Report

Ecological Status Classification Schemes for the Alazani/Ganikh River basin

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Address : Hulla & Co. Human Dynamics KG
13, Knjaz Dondukov Blvd. , fl. 3
Sofia 1000, Bulgaria

Tel. number : +35929359978

Fax number : +35929359970

Contact person Ivan Davidov

Signatures : ___________________

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Author of report: Peter Rončák & Romina Álvarez-Troncoso

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EC M & E team ___________________ ___________________ ______________
[name] [signature] [date]

EC Delegation ___________________ ___________________ ______________
[name] [signature] [date]

ENPI Bureau ___________________ ___________________ ______________
[task manager] [name] [signature] [date]

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1 INTRODUCTION

The objective of this ecological classification is to assign rivers (natural water bodies) into 5 classes of ecological status: high, good, moderate, poor, and bad. The high status corresponds to undisturbed conditions showing no or minor deviation from the reference values, whereas in good and moderate status classes the deviation is slight and moderate, respectively. The deviation is measured in relative terms as the Ecological Quality Ratio (EQR = observed value/reference value). The key problems are to set numerical class boundaries for the quality parameters and elements and to combine the information from many parameters and elements.

The scheme used classifies river water bodies based on: (i) macroinvertebrate status as a biological element, (ii) physico-chemical status and (iii) hydromorphological elements. To establish reference conditions, values and class boundary data from previous surveys in the Alazani/Ganikh River basin (2012 – 2015) were used. Where possible, the estimated reference values and class boundaries are compared with those reported from other EU Member countries.

In chapters below, both methodologies to establish the reference conditions values for selected metrics, seasonality of the metrics and their variations within water body type and among types are presented and discussed and also relationships between biological quality elements and physico-chemical parameters were investigated (correlation analysis). These steps went to the development of ecological classification schemes (EQR boundaries for H/G, G/M, M/P and P/B for 5 metrics) for river water types (characteristic for the pilot river basin). Furthermore, those ecological classification schemes for the Alazani/Ganikh River basin were tested based on the data from the JFS 2016 (spring) for 16 sampling locations that covered three river water types (Small mountainous rivers, Middle mountainous braided rivers and Middle mountainous rivers).

2 SAMPLING LOCATIONS IN THE PILOT RIVER BASINS

To develop an ecological status classification scheme for the water body group types (see 2.1) the following three main types of sampling locations were selected in the Alazani basin:

- Where reference conditions (or insignificant anthropogenic impact) are expected (representing high quality status);
- Where lower water quality status are expected, with pressure from significant point sand diffuse pollution sources (representing good, moderate, poor and bad status);
- Where the river crosses a state boundary.

2.1 Sampling location with specific reference conditions

The WFD provides 3 options to define reference conditions:

- Use of data from physically similar, quasi-pristine locations.
- Modelling.
- Expert judgement.

In the JFSs it was decided to use a method combining elements of the first and third of these options. Selection of the potential locations to represent reference conditions involved the following main steps:

- An initial scoping study using maps and historical literature for preliminary identification.
- Pressure – impact analysis results.
- Reconnaissance mission by experts (hydrology, hydrobiology, chemistry).
- Sampling for macro-invertebrates, hydro-morphological quality elements and physicochemical parameters.
- Reassessment of the selected locations based on the data from the first JFSs rounds.
- A second reconnaissance mission to confirm (or otherwise) the locations for reference conditions.

The above steps allowed for more or less adequate selection of sampling locations representative of the specific reference conditions.
Because no typology was originally undertaken for the Alazani River basin, the river network was subdivided into three water body groups:

- The Small ´gravel´ mountainous rivers represented by the following sampling locations - *the Batsara - upstream, the Bitdilichay - Yuxari Chardagli and the Qumchay – Qumkendi.*
- The Middle ´gravel´ mountainous rivers represented by the following sampling locations – *the Stori – Lechuri upstream, the Stori – Lechuri downstream, the Gurmukhchay – Ilisu*.
- The Middle ´gravel´ mountainous braided rivers represented by the following sampling locations – *the Kabal – Kabalhesi, the Balakanchay – upstream, the Talachay – upstream, the Meshlek – mouth, the Acchay – Acchay, the Kishchay – Darmaq*.

For those groups reference condition locations were selected and data from the JFS (2012 – 2015) was analysed to develop an ecological status classification scheme (ESCS).
Photographs of three sampling locations expected to be reference conditions are shown in Figs 1 - 3.

Figure 1 Sampling location on the Talachay River

Figure 2 Sampling location Ilisu on the Gurmukhchay River

Figure 3 Sampling location on the Batsara River (mouth)

2.2 Sampling and analysis methods

A modified multi-habitat sampling method was used, in accordance with AQEM/STAR methodology. The replicates were sampled using a 30 x 30 cm mouth size net (0,5 mm mesh size). The replicates were selected according to the percentage ratio of the main bottom substrata (pro-rata multi-habitat approach). Kick-sampling and wash sampling was undertaken, usually, entailing a 50:50 ratio between kick-sampling and wash sampling for the upper part of the river basin and 100 % kick-sampling for the downstream part (alluvial plain). The way of sampling is illustrated in Fig. 4. The total area sampled per site was 1 m^2. Samples were fixed with the ethanol (80%), stored in a cool box and delivered to the laboratory for sorting and identification.

