

Statistical Data on Macro Invertebrates' Seasonal Distribution in Erzeni River, Albania, During 2011 - 2013

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ABSTRACT: Erzeni River flows in central Albania. The geographical position and geologic composition of the River basin have a specific study importance. In this study macro invertebrate fauna composition and the water quality assessment have been carried out for the monitoring period 2011 – 2013, in three sampling stations. The study presents the aquatic ecosystems situation based on data gathered on invertebrate fauna. Invertebrate fauna distribution into the River basin has been statistically analysed and seasonal distribution of benthic macro invertebrate taxa has been assessed. For the data interpretation has been considered as well the tolerance of macro invertebrate groups toward water pollution; they are good indicators of biodiversity and habitat quality and their presence is closely connected with the general ecological status of the river ecosystem. [34]. Benthic macro invertebrates are determined as crucial elements and have a great importance in the biological assessment of water quality (Water Framework Directive - WFD). Statistical evaluation of invertebrate population distribution has been carried out using the non parametric Mann – Whitney Test.

KEYWORDS: Sensitive species, Mann-Whitney Test/U Test, seasonal distribution, statistical data.

I. INTRODUCTION

Image Erzeni River flows in an area with sandy – clay deposits and this occurrence shows a close connection between habitat and benthic indicators and widely between hydrology and biodiversity [56]. Benthic invertebrates have a double role of a direct consume (respiratory and alimentary) and fragmentation of particles into simple substances, taking in consideration the transferring process and elaboration of organic material present in running waters. Macro invertebrates are good indicators of water quality in particular and of environmental conditions in general. Their life cycle is closely connected to the aquatic ecosystem changes, which are reflected in variations of individual density level, species abundance or different values of quality indexes. The importance of invertebrates as biological indicators of water quality has been one of the reasons for studying their seasonal distribution in the defined monitoring stations. The study provides data on benthic invertebrates' distribution in River Erzeni. Benthic invertebrates' communities' distribution in different seasons has been assessed using Mann-Whitney Test/U Test. Samples are taken at the monitoring stations, during 2011 – 2013. Furthermore, the study helped in understanding that sensitive taxa toward water pollution are as well sensitive toward climate changes.

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II. RELATED WORK

Sampling

The sampling method of aquatic macro invertebrates is based on the methods according to [10], [17], [36], [3], [4], [5], [6], [7]. Benthic invertebrates were taken from the river bottom (40 – 60 cm) with a kick - net in order to gain sufficient samples from larger depths of water. The net is held upright on the stream bed by one individual, while the stream bottom upstream of the net is physically disrupted by a second individual. Kicking and turning over rocks and logs with the feet and hands dislodges organisms which are washed into the net by the current. The samples were collected from areas of differing current speed. In very small streams or in sandy areas lacking riffles, kicks are taken from root mats, snags or bank areas. All types of benthic macro invertebrates were collected by this sampling device, but method emphasizes species that live in fast flowing water. This technique gives consistent results [26], [2] and it was used to gather good results during the investigations in three monitoring stations at Erzeni River, Albania: Mullet – station one, Damjan - Fortuzaj – station two and Shijak – station three. The monitoring stations are selected based on geographic expansion of the River flow and the relations between the river stations and surrounding urban areas. Also the villages have a considerable number of inhabitants. The kick - net method takes the quantitative aspect into account, if the necessary experience is present [49]. In addition sampling plots were taken to be representative whereas within a station were taken three randomly samples, according a seasonal calendar during the period 2011 - 2013. The field work is organized in daily expeditions, one for each season. To take one sampling plot are needed 30 sec and per each field trip are taken 3 of them in different stations. All benthic macro invertebrates are kept in 95% ETOH. Before mailing the jars are completely filled with alcohol to reduce damage to the specimen. They then are carefully packed with enough packing material to prevent breakage. Lab sheets and all the associated material is conserved in the laboratory. For the identification of benthic invertebrates are used different publications as [67], [19], [24], [38], [29], [62], [11], [48].

Statistical analyses

Mann-Whitney Test is used to assess the difference between distributions of two populations; in cases the samples are taken randomly and independently and there is at list an order level. Mann-Whitney Test is the alternative of Student Test (used widely in many literatures). Student Test is used in cases of normal distribution of samples and equal samples variance. In cases of comparison of two samples with a very small number of elements and their distribution is unknown, the use of Mann-Whitney Test is fully justified.

Preliminary or zero Hypothesis: Populations from which are taken the samples are identical.

