas (2001) discuss various geostatistical models that characterize the spatial variation of the design of different research in fisheries. Also considered is the expected development of geostatistics which relates to multivariate structure, temporal variability and the adaptation of sampling. [8]

The processes based on mathematical modeling are a valuable tool for informing such decisions, because the measurement data are often rare and can not be extrapolated to study the environmental impact of various policy options. Here, we bring together previously developed and evaluated modeling framework for basins, water bodies, and food web bioaccumulation of mercury (Knightes et al. 2009). [9]

During water quality monitorng, an important position occupies statistical analysis of data, using specific software as well as interpretation of the obtained values.

2. Materials and methods

For the purpose of this paper results of community organism analysis of the river Spreča from 2015 and 2016 were analysed (Skenderović, 2016.).[4] Fishes are divided in six sites, relevant to the needs of researches by using the generating aggregate type ELT 62 II GI power 3 kW by using standing triple network type with different sized meshes, as well as by using fishing gear and accessories. Research sites are located on the longitudinal profile of the upper river Spreča. The 1st site – delta of Spreča to Modrac Lake, next site (Strašanj) Živinica areas. The middle flow of the river Spreča includes two sites: site of Ciljuge, site of Pjernice and site of Crne Bare.

Near the river Kalesija is the sixth site (Mandura), closer to the source area of these streams.

Samples of betos were taken using standard methods of Surber netand kick - sampling method. The physical - chemical analysis of water from three characteristic sites of the researched parts of stream was conducted by the Institute of Public Health of Tuzla Canton.

Application of Softwer BioDiversity Pro

Softwer *BioDiversity Pro* (McAleece, et all. 1997)[1] is statistical softwer package for Windows PC that allows computation of numerous measures of differences that need to be calculated for the appearance of the taxon to the samples. This softwer is free and very useful for many researches in the world. It is used in the cases when the descriptive statistic, graphical presentation of data on individual taxa or living communities is needed. Besides, by using this program, it is possible to compute a rank correlation, variance and covariance, cluster analysis, Kulczyński, Mann-Whitney index and many other parameters. Program works in such a way that after sample data input automatically calculates and provides data on descriptive statistics. Afer that process, graphical presentation of the entered data is possible and available. BioDiversity Software is to calculate the diversity index of biological communities for which key parameter is the number of species in a locality and their total number in the habitat. Understanding of these indices requires the understanding of the following terms: the wealth of species and their uniformity. If a sample contains more species, the sample will be richer. Sample which has similar number of individuals of certain species, will have a greater uniformity. These parameters are commonly used to handle large data bases and with additional data (eg. physical-chemical parameters) can play an important role in determining the ecological status of the area of research. Preprocessed results are analyzed by cluster analysis based on Bray – Curtis index of diversity (Bray and Curtis, 1957), [10] which shows the similarity in composition of the organism of population between the research sites. Obtained results for each locality research are followed by the examination of the diversity of the biocenosis communities researched by Shannon-Weaver index (H) (Shannon and Weaver, 1949), which uses the relative diversity abudance for individual taxa[11] .

The first step is calculation of P_i for each category (e.g. species). Then the result is multiplied by the logarithm of the number. Natural logarithm is commonly used. Index is calculated from the sum of negative numbers.

$$H' = -\Sigma Pi \log_2 Pi$$

Value of P_i is the density of single taxa (i.e. Total number of individuals and total biomass) in comparison to the combined. Formally, it will be as follows:

$$P_i = n_i/N$$

Where N is total number of individuals of a particular specie.

H' – the value of diversity index,

Pi – the relative representation of i taxon in the sample; $\log_2(x)/\log^2$

3. Results and Discussion

To assess the ecological status of river Spreča, during research period, pshysico-chemical and biological analysis of water were done.

Physico-chemical characteristics of water

Consideration of physico-chemical parameters of water, which also create a set of abiotic factors, has a great importance to ecological- ichthyological research in aquatic ecosystems.

For the purpose of this paper, two physico-chemical analysis of water have been carried out. In addition to this, sites forphysico-chemical analysis of water were selected with aim to determine the impact of wastewaters (water from households, industrial wastewaters, water from agriculture and radioactive waters)

In the lower and upper parts of the river Spreča, analyses of physico-chemical characteristics of water have been carried out by Public Health Department of Tuzla Canton in Tuzla Municipality. Water of lower flow part is yellowish, with pH value to 8,0. Water contains nitrate to 1,911 mg/l and nitrite to 0,005 mg/l.