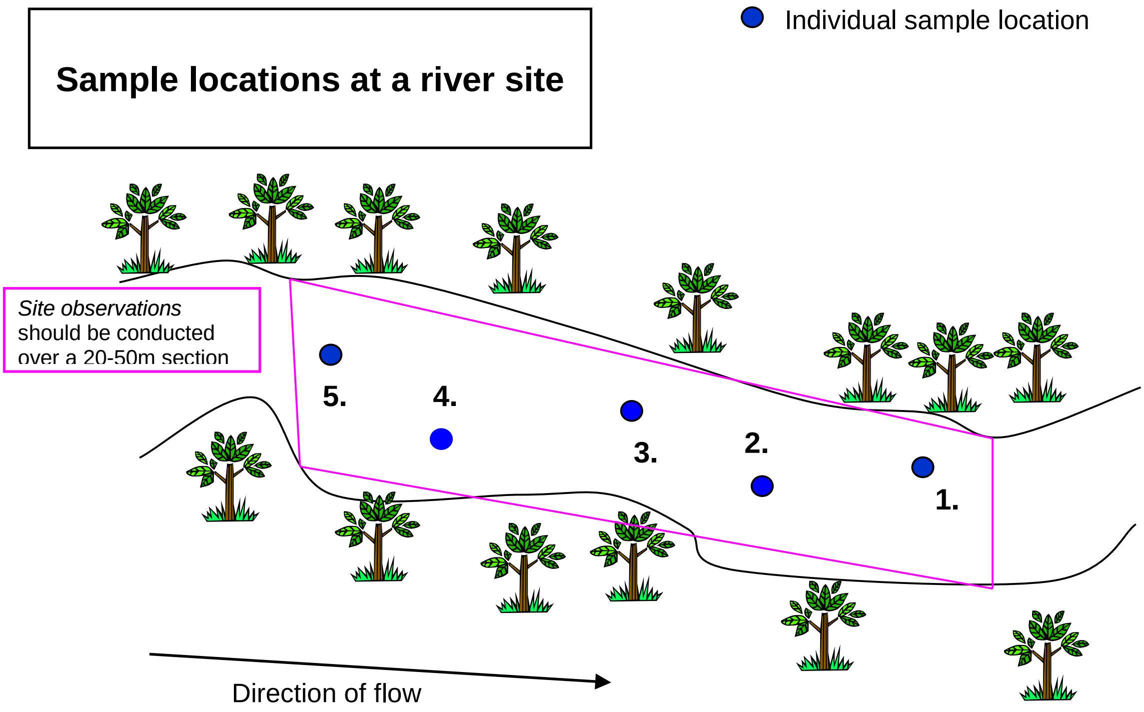

Figure 4 Scheme of the placement of replicate samples within a single river riffle stretch in relation to direction of flow.

Water samples were collected by National Environmental Agency of Georgia (Georgian part of the Alazani River basin) and by National Environmental Monitoring Department (Azeri part of the Alazani River basin).

2.3 Macroinvertebrates community

The available macroinvertebrate data from the Alazani/Ganikh River basin consisted of samples from 13 reference locations (small, middle gravel mountainous and middle gravel mountainous braided river group types) and from 8 monitoring locations impacted by human activities. Samples were collected seasonally during 2012 - 2016: spring (April-May), summer (August 2012 and 2013) and autumn (October-November). The reference locations data and data sets from impacted locations were included in the ecological status classification scheme development.

The most abundant families were the Diptera *Chironomidae, Simuliidae and Blephariceridae*, the Trichoptera *Rhyncophilidae, Hydropsychidae, Sericostomatidae and Limnephilidae* and the Plecoptera *Perlidae, Perlodidae, Leuctridae and Nemouridae,* the Ephemeroptera *Heptageniidae and Baetidae*.

For illustration, the overall number of families per order is presented for the Alazani/Ganikh River basin in Fig. 5 and 6

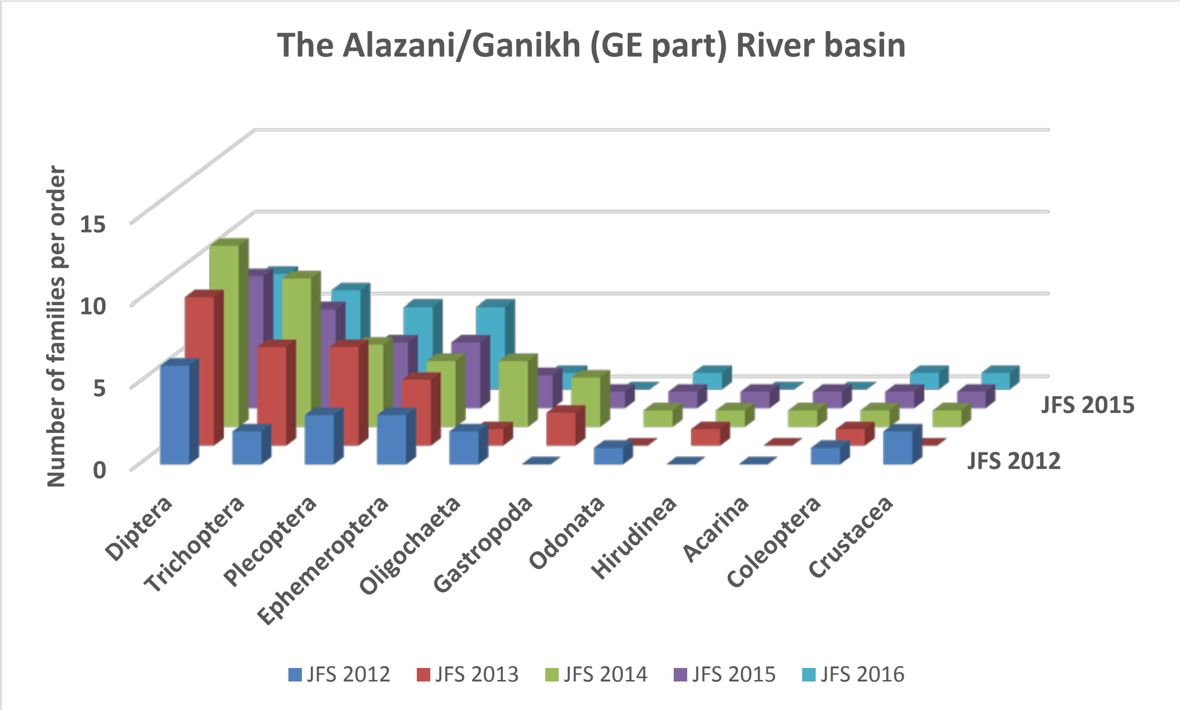

Figure 5 Number of macroinvertebrate taxa in taxonomic groups for the Alazani/Ganikh (GE part) River basin (JFS 2012 - 2016)