Alternative Hypothesis: The populations are not identical.

Hereinafter we emphasize that this method is not carried out through the means of the populations respectively, as both distributions might have the same mean, but might be in completely different forms. So theoretically it is possible to obtain a statistical significant result through U Test even when the two population means are the same.

Calculation:

Na – number of first group values

Nb - number of second group values

1. The values are ranked from the smallest to the biggest (taking in consideration that in this order the value corresponds to the groups named A and B)
2. The ranked values positions are summed; e.g. A – the sum is named Ta.
3. The statistic U_{obs} Mann-Whitney is calculated

$$U_{obs} = Na.Nb + Na(Na+1)/2 - Ta$$

The calculated value U_{obs} is compared to the table value of Mann – Whitney for the values couple Na and Nb.

III. EXPERIMENTAL RESULTS

Through the non parametric U Test/ Mann-Whitney is shown the difference between the distributions of the identified macro-invertebrate families according to different seasons. The comparison of families is done in pair basis – comparing the same benthic macro invertebrate family distribution in two different seasons.

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The following tables present the population distribution of invertebrate families in different seasons in Erzeni River, Albania. Table 1 shows the difference of macro invertebrate families' distribution from spring to summer for the monitoring period 2011-2013 at three monitoring stations of Erzeni River, Albania.

Invertebrate taxa which appear to have significant differences in their seasonal (Spring/Summer) distribution are mainly the families of *Ephemeroptera* Order (*Oligoneuridae*, *Ephemerillidae*); Close to the significant difference appears to be *Heptagenidae* taxa/*Ephemeroptera* order. *Ephemeroptera* Order is included into the benthos sensitive group toward water pollution [20], [21], which means that this taxa shows sensitiveness even towards climate conditions, in the present case towards temperature, precipitation and solar radiation [50]. Significant differences for the seasonal distribution show as well population of *Trichoptera* Order/ *Hydropsychidae* Family; the taxa is classified as medium tolerant taxa toward pollution [20], [21] and the optimal period for its growth is summer season [50]; anyhow *Trichoptera* taxa reflects very well climate changes through its population distribution from spring to summer.

Table 1: Calculation of the distribution difference of benthic macro invertebrate populations during spring and summer through U Test at Erzeni River, Albania

		Test: 0-9														
		Test U : $\frac{Na \cdot Nb + Na(Na+1)/2 - Ta}{\sqrt{Na \cdot Nb}}$														
		1	2	3	4	5	6	Ta	Test U	Na	Nb	Na(Na+1)/2	Ta			
Spring	Heptagenidae	24	33	51									6.5	15	8.5	Close to significance difference
Summer	Heptagenidae	51	108	54				51	54	108	15		0.5			
Spring	Oligoneuridae	18	19	21				18	19	21	15		15		0	Significant difference
Summer	Oligoneuridae	0	0	0	0	0										
Spring	Ephemerillidae	24	27	30	24			27	30				6	15	9	Significant difference
Summer	Ephemerillidae	195	255	306				195	255	306	15				0	
Spring	Baetidae	24	57	213				24	57	213			13	15	2.5	
Summer	Baetidae	0	15	213	0	15				213	8.5				6.5	
Spring	Chironomidae	45	15	18	15	18			45				8	15	7	
Summer	Chironomidae	19	28	125				19	28	125						
Spring	Ceratopogonidae	18	21	27				18	21	27			12	15	3	
Summer	Ceratopogonidae	81	9	9	9	9				81						
Spring	Physidae	0	0	0	0	0	0						12	15	3	
Summer	Physidae	0	1	0				0	0	1						
Spring	Gomphidae	0	3	0	0	0				3	11		15		4.5	
Summer	Gomphidae	3	0	0				0	0	3						
Spring	Hydropsychidae	0	0	66	0	0	66						6	15	9	Significant difference
Summer	Hydropsychidae	159	75	144				75	144	159	15					
Spring	Haplotaxidae	0	0	0									15	15		
Summer	Haplotaxidae	0	0	0	Non sesne/ no values											
Spring	Tabanidae	0	0	0	0	0							7.5	15	7.5	
Summer	Tabanidae	0	5	15				0	5	15						

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Seasonal distribution of identified taxa during the monitoring period in Erzeni River, Albania shows the individual number variation due to climate conditions changes along the aquatic ecosystem. Climate theories pay particular attention to climate conditions and their favourable or inhibitory action into the invertebrate population dynamics [46]. It is known the direct influence of solar radiation, temperature, humidity, precipitation, etc. at different seasons on the invertebrates' growth, vitality and reproduction. Generally it is accepted the influence of the climate factors complex on the invertebrates' biology [46], [66]. Seasonal type of individual number dynamic is characteristic for species with significant population density growth during a determinate season; the individual quantity of this type can increase too much during the vegetation period corresponding spring or autumn, reproducing the species each year [50], [46]. It is important that for the invertebrates, especially insects, which link a part of their life to the aquatic ecosystem, factors such as temperature, chemical parameters and dissolved oxygen into the water are considered as vital factors.