The content of sulfate is 19,91 to 27,64 mg/l. $KMnO_4$ consumption is increased to 17,12 mg/l. BPK_5 ammounts from 0,79 to 0,92 mg/l. The suspended matter amounts from 96 to 120 mg/l. The content of oxygen is higher in water with lower temperatures, so on these sites it is from 20,90 to 24,60 mg/l. Increased amounts of suspended matter are observed after receiving wastewaters from furniture factory ,,Konjuh - Živinice" and the sewage Živinice. Similar results were obtained in the area of Kalesija (L- 6).

According to the categorization of water flow , which was based on physico-chemical analysis and other indicators, the upper flow of river Spreča belongs to the second class of water quality. The water quality of the upper flow of Spreča upstream from reservoir Modrac (after flows into Gostelje) is far below the categorization because in Oskov and Gostelj there is flow of wastewater separation of mines Banovića and Đurđevika, timber industry ,,Konjuh" in Živinice. All the way to the point of water sampling, the water quality is rapidly deteriorated in this part of the basin, particularly in terms of suspended matters which mainly come from sludge, separation of coal, so that high content of suspended matters classiflies upper flow of basin Spreča into IV quality class (Cvijić and Tomec,1975). **[**12**]**

The state of suspended matters in watercourses is constantly changing, therefore the state of water quality in some places of the hydrosystem depends on the time and the method of sampling.

Biological indicators of water quality

Biological assessment of aquatic ecosystems is based on mutual influences of organism communities and biotopes, as well as complex relations prevailing within the ecosystem and specific responses of acquatic organism to the change of physico-chemical factors (Nalić, 2013.).[5]

Macroinvertebrates of zoobenthos of river Spreča

In order to achieve reliable assessment of water quality of the river Spreča, the processing of zoobenthos, collected from the top, middle and lower part of the researched part of river Spreča have been carried out. The material was taken from Surber net. The conducted analyses of zoobenthos show a change in the schedule of the individual in the longitudinal profile of river

Spreča. Analysis results reveal that the phenomenon in the lower and middle watercourse is dominated by representatives of Insecta: Diptera, Plecoptera, Trichoptera, several individulas of Hirudinea, some representatives of Gastropoda, as well as several representatives of Oligochaeta from the family

Tubificidae. The upper flow of Spreča is characterized by the representatives of Diptera and *Simulium* sp., then a few representatives of Trichoptera and significant number of crabs from the genus *Gammarus* which is present throughout the entire flow of the river. Similar data are obtained by Habdija et. all. (1983). [13]

The composition of zoobenthos shows β-mesosaprobic character in the upper flow of the river, and in the middle flow shows α-mesosaprobic character. Water quality of the researched flow of the river Spreča upstream from the reservoir Modrac after the flow into Gostelje fall, because Gostelja and Oskovo are burdened with waterwaste from the coal Đurđevik and Banovići, and the wood industry „Konjuh" Živinice as well as waters from the sewage network of the village. Water quality has deteriorated rapidly in this part of the basin, and because of the suspended matters classifies the upper flow of the Spreča river in the IV quality class.