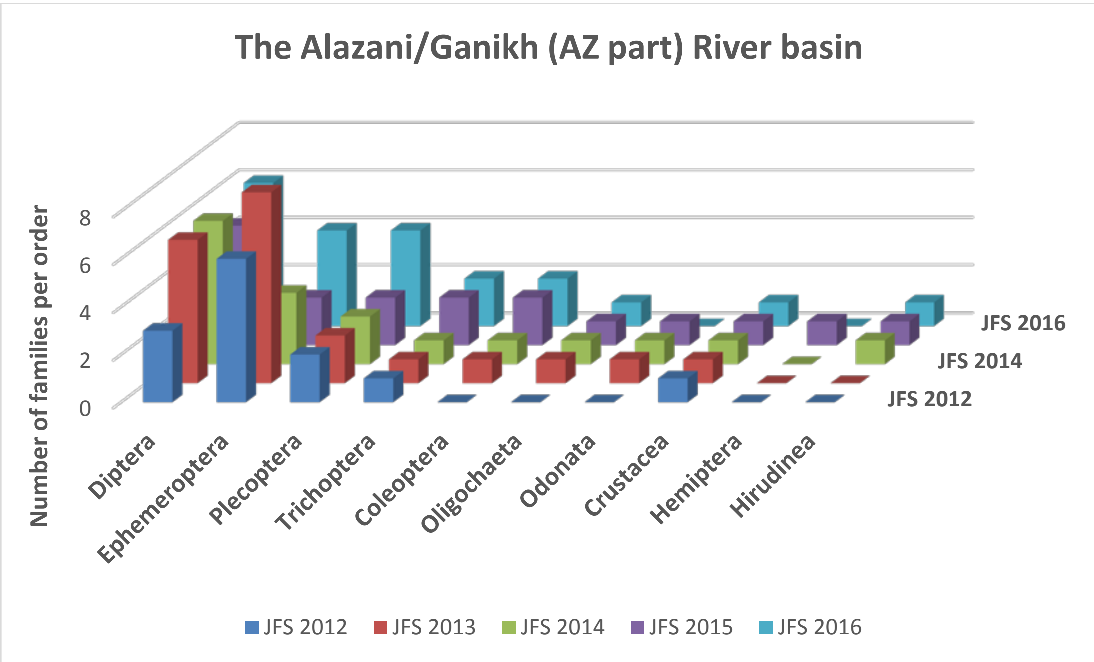

Figure 6 Number of macroinvertebrate taxa in taxonomic groups for the Alazani/Ganikh (AZ part) River basin (JFS 2012 - 2016)

Note:	*There was also found a big difference observed in both abundance and composition of the macroinvertebrates taxa in samples from Georgian and Azeri part of the Alazani River basin.*

2.4 Environmental data

All sampling locations were surveyed for general physico-chemical parameters and other specific pollutants (heavy metals) as it is presented in Tab. 1.

Table 1 Physico-chemical parameters and other specific pollutants used in the assessment of the ecological status in the Alazani/Ganikh River basin

Quality elements	Indicative parameters
thermal conditions	*water temperature*
oxygenation conditions	*dissolved oxygen, oxygen saturation* *BOD5* *COD* *total suspended solids*
nutrient conditions	*NO3* *NH4* *PO4 (orthophosphates)*
salinity	*Conductivity* *Cl* *SO4* *total dissolved solids (total mineralization)*
acidification status	*pH*
Other specific pollutants - heavy metals	*As, Cd, Cu, Ni, Pb, Zn*

Standardised methods were used for the subsequent analysis of the physico-chemical quality parameters.
Hydro-morphological degradation of the streams was evaluated based on the Hydromorphological Site Protocol and Hydromorphology Assessment Protocol (see Annex 1) and quantified by the hydromorphology quality score (HMQS).

3 METRICS AND REFRENCE CONDITIONS VALUES

The normative definitions of ecological status classes given in Annex V of the WFD, include five characteristics of river benthic invertebrate assemblages:

(i) Composition and
(ii) Abundance of taxa,
(iii) Ratio of disturbance sensitive taxa to insensitive taxa,
(iv) Level of diversity, and
(v) Occurrence of major taxonomic groups.

If the normative definitions are to be taken strictly, all of these features of macroinvertebrate community structure should be measured for the purpose of ecological classification. In practice, all these community descriptors can be interpreted in many ways, and a large number of metrics (parameters, variables or indices) commonly used in biological assessment can be used to describe them.

3.1 Selection of metrics

In the case of the Alazani/Ganikh River basin, metrics were calculated with AQEM (Asterics) software and these were used in the selection of candidate metrics. A good metric should have a small within-type variation in reference condition, hence allowing for detection of human impact. This requirement was examined by calculating coefficient of variation for reference sites within a type and by comparing the values between reference conditions and monitoring sites (t-tests). The metric values were also correlated (Pearson correlation) with variables indicative of human influence.
The following metrics were selected:
BMWP Score, BBI, IBE, EPT Taxa and Margalef's Diversity Index.

The Biological Monitoring Working Party Score (BMWP) *is a procedure for measuring water quality using macroinvertebrates as biological indicators. The method is based on the principle that different aquatic invertebrates have different tolerances to pollutants. In the case of BMWP, this is based on the sensitivity/tolerance to organic pollution (i.e. nutrient enrichment that can affect the availability of dissolved oxygen). The division of invertebrates into taxonomic groups is undertaken predominantly at family level (81 families), but with one order (oligochaeta). In the case of BMWP, the presence of mayflies or stoneflies, for instance indicate the cleanest river and are given a* ***tolerance score of 10****. The lowest scoring invertebrates are* ***worms (Oligochaeta) which score 1.*** *The number of different macroinvertebrates is also an important factor, because the better quality water is assumed to contain fewer pollutants that would exclude "sensitive" species resulting in a higher diversity.*

BBI The Belgian Biotic Index is based upon the relative sensitivity of specific indicator species to pollution and the diversity of species present. The index value varies from 0 (extremely bad quality) to 10 (extremely good quality). Initially, the invertebrates present are divided into 7 main faunal groups (at order, family and/or genus level), then the number of systematic units is counted. The division of taxa into systematic units is undertaken predominantly at family and genus level, and results are compared with a pre-determined 5-class look-up table. Overall, the index is based on a combination of taxa diversity (1415 taxa) and presence or absence of specific indicator groups.