Table 2: Calculation of the distribution difference of benthic macro invertebrate populations during summer and autumn through U Test at Erzeni River, Albania

													Test: 0-9	
						1	2	3	4	5	6	Ta	Test U :Na*Nb+Na(Na+1)/2-Ta	
Summer	Heptagenidae	51	108	54			51	54		108		10	15	5
Autumn	Heptagenidae	72	48	153	48				72		153	11		4
Summer	Oligoneuridae	0	0	0		Non sesne/ no values							15	15
Autumn	Oligoneuridae	0	0	0										
Summer	Ephemerillidae	195	255	306					195	255	306	15	15	Significant difference
Autumn	Ephemerillidae	0	0	0	0	0	0					6		9
Summer	Baetidae	0	15	213	0			15			213	10.5	15	4.5
Autumn	Baetidae	0	34	63		0		34	63			10.5		4.5
Summer	Chironomidae	19	28	125	19	28				125		8	15	7
Autumn	Chironomidae	45	58	175			45	58		175				
Summer	Ceratopogonidae	81	9	9		9	9				81	11	15	4
Autumn	Ceratopogonidae	16	6	42	6			16	42					
Summer	Physidae	0	1	0	0	0				1		10	15	5
Autumn	Physidae	15	0	0			0	0			15			
Summer	Gomphidae	3	0	0	0	0	3					7	15	8
Autumn	Gomphidae	4	3	3				3	3	4				
Summer	Hydropsychidae	159	75	144		75				144	159	13	15	2
Autumn	Hydropsychidae	42	81	100	42		81	100						
Summer	Haplotaenidae	0	0	0		Non sesne/ no values							15	15
Autumn	Haplotaenidae	0	0	0										
Summer	Tabanidae	0	5	15	0				5	15	13	15	15	2
Autumn	Tabanidae	0	2	0		0	0	2						

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From summer to autumn the only taxa showing significant differences on the seasonal distribution is *Ephemerillidae* Family / Order *Ephemeroptera*, which is classified as a very sensitive taxa toward pollution [20], [21] and according U Test appears to be sensitive toward abiotic changes as well.

The significant difference of seasonal distribution for sensitive benthic taxa occurs also due to the pollution concentration into the water during the elevated temperatures and missing precipitations (warm seasons – spring, summer, autumn), which cause water vaporisation, decrease of water quantity into the river basin and as consequence eutrofication of the aquatic ecosystem.

The following table shows the distribution of invertebrate taxa during autumn and winter.

Table 3: Calculation of the distribution difference of benthic macro invertebrate populations during autumn and winter through U Test at Erzeni River, Albania

													Test: 0-9	
													Testi U :Na*Nb+Na(Na+1)/2-Ta	
													Significant difference	
		1	2	3	4	5	6	Ta	15	15	0			
Autumn	Heptagenidae	72	48	153				48	72	153	15	15	0	Significant difference
Winter	Heptagenidae	0	13	0	0	0	13					15		
Autumn	Oligoneuridae	0	0	0		Non sesne/ no values						15	15	
Winter	Oligoneuridae	0	0	0										
Autumn	Ephemerillidae	0	0	0	0	0				9	15	6		
Winter	Ephemerillidae	0	0	11			0	0	11	12		3		
Autumn	Baetidae	0	34	63	0		34	63		10.5	15	4.5		
Winter	Baetidae	0	33	123		0	33			123		15		
Autumn	Chironomidae	45	58	175			45	58		175	13	15	2	
Winter	Chironomidae	21	25	75	21	25		75						
Autumn	Ceratopogonidae	16	6	42		6		16		42	12	15	3	
Winter	Ceratopogonidae	0	7	26	0	7		26						
Autumn	Physidae	15	0	0	0	0		15		10	15	5		
Winter	Physidae	16	0	0		0	0		16					
Autumn	Gomphidae	4	3	3				3	3	4	15	15	0	Significant difference
Winter	Gomphidae	0	0	0	0	0								
Autumn	Hydropsychidae	42		81	100									Close to the significant difference
Winter	Hydropsychidae	0	16	69	0	15		69						
Autumn	Haplotaenidae	0	0	0							15	15		
Winter	Haplotaenidae	0	0	0		Non sesne/ no values								
Autumn	Tabanidae	0	2	0			0	0	6	12	15	3		
Winter	Tabanidae	0	0	0	0	0								