The level of diversity of ichthyo-population of the river Spreča

The conducted researches show richness of the river Spreča with fish species. Based on the basis of the ichthyo research it is determined that river Spreča is inhibited with 16 species (subspecies) of fishes from five families. By the number of identified species, the most numerous family is Cyprinidae which is represented by 10 species. From cyprinidare is presented the Danube barbel – *Barbus balcanicus* (Kotlik, Tsigenopulos, Rab & Berrebi, 2002), gudgeon – *Gobio obtusirostris* (Linnaeus, 1758), bream – *Abramis brama* (Linnaeus), 1758), wagtail – *Alburnoides bipunctatus* (Bloch, 1782), bleak– *Alburnus alburnus* (Linnaeus, 1758), minnow – *Rhodeus amarus* (Bloch, 1782), roach – *Scardinius erythrophthalmus* (Linnaeus, 1758), sneep – *Chondrostoma nasus* (Linnaeus, 1758). Apart from the listed species and subspecies of cyprinid fishes, the presence of roach was noted – *Rutilus rutilus* (Linnaeus, 1758), as well as chub – *Squalius cephalus* (Linnaeus, 1758). In the total catch of the family Esocidae, Cobitidae i Petromyzontidae are presented with one specie, or 7,7%, the family of Percidae is presented with three species or 15,38% while the family of Cyprinidae is the most numerous and with recorded ten species takes a share of 61,53% in the total catch. On the site 1 – delta of Spreča in the Lake of Modrac 220 (28, 20%) specimens of fish were caught and they are grouped into seven different types, on the 2nd and 3th site of the area Živinica and the village of Dubrava from the river Spreča nine kinds of species of fish were caught with 95 individuals or 12,17%. On the 4th site– Pjernice, 12 species were analysed with 150 individuals or 19, 23% participation in the ichtyo sample. On the site of Crne Bare (area village D. Rainci) 115 fishes were caught (14, 78%) with different fish species (9 species) and on the site of Mandura are recorded 105 (13, 46%) species of fish from 7 different kinds. On this part of river Spreča, based on longitudinal fish schedule, water stream can be divided into two streams, in which there is no sharp boundary (Kerovec, 1988). [14].

The first zone is barbel zone (*Barbus barbus)*, it concides with the upper flow of the river, common species along with the barbel are: chub, clamp, perch, trout, roach, bleak. This zone extends from the area of Donji Rainci (L – 5) to the spring of the river Spreča. Behind the barbel region, spreads the bream zone (*Abramis brama)* or cyprinid region which includes middle and lower streams of the river, where the speed of the river is small, the bottom is muddy-sandy

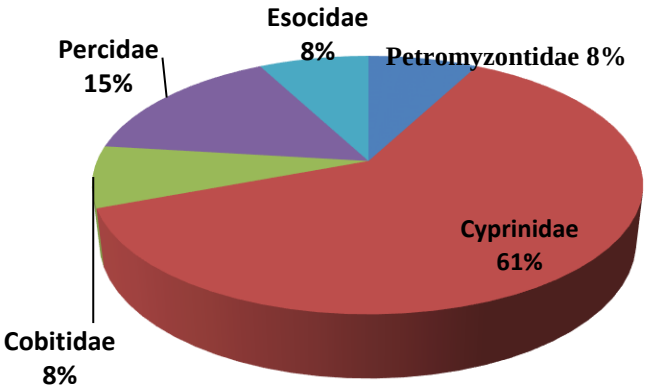

Chart 1. The relative number of families in the total of ichtyo sample

and ocassionaly occur situations with very low values of dissolved oxygen. Part of the river Spreča with such characteristics of the watercourse and characteristic types of the beacon spread from site 1 to site 5. (Matoničkin and Pavletić, 1972). [15]

According to Hristić (1982), [16] running waters, in fishing terms, are divided into four regions: salmonid, grayling, barbel and cyprinid region. And thus Spreča being the main running water in this

area, on its way from spring to the mouth, provides various conditions for the living of certain species of fish. According to Zelinka (1971), [17]

Spreča above Osmaka has a small fall and its spring is not far away. Life community indicates that the water is clean, and the temperature of the water only in short-time can exceed 20 C, these are characteristics of oligo saprobic water, which are very favourable conditions for grayling. In this part of river Spreča, the breeding of trout is not possible because the quantity of oxygen is 4 mg/l, and the trout does not allow long time falling of oxygen value below 8 mg/l. Spreča, downstream from Kalesija to the mouth of river Small Spreča (from site 6 to site 4), has a favourable characteristics for barbel (barbel zone). Further downstream there is a region of bream, till the mouth of Gostilje into Spreča (site 2), with sandy or muddy bottom, this section of water has β- mesasaprobic character. Zelinka (1971) [17] falls down to Spreča, under the dam of Modrac Lake, this part is inhibited with fishes from the brook barbel and the bream zone. According to data on the composition of fish communities inhibitating river Spreča, on the broader area of Doboj, the most common region is cyprinid region.

According to Hristić (1982), [16] characteristics of running water of cyprinid region are slow flow of water, lower shores, and expressed flood zone. These are the main characteristics of the hydrological conditions of the fisherman region. Flood zone is particulary important for the expression of natural production of the fish habitats. This arragement of individual fish species in the river Spreča, with minor variations, is the expected distribution of species already established by characteristic region.