IBE: *The IBE method derives from the Trent Biotic Index (Woodiwiss 1964). It is based on two evaluation parameters: taxonomic richness and the presence of pollution-sensitive taxa. This method offers synthetic information about the general conditions of river ecosystems, underlining potential alterations.*

The ETP Taxa (ETP) *displays the richness within the insects groups (Ephemeroptera, Trichoptera and Plecoptera), which are considered to be sensitive to pollution and will increase with increasing water* *quality. The ETP Index is equal to the total number of families represented within these three orders of in the sample.*

Margalef's Diversity Index *is a simple-to-calculate measure of taxonomic (species) richness, best employed on large sample sizes. It is a combination of the number of taxa (species) counted and the total number of individuals sampled.*

3.2 Establishment of the type-specific reference conditions values

Type-specific reference conditions values can be established either on the basis of data from reference sites, or, if data are insufficient, using modelling, expert judgement or their combination and also the reference conditions values from neighbouring countries or catchment areas. In the case of the Alazani River basin, reference conditions values were established from the JFS results (2012 – 2015) for the middle gravel braided (separately for Georgian part and Azerbaijan part), middle gravel and small gravel mountainous river types. For the large river, reference conditions values was not possible to establish for the macroinvertebrates taxa due to lack of data (no locations were found without human impact on the given water body type).

3.2.1 Effect of sampling season

Generally, macroinvertebrate fauna data has differed between spring and autumn. Therefore, an analysis of data from the reference sites was undertaken for the metrics described above. Student´s t-tests were used to test the null hypothesis that "the means of spring and autumn data sets for the selected metrics in the Alazani/Ganikh River basin are equal". As it is presented in Tab. 2, the results from the analysis have shown that there is significant difference between spring and autumn data for the river group types in the Alazani/Ganikh River basin (p value were higher than 0,05), except of Margalef's Diversity Index for the middle ´gravel´ mountainous braided rivers (bolded value). However, to confirm the effect of the sampling season on the macroinvertebrate fauna the large data sets to cover different years regarding the climate and precipitation situations should be used. Furthermore, sampling time and identification methods may also affect the results.

Table 2 Student´s t-test (p values, T2) for the spring and autumn data sets of the selected metrics for the Alazani/Ganikh River basin (2012 – 2015)

	BMWP Score	BBI	IBE	EPT Taxa	Margalef's Diversity Index
Small ´gravel´ mountainous river type p values (T2)	0,42	0,47	0,25	0,32	0,44
Middle ´gravel´ mountainous river type p values (T2)	0,42	0,17	0,26	0,25	0,42
The Middle ´gravel´ mountainous braided rivers	0,36	0,35	0,28	0,43	**0,04**

3.2.2 Variation of selected metrics

One of the assumption in the process of metrics selection is to test the within type variation. Selected metrics should have low within type variation (less than 30%). In case of the Alazani/Ganikh River basin, selected metrics had coefficient of variation among reference locations higher than 30 %, except of BBI and IBE index (see Tab. 3 (bolded values)). This finding means that the within – type variations are quite high for sampling seasons (2012 -2015) for reference conditions locations. This fact can also indicate the natural unstable conditions, probably due to hydrological and hydraulics conditions of the rivers.

Table 3 Coefficients of variation of the selected metrics for different sampling seasons for the small gravel mountainous water body type for reference conditions locations in the Alazani/Ganikh River basin (2012 -2015).

	Spring	Autumn	All (2012-2015)
BMWP Score			
cv – Ref – Con locations	0,5	0,6	0,53
BBI			
cv – Ref – Con locations	**0,11**	**0,1**	**0,1**
IBE			
cv – Ref – Con locations	**0,1**	**0,2**	**0,18**
EPT Taxa			
cv – Ref – Con locations	0,5	0,7	0,6
Margalef's Diversity Index			
cv – Ref – Con locations	0,6	0,6	0,63

Another important aspect of the selected metrics is that their values should be significantly different between reference condition locations and impacted locations. The variation of the metrics values in the monitoring locations (impacted sites) was also high similar to the reference conditions locations.

3.2.3 Metrics redundancy

When metrics are selected, it is also necessary to test on the redundancy among them. As it can be seen from the results presented in Tab. 4, there is quite strong correlation among them, except correlation between BMWP Score and BBI (r=0,63) and BBI and Margalef's Diversity Index (r=0,61). However, the results can be effected by the very high variation and also by the short datasets that has been investigated.

Table 4 Pearson correlations between selected metrics ($p < 0.05$). N = 32 (spring and autumn seasons from years 2012 – 2015) for the middle gravel mountainous braided river type in the Alazani/Ganikh River basin (Correlations ≥ 0,7 or ≤ -0,7 are bolded)

	BBI	IBE*	EPT	Margalef's Diversity Index
BMWP Score	0,63		**0,84**	**0,79**
BBI			**0,70**	0,61
IBE				**0,76**
EPT				**0,71**

**correlation analysis was not done due fact that only several values are available for IBE index*

Note: in this analysis simple correlation coefficient "r" was used that indicates the relationship and dependence between variables (the close to 1 (or -1) the stronger dependence, the closer to 0 the weaker dependence).

4 CLASS BOUNDARIES AND CLASSIFICATION

Data for 5 selected metrics from three reference conditions locations in the Alazani River basin were used to calculate the reference conditions values distribution (percentiles).
In most cases the reference locations have, unavoidably, some degree of human influence, and thus do not fully represent true reference conditions. This is was taken into account by setting the High/Good –boundary (e.g. 25th %, 50th %) of the distribution of metric values among the reference locations within a type (see Fig. 7).