From autumn to winter are noticed significant differences of taxa distribution for three invertebrate families; beside *Ephemeroptera* Order (*Heptagenidae* Family which has significant distribution difference and *Hydropsychidae* Family/*Trichoptera* Order which appears to be close to the significant distribution difference), there is another significant difference of taxa seasonal distribution for *Gomphidae/Odonata*. *Odonata* taxa is considered as benthos tolerant group [20], [21] and has shown differences toward significant climate conditions, mainly temperature decrease from autumn to winter season. The distribution differences of *Odonata* taxa appear to be due to significant decrease of temperature from autumn which has been pretty warm directly to low values in winter season for the monitoring period; significant differences has been also at precipitation level, solar radiation from autumn to winter.

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Based on the U Test results, it is concluded that the decrease of temperature and variations of climate conditions in general (from autumn – winter) influence the distribution of populations with medium tolerance toward pollution [20], [21], which decrease mainly due to the temperature decrease (Table 3) and other climate factors significant variation.

Table 4: Calculation of the distribution difference of benthic macro invertebrate populations during summer and winter through U Test at Erzeni River, Albania

													Test: 0-9		
		1	2	3	4	5	6	Ta	Test U	:Na*Nb+Na(Na+1)/2-Ta					
Summer	Heptagenidae	51	108	54				51	54	108	15	15	0	Significant difference	
Winter	Heptagenidae	0	13	0	0	0	13						15		
Summer	Oligoneuridae	0	0	0		Non sesne/ no values						15	15		
Winter	Oligoneuridae	0	0	0											
Summer	Ephemerillidae	195	255	306				195	255	306	15	15	0	Significant difference	
Winter	Ephemerillidae	0	0	11	0	0	11						15		
Summer	Baetidae	0	15	213	0		15			213	10.5	15	4.5		
Winter	Baetidae	0	33	123		0		33	123				15		
Summer	Chironomidae	19	28	125	19			28		125	11	15	4		
Winter	Chironomidae	21	25	75		21	25		75						
Summer	Ceratopogonidae	81	9	9			9	9		81	13	15	2		
Winter	Ceratopogonidae	0	7	26	0	7			26						
Summer	Physidae	0	1	0	0	0			1		10	15	5		
Winter	Physidae	16	0	0			0	0		16					
Summer	Gomphidae	3	0	0				0	0	3	12	15	3		
Winter	Gomphidae	0	0	0	0	0									
Summer	Hydropsychidae	159	75	144				75	144	159	15	15	0	Significant difference	
Winter	Hydropsychidae	0	16	69	0	16	69								
Summer	Haplotaenidae	0	0	0		Non sesne/ no values						15	15		
Winter	Haplotaenidae	0	0	0											
Summer	Tabanidae	0	5	15				0	5	15	13.5	15	1.5	Close to the Significant difference	
Winter	Tabanidae	0	0	0	0	0	0				7.5		7.5		

Winter 2011 – 2013 is characterized from temperature and solar radiation intensity decrease, increase of precipitation and humidity. Precipitations, especially the strong ones, cause the decrease of macro invertebrate population density; strong precipitations influence as well the aquatic vegetation coverage and river benthos due to the differences at the flow rate. However many invertebrate/insects are adapted to the climate factors through the diapauses [46]. During diapauses substances exchange process is decreased, as well the physiologic processes are carried out slowly. Differences of temperatures, solar radiations and precipitations during summer and winter, are reflected at taxa distribution (Table 4). *Ephemeroptera* Order (Families *Heptagenidae*, *Ephemerillidae*), *Trichoptera* Order (*Hydropsychidae*) and *Diptera* Order (*Tabanidae*) show significant population distribution differences in both seasons. It is important to underline that *Ephemeroptera* Order (benthos sensitive taxa – [21]) shows significant distribution differences at each season; the same significant differences from one season to another shows

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Hydropsychidae/Trichoptera taxa (medium tolerant taxa – [21]). Based on Mann – Whitney assessment it is noticed that sensitive and medium tolerant taxa toward water pollution show the same tolerance/sensitivity toward environmental abiotic conditions.