After qualitative-quantitative analysis of fish specimens caught on sites of research, an analysis of differences of researched ichtyo-population for the researched upper flow of the river Spreča was conducted. In order to observe the complete picture of ichtyo-population of the river Spreča, culster analysis is done, which also represents statistical technique for identifying relatively homogenous group of ichtyo-population. Cluster analysis of ichtyo-population was carried out on the basis of Bray- Curtis similarity index (Bray and Curtis, 1957).[10] Conducting a cluster analysis we tried to determine the degree of similarity or at least the difference between the fish community at different sites of the research. According to the data presented in Tables 1. and 2., it is clear that according to the diversity of the present species of the fish, the most similar sites are L1 – the mouth of Spreča into Modrac Lake and L3 – site of Ciljuge with similarity percentage of 98,73%. Site similar to them is site 2 (Strašanj) 93,73% and the site of Mandura (L6) with similarity of percentage in the amount of 93,07%. Sites of Pjernice (L4) and Crne Bare are separated into group with similarity percentage of 93,83%.

Tabel 1. The similarity of certain sites of fish cathes based on present fish species

Step	Clusters	Distance	Similarity	Joined 1	Joined 2
1	5	1,2603209	98,7396791	1	3
2	4	6,13633633	93,8636637	4	5
3	3	6,26192617	93,7380738	1	2
4	2	6,92007017	93,0799298	1	6
5	1	14,6453714	85,3546286	1	4

Tabel 2. Percentage of similarity between sites based on diversity of fish cathes

Similarity Matrix	L1	L2	L3	L4	L5	L6
L1	*	93,7381	98,7397	73,4835	79,2827	91,8267
L2	*	*	92,4837	79,4034	85,3546	85,6383
L3	*	*	*	72,3157	78,0796	93,0799
L4	*	*	*	*	93,8637	66,0461
L5	*	*	*	*	*	71,5905
L6	*	*	*	*	*	*

Results of diversity of the researched fish population by sites are presented in the chart 2. As seen in the chart, the greatest degree of similarity have fish samples caught on the site of the mouth of river Spreča into Modrac Lake (L1) and Ciljuge site (L3). Ichtyo sample caught on the Strašanj has smaller index of similarity (L2) and even lower index of similarity has a sample from the site Mandura (L6). In a separate group are distinguished samples from sites Pjernice (L4) and Crne Bare (L5) with high level of similarity 93,86%.

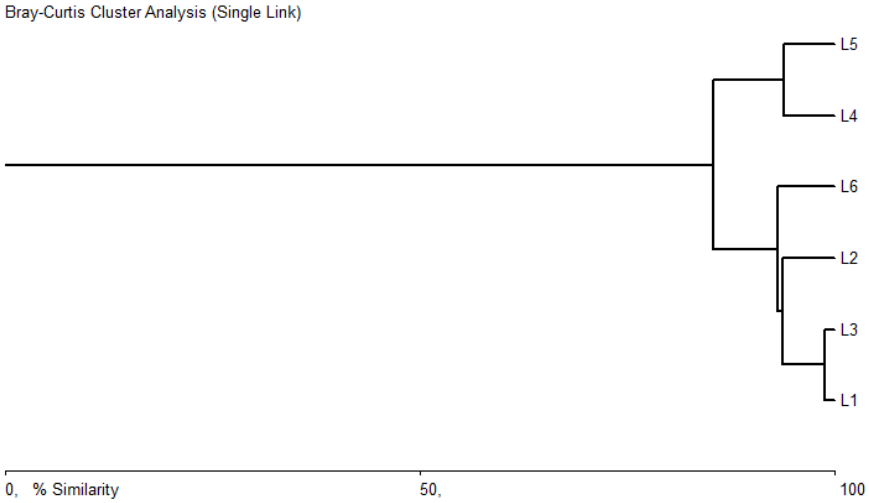

Chart 2. Preview of cluster analysis of ichtyo fauna samples of the river Spreča

Similar index value of diversity is obtained on the other sites of research which is shown in Table 3. Obtained value of diversity index between one and two sites of research indicates
to gross water pollution, with the exception of site 4 which has a determined index of diversity above 2, indicating to a small level of water pollution. Diversity of ichtyo-population based on sites of research is shown by Shannon – Weaver index of diversity. When using this index all taxa have to be brought to the same level. In this case Shannon – Weaver index of diversity is calculated by the level of species. Diversity analysis has been done for all six sites, and the results are shown in the table 3. and chart 3. Based on the result of diversity index it can be concluded that they are quite different on some sites of research which indicates heterogeneity of researched ecosystems of ichtyo-populations.