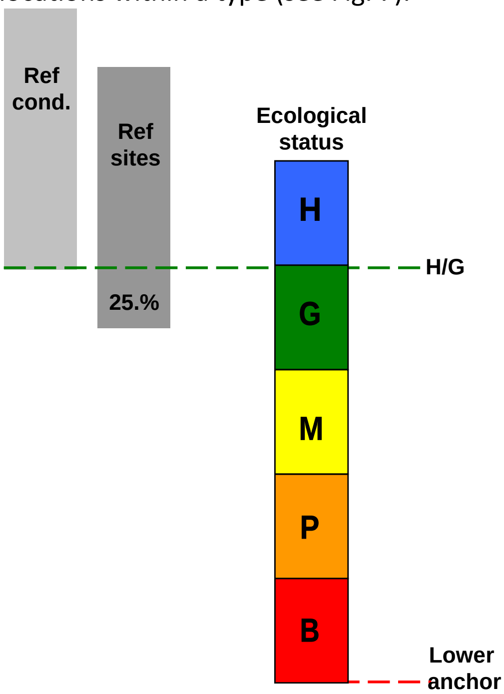

Figure 7 A schematic presentation of the class boundary setting for biological parameters. H = High, G = Good, M = Moderate, P = Poor and B = Bad ecological status.

A crucial point in the boundary setting is also the selection the lower anchor (LA) values for metrics. This can be the lowest (i.e. worst) value observed in the data or the theoretical minimum (i.e. worst) value of the metric. The remaining class boundaries Good/Moderate (G/M), Moderate/Poor (M/P) and Poor/Bad (P/B) were established, e.g. by dividing the range between the LA and G/M boundary evenly into three bands (but there are other, inevitably equally arbitrary options).
In the case of the Alazani/Ganikh River basin, H/G boundary was set to 25th percentile of type-specific reference value distribution and to illustrate the effect of the H/G-boundary value. LA was set to the approximate theoretical minimum value (i.e. the lowest attainable value („0“)) of the metric and quality classes were evenly spaced within the range LA – G/M class boundary. The results are presented in Tab. 5, 6, 7 and 8.

Note: The differences in the boundary values for the ecological status classes between spring and autumn are visible only for BMWP Score metric, similarly to the results of the Student´s t-test (the means of spring and autumn data sets are equal) as it was described in chapter above.

Table 5 Class boundaries for BMWP Score, BBI, IBE, EPT – Taxa and Margalef's Diversity Index for the Alazani/Ganikh River basin (based on JFS 2012 – 2015) for middle gravel mountainous river water type H/G – 25th % tile

	Altitude 200 – 1200 m a.s.l.																			
	Spring										*Autumn*									
	BMWP Score	*EQR*	*BBI*	*EQR*	*IBE*	*EQR*	*EPT - Taxa*	*EQR*	*Margalef's Diversity Index*	*EQR*	*BMWP Score*	*EQR*	*BBI*	*EQR*	*IBE*	*EQR*	*EPT - Taxa*	*EQR*	*Margalef's Diversity Index*	*EQR*
H/G**	102	**0,96**	*9,0*	**0,9**	9,6	**0,94**	15	**0,92**	4,0	**0,95**	95	**0,82**	*8,0*	**0,88**	8,4	**0,94**	10	**0,83**	3,6	**0,95**
G/M***	64	**0,6**	6,0	**0,6**	5,1	**0,6**	10	**0,6**	2,52	**0,6**	69	**0,6**	5,4	**0,6**	5,1	**0,6**	7	**0,6**	2,28	**0,6**
M/P***	42	**0,4**	4,0	**0,4**	3,4	**0,4**	6	**0,4**	1,68	**0,4**	46	**0,4**	3,6	**0,4**	3,4	**0,4**	5	**0,4**	1,52	**0,4**
P/B***	21	**0,2**	2,0	**0,2**	1,7	**0,2**	3	**0,2**	0,84	**0,2**	23	**0,2**	1,8	**0,2**	1,7	**0,2**	2	**0,2**	0,76	**0,2**
Lower anchor	0		0		0		0		0		0		0		0		0		0	

*** H/G – 25th % tile; *** other boundaries were distributed equally*

Table 6 Class boundaries for BMWP Score, BBI, IBE, EPT – Taxa and Margalef's Diversity Index for the Alazani/Ganikh River basin (based on JFS 2012 – 2014) for small gravel mountainous river water type with H/G – 25th % tile

	Altitude 200 – 1200 m a.s.l.									
	All data									
	BMWP Score	*EQR*	*BBI*	*EQR*	*IBE*	*EQR*	*EPT - Taxa*	*EQR*	*Margalef's Diversity Index*	*EQR*
H/G**	80	**0,82**	8	**0,88**	8,2	**0,93**	9	**0,83**	2,7	**0,82**
G/M***	59	**0,6**	5,4	**0,6**	5,2	**0,6**	7	**0,6**	1,98	**0,6**
M/P***	40	**0,4**	3,6	**0,4**	3,4	**0,4**	4	**0,4**	1,32	**0,4**
P/B***	20	**0,2**	1,8	**0,2**	1,7	**0,2**	2	**0,2**	0,66	**0,2**
Lower anchor	0		0		0		0		0	

*** H/G – 25th % tile; *** other boundaries were distributed equally*

Table 7 Class boundaries for BMWP Score, BBI, IBE, EPT – Taxa and Margalef's Diversity Index for the Alazani/Ganikh River basin (based on JFS 2012 – 2015) for middle mountainous braided river water type with H/G – 25th % tile

	Altitude 200 – 1200 m a.s.l.									
	All data									
	BMWP Score	***EQR***	***BBI***	***EQR***	***IBE***	***EQR***	***EPT - Taxa***	***EQR***	***Margalef's Diversity Index***	***EQR***
H/G**	32	**0,8**	8	**0,87**	8,0	**0,94**	6	**0,7**	2,0	**0,82**
G/M***	24	**0,6**	4,8	**0,6**	4,9	**0,6**	5	**0,6**	1,68	**0,6**
M/P***	16	**0,4**	3,2	**0,4**	3,3	**0,4**	4	**0,4**	1,12	**0,4**
P/B***	8	**0,2**	1,6	**0,2**	1,7	**0,2**	2	**0,2**	0,56	**0,2**
Lower anchor	0		0		0		0		0	

*** H/G – 25th % tile; *** other boundaries were distributed equally*

4.1 Classification schemes for the macroinvertebrates in the Alazani/Ganikh River basin

Based on the previous analysis of the macroinvertebrates data from the JFS in the Alazani/Ganikh River basin (2012 – 2015) the classifications schemes were developed for the "small gravel mountainous", "middle gravel mountainous river" and "middle gravel braided mountainous river types". Combined data sets (spring and autumn) were used in this process and classification schemes are presented in Table 8, 9 and 10.