Table 5: Calculation of the distribution difference of benthic macro invertebrate populations during winter and spring through U Test at Erzeni River, Albania

													Test: 0-9		
													Test U : $\frac{Na * Nb + Na(Na+1)}{2} - Ta$		
		1	2	3	4	5	6	Ta							
Winter	Heptagenidae	0	13	0	0	0	13					6	15	9	Significant difference
Spring	Heptagenidae	24	33	51				24	33	51				15	
Winter	Oligoneuridae	0	0	0	0	0	0					6	15	9	Significant difference
Spring	Oligoneuridae	18	19	21				18	19	21					
Winter	Ephemerillidae	0	0	11	0	0	11					6	15	9	Significant difference
Spring	Ephemerillidae	24	27	30				24	27	30				15	
Winter	Baetidae	0	33	123	0		33		123			9	15	6	
Spring	Baetidae	24	57	213			24		57		213			15	
Winter	Chironomidae	21	25	75			21	25		75	13	15		2	
Spring	Chironomidae	45	15	18	15		18			45					
Winter	Ceratopogonidae	0	7	26	0		7			26		8	15	7	
Spring	Ceratopogonidae	18	21	27				18	21		27				
Winter	Physidae	16	0	0				0	0	16	12	15		3	
Spring	Physidae	0	0	0	0		0	0							
Winter	Gomphidae	0	0	0	0		0	0				9	15	6	
Spring	Gomphidae	0	3	0				0	0	3					
Winter	Hydropsychidae	0	16	69				0	16		69	12	15	3	
Spring	Hydropsychidae	0	0	66	0		0			66					
Winter	Haplaxidae	0	0	0			Non sesne/ no values						15	15	
Spring	Haplaxidae	0	0	0											
Winter	Tabanidae	0	0	0			Non sesne/ no values						15	15	
Spring	Tabanidae	0	0	0										15	

From winter to spring the temperature changes during the monitoring period, have been scarce due to the climate changes and prolongation of winter and summer, merging the intermediate seasons (spring, autumn); so the distribution differences has appeared for benthos sensitive taxa (Order *Ephemeroptera*- Families: *Heptagenidae*, *Oligoneuridae*, *Ephemerillidae*). The results obtained from the U Test (Table 5) shows the taxa sensitivity correlation between sensitivity towards water pollution and abiotic environmental conditions.

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IV. CONCLUSIONS

1. Based on the population distribution assessment for macro invertebrate taxa at Erzeni River, Albania, it is concluded that sensitive taxa toward water pollution show the same sensitiveness toward climate and environmental conditions.
2. Invertebrate taxa which appear to have significant differences in their seasonal (Spring/Summer) distribution are mainly the families of *Ephemeroptera* Order (*Oligoneuridae*, *Ephemerillidae*) (Tab. 1)
3. From summer to autumn the only taxa showing significant differences on the seasonal distribution is *Ephemerillidae* Family / Order *Ephemeroptera*, which is classified as a very sensitive taxa toward pollution [20], [21], (Tab. 2).
4. Based on the U Test results, it is concluded that the decrease of temperature (from autumn – winter) influences the distribution of populations with medium tolerance toward pollution [20], [21], which decrease due to the temperature decrease and significant variations of other climate condition (Tab. 3).
5. Significant differences of temperatures, solar radiations and precipitations from summer to winter, are reflected at taxa distribution (Tab. 4). *Ephemeroptera* Order (Families *Heptagenidae*, *Ephemerillidae*), *Trichoptera* Order (*Hydropsychidae*) and *Diptera* Order (*Tabanidae*) show significant population distribution differences in both seasons.
6. From winter to spring the temperature variation during the monitoring period, have been scarce due to the climate changes and prolongation of the main seasons (winter and summer) while the intermediate seasons (spring, autumn) tends to disappear; so the distribution differences has appeared for benthos sensitive taxa (Order *Ephemeroptera*- Families: *Heptagenidae*, *Oligoneuridae*, *Ephemerillidae*).
7. *Ephemeroptera* Order (benthos sensitive taxa – [21]) shows significant distribution differences in each season; the same significant differences from one season to another shows *Hydropsychidae/Trichoptera* taxa (medium tolerant taxa – [21]) (Tabs. 1-5).
8. Based on Mann – Whitney assessment it is noticed that sensitive and medium tolerant taxa toward water pollution show the same tolerance/sensitivity toward environmental abiotic conditions.

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