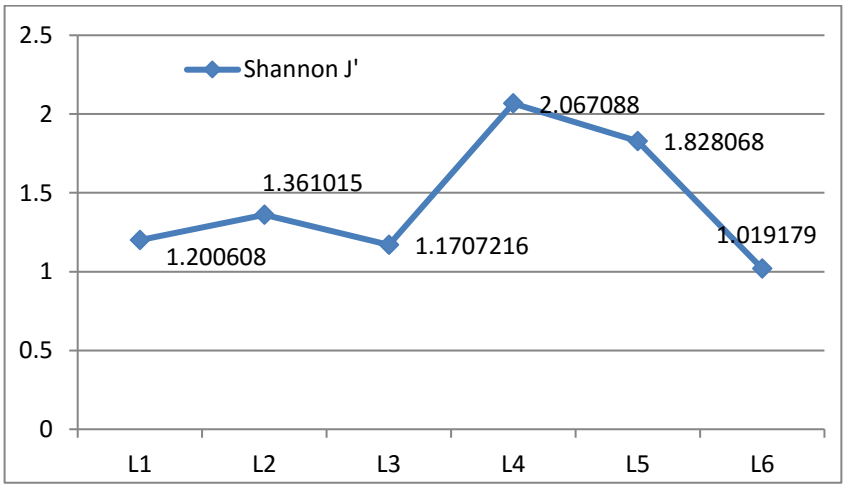

Chart 3. The value of Shannon – Weaver index based on site research

The diversity index from the site Pjernice (L4) indicates the highest value (2,067088) which means that the fish population is most developed in the sample from this site.

Lower values of diversity were registered on the Mandura site (L6) whose amount is 1,019179.

Our research has shown that there is a correlation between the biological and the physico-chemical parameters of water quality of the river Spreča. The use of Shannon Index (index fish community diversity) or number of individuals (total abundance) of fish community, as environmental objective, GP identify the most ecologically relevant hydrological indicators (ERHIs) of 32 indicators of hydrological change, for the case study sites, the upper Illinois River (Yi-Chen et al. 2008). [18]

Tabel 3. Sites of research with Shannon – Weaverovim index of diversity

Index	**L1**	**L2**	**L3**	**L4**	**L5**	**L6**
Shannon J'	1,200608	1,361015	1,170722	2,067088	1,828068	1,019179

4. Conclusion

This paper describes the importance of the softwer application in the assessment of water quality. Using an example of the river Spreča we have shown the application of *BioDiversity Pro*softwer–statistical softwer package in the assessment of water quality. Based on physico-chemical analysis and other indicators, upper flow of the river Spreča belongs to the second class of water quality. The composition of the zoobenthos of the river Spreča shows β-mesosaprobic character in the upper flow, going to the mouth of the river, the lower flow shows polysaprobic character. Based on the longitudinal schedule of fish, Spreča can be divided in two zones, first zone is zone of barbel and corresponds to the upper flow of the river (from site 5 to spring zone).

Behind the barbel region spreads the bream zone or cyprinid region that spreads from site 1 to site 5.

Cluster analysis shows that the most similar by the diversity of fishes are sites L1 – the mouth of river Spreča in Modrac Lake and L3 – Ciljuga site with the precentage of similarity of 98,73%.

In the special group are seperated samples from sites Pjernice and Crne Bare with level of similarity of 93,86%. Based on the results of Shannon – Weaver diversity index, it can be concluded that the greatest value of diversity are (2,067088) from Pjernica site (L4), and the lowest values of diversity are registered on the Mandura site (L6). Conducted researches have shown that Spreča river, regarding relevant hydrographic, physical, chemical and biological parameters represents ecosystem that can be categorized as mesosaprobic, aquatic ecosystem. The results of research show to the necessity of continuous monitoring implementation aiming at timely forecasting of changes in water quality by using application of appropriate softwer package.

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