Table 8 Classification scheme for the Middle gravel mountainous river type in the Alazani/Ganikh River basin

	Middle gravel mountainous type				
Class	I	II	III	IV	V
EQR	>0,86	>0,6	>0,4	>0,2	≤0,2
BMWP Score	**>95**	**>66**	**>44**	**>22**	**≤22**
EQR	>0,89	>0,6	>0,4	>0,2	≤0,2
BBI	**>8,0**	**>5,2**	**>3,6**	**>1,8**	**≤1,8**
EQR	>0,94	>0,6	>0,4	>0,2	≤0,2
IBE	**>8,5**	**>5,4**	**>3,6**	**>1,8**	**≤1,2**
EQR	>0,83	>0,6	>0,4	>0,2	≤0,2
EPT	**>10**	**>8**	**>5**	**>3**	**≤3**
EQR	>0,88	>0,6	>0,4	>0,2	≤0,2
Margalef's Diversity Index	**>3,4**	**>2,25**	**>1,4**	**>0,7**	**≤0,7**
Multimetrics Index EQR	**>0,88**	**>0,6**	**>0,4**	**>0,2**	**≤0,2**

Table 9 Classification scheme for the Middle gravel braided mountainous river type in the Alazani/Ganikh River basin

	Middle gravel braided mountainous type				
Class	I	II	III	IV	V
EQR	>0,8	>0,6	>0,4	>0,2	≤0,2
BMWP Score	**>32**	**>24**	**>16**	**>8**	**≤8**
EQR	>0,88	>0,6	>0,4	>0,2	≤0,2
BBI	**>8**	**>5,4**	**>3,6**	**>1,8**	**≤1,8**
EQR	>0,94	>0,6	>0,4	>0,2	≤0,2
IBE	**>7,8**	**>4,9**	**>3,3**	**>1,7**	**≤1,7**
EQR	>0,7	>0,6	>0,4	>0,2	≤0,2
EPT	**>6**	**>5**	**>4**	**>2**	**≤2**
EQR	>0,82	>0,6	>0,4	>0,2	≤0,2
Margalef's Diversity Index	**>2,0**	**>1,68**	**>1,12**	**>0,56**	**≤0,56**
Multimetrics Index EQR	**>0,83**	**>0,6**	**>0,4**	**>0,2**	**≤0,2**

Table 10 Classification scheme for the Small gravel mountainous river type in the Alazani/Ganikh River basin

	Small gravel mountainous type				
Class	I	II	III	IV	V
EQR	>0,82	>0,6	>0,4	>0,2	≤0,2
BMWP Score	**>80**	**>59**	**>40**	**>20**	**≤20**
EQR	>0,88	>0,6	>0,4	>0,2	≤0,2
BBI	**>8**	**>5,4**	**>3,6**	**>1,8**	**≤1,8**
EQR	>0,93	>0,6	>0,4	>0,2	≤0,2
IBE	**>8,2**	**>5,2**	**>3,4**	**>1,7**	**≤1,7**
EQR	>0,83	>0,6	>0,4	>0,2	≤0,2
EPT	**>9**	**>7**	**>4**	**>2**	**≤2**
EQR	>0,82	>0,6	>0,4	>0,2	≤0,2
Margalef's Diversity Index	**>2,7**	**>1,98**	**>1,32**	**>0,66**	**≤0,66**
Multimetrics Index EQR	**>0,86**	**>0,6**	**>0,4**	**>0,2**	**≤0,2**

Note: Multi-metrics Index EQR values were calculated as averages EQRs values for the selected metrics.

4.2 Comparison of the class boundaries with other regions

Classification schemes established for the Alazani River basin (BMWP Score and EPT Taxa) were compared with the class boundaries established and used in the Slovakia for the similar types of the water bodies (see Table 11 and 12).
Compared results show that class boundaries values of the Slovak classification schemes for the Middle gravel mountainous river type both BMWP Score and EPT Taxa have higher values as it in the Alazani/Ganikh River basin. Such large differences might be a signal of the differences in sampling methods (e.g. timing, personnel, site selection, etc.) and also in natural conditions (e.g. hydrological regime and high water velocities). On the other hand, for the Small gravel mountainous river types the class boundaries are only slightly different for the BMWP Score and for the EPT Taxa differences are higher (similarly as it was in the case of Middle gravel mountainous type).

Table 11 Comparison of the class boundaries for the BMWP Score and EPT Taxa between the Alazani/Ganikh classification scheme (Middle gravel mountainous type) and classification scheme in the Slovak Republic (Carpatian Middle gravel mountainous river type)

	Middle gravel mountainous type				
	I	II	III	IV	V
BMWP – Alazani/Ganikh	**>95**	**>66**	**>44**	**>22**	**≤22**
BMWP - SR	>139	>105	>71	>37	≤37
EPT Taxa – Alazani/Ganikh	**>10**	**>7**	**>5**	**>3**	**≤3**
EPT Taxa - SR	>24	>18	>12	>6	≤6

Table 12 Comparison of the class boundaries for the BMWP Score and EPT Taxa between the Alazani/Ganikh classification scheme (Small gravel mountainous river types) and classification scheme in the Slovak Republic (Carpatian small gravel mountainous river type)

	Small gravel mountainous type				
	I	II	III	IV	V
BMWP - Alazani	**>80**	**>59**	**>40**	**>20**	**≤20**
BMWP - SR	>98	>75	>51	>27	≤27
EPT Taxa - Alazani	**>9**	**>7**	**>4**	**>2**	**≤2**
EPT Taxa - SR	>15	>11	>8	>4	≤4

4.3 Class boundaries for physico-chemical parameters

Note: The values of the physic-chemical quality elements must be taken into account when assigning water bodies to the high and good ecological status classes.

Based on the pressure and impact analysis organic pollution from untreated waste waters and nutrients from agricultural activities in the Alazani/Ganikh River basin are stress factors. Therefore, BOD_5, COD, O_2, $N\text{-}NH_4$, $N\text{-}NO_3$, P-PO4 were included in the JFS programme and also to the classification system development (correlation analysis). Heavy metals were not assessed, but the classification scheme was developed for Cu and Zn. Water quality data produced by *"NATO SfP Programme, Project: 977991 SfP" (www.kura-araks-natosfp.org/data)* were used to calculate the background concentrations (see Tab. 13). The reason for do not assess heavy metals was due to uncertainties of the high variations of the concentrations during the JFSs period (2012 – 2016). There were not found any connections to both natural variations and/or human activities impacts on such values.

Table 13 Calculated background concentrations for selected heavy metals in the Alazani/Ganikh River basin (based on the results from JFSs 2012 – 2015)

	Cu µg/l	Zn µg/l
Background concentration	5,3	16,9

4.3.1 Relationship with stressors

To find critical threshold or class boundary values for variables indicative of human induced stress (water quality should support biotic elements (WFD Annex V)) they can be correlated with the estimated biological EQRs or biological status. In this case, Pearson correlations were used to analyse the relation between BOD_5 and other selected physico-chemical parameters, and also between the BMWP Score and selected water quality parameters. Results from the analysis have shown that there is only a weak relationship between BOD_5 and other parameters (COD, N-NH_4, N-NO_3 and P-$PO_{4)}$ (see Tab. 14) and also between BMWP Score and physico-chemical parameters (see Tab. 15).

Table 14 Pearson correlations between selected BOD5 and selected physico-chemical parameters ($p < 0,05$). N = 36 (spring and autumn seasons from 2012 – 2015) for Middle gravel mountainous river type in the Alazani/Ganikh River basin

	02	COD	N-NH_4	N-$N0_3$	P-PO_4
BOD 5	0,074	0,074	0,21	0,24	0,20

Table 15 Pearson correlations between BMWP Score and selected physico-chemical parameters ($p < 0,05$). N = 36 (spring and autumn seasons from 2012 – 2014) for Middle gravel mountainous river type in the Alazani/Ganikh River basin

	BOD_5	O_2	COD	N-NH_4	Cu	Ni
BMWP – RC	0,27	0,14	0,02	0,55	0,14	0,07

Due to weak correlations it is not possible to indicate the association between the pressure variables and macroinvertebrates metrics. Therefore, it was decided to use data from the both national monitoring programmes and JFSs with expert judgement in setting the EQR boundaries of the selected pressure variables (see Tab. 16, 17 and 18).

Table 16 Classification scheme for general physico-chemical parameters for Small gravel mountainous river types in the Alazani/Ganikh River basin

Parameter		unit	I	II	III
Temperature	90%-tile	°C	<18	<21	≥21
Conductivity		µS/cm			
pH		-	(7,0; 8,5)	(6,0; 7,0> or <8,5; 9)	≤ 6,0 or ≥ 9,0
Dissolved oxygen	Min	mg/l	>8,0	>6,0	≤6,0
BOD5	Mean	mg/l	<2,0	<4,0	≥4,0
COD-Cr	Mean	mg/l	<6,0	<15,0	≥15,0
N-NH4	Mean	mg/l	<0,15	<0,5	≥0,5
N-NO3	Mean	mg/l	<1,5	<3,0	≥3,0
P-PO4	Mean	mg/l	<0,03	<0,08	≥0,08

Table 17 Classification scheme for general physico-chemical parameters for Middle gravel mountainous and braided river types in the Alazani/Ganikh River basin

Parameter		unit	I	II	III
Temperature	Mean	°C	<20	<23	≥23
Conductivity		µS/cm			
pH		-	(7,0; 8,5)	(6,0; 7,0> or <8,5; 9)	≤ 6,0 or ≥ 9,0
Dissolved oxygen	Min	mg/l	>7,0	>6,0	≤6,0
BOD5	Mean	mg/l	<3,0	<5,0	≥5,0
COD-Cr	Mean	mg/l	<7,0	<15,0	≥15,0
N-NH4	Mean	mg/l	<0,15	<0,5	≥0,5
N-NO3	Mean	mg/l	<1,5	<3,0	≥3,0
P-PO4	Mean	mg/l	<0,04	<0,08	≥0,08

Table 18 Classification scheme for other specific pollutants relevant for the Alazani/Ganikh River basin

Parameter		unit	I	II	III
Cu	Mean	µg/l	<5,3	<10,0	≥10,0
Zn	Mean	µg/l	<16,9	<40,0	≥40,0

Mean annual concentrations (in case of oxygen concentration minimum value) of the physico-chemical parameters (general conditions) are recommended to be used to classify ecological status. However, in the case of the EPIRB project only two sampling rounds in given year can be used to classify the ecological status. Due to this fact, it was decided to evaluate data (long-term data at least 3 years) from the national monitoring programme for selected parameters and calculate the mean and standard deviation values for each month. The data from the JFSs sampling round were compared with the given month whether they fit with the long term values (see Fig. 8). This approach was used to illustrate the necessity to use the annual means values of physico-chemical parameters to support the ecological status classification of surface (running) water.

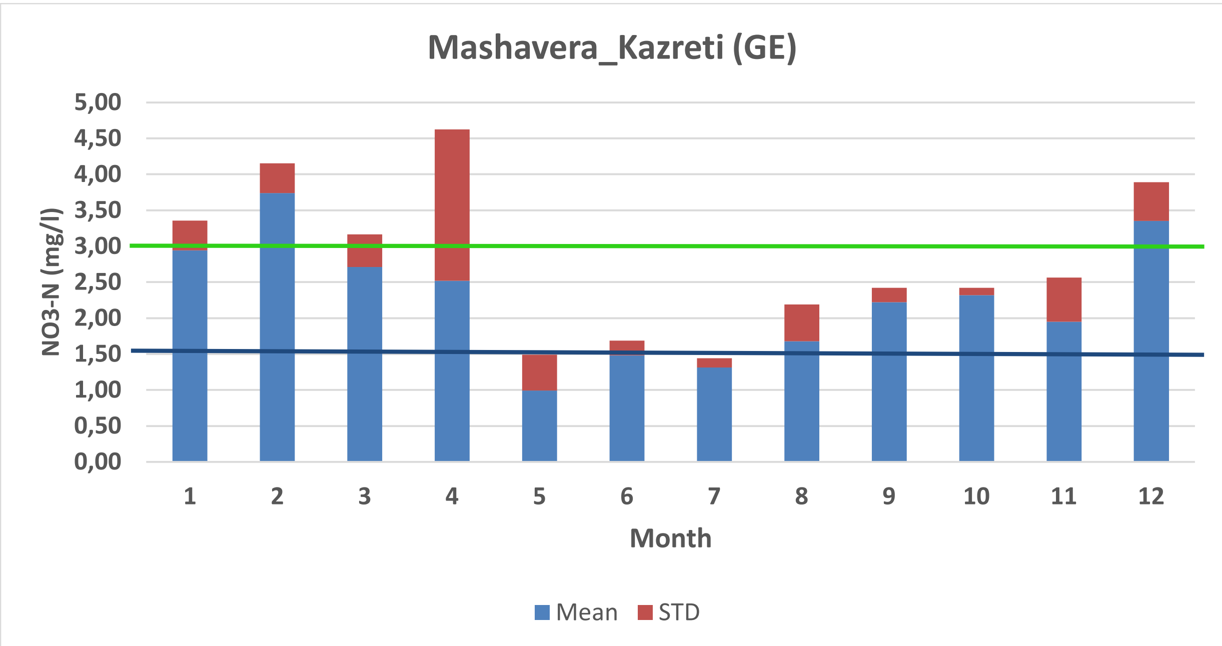

Figure 8 Long-term monthly mean concentrations and standard deviations of NO_3-N (blue line is High status and green line Good status limit values).

4.4 Class boundaries for hydromorphological quality elements

Hydromorphological quality elements (HMQE) must be taken into account when assigning water bodies to the high ecological status class. For the other status classes, the HMQE are required to have conditions which are consistent with the biological values set for the biological class for each water body type.
The HMQE assessment system for the classification of the ecological status in EPIRB project pilot river basins is presented in Tab. 19. This preliminary Hydromorphological Quality Score system was used in Slovakia to classify the water bodies (SHMI, 2004).

Table 19 Preliminary boundaries of the hydromorphological quality classes (SHMI, 2004)

Hydromorphological quality class		Limit values		Colour
1	High	1,0 – 1,7		
2	Good	1,8 – 2,5		
3	Moderate	2,6 – 3,4		
4	Poor	3,5 – 4,2		
5	Bad	4,3 – 5,0		

4.5 Relationship between biological, hydromorphological and physico-chemical quality elements

There are three quality elements that are used in the assessment of the ecological status of the water bodies: biological, physico-chemical and hydromorphological quality elements (Fig. 9). To classify ecological status, the WFD stipulates that the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements should be used (Annex V, 1.4.2. (i)). This is consistent with the WFD "one out all out" approach.

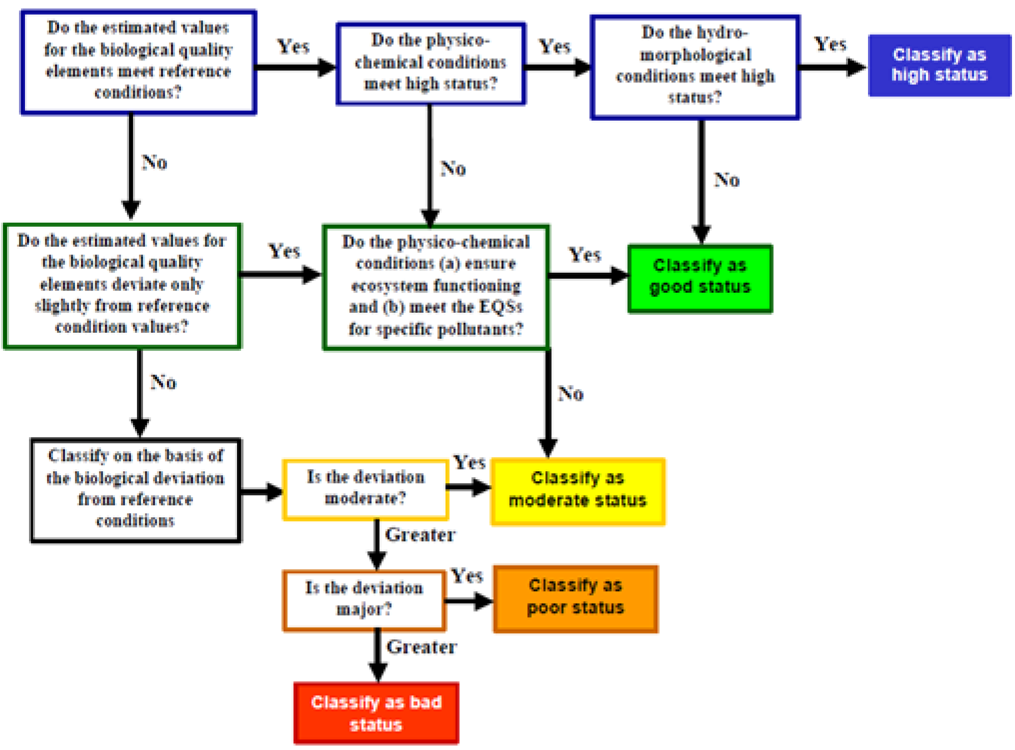

Figure 9 Assessment of the ecological status (reproduced from WFD CIS Guidance documents 10 and 5)

5 CLASSIFICATION EXERCISE

The developed ecological status classifications systems for the Alazani/Ganikh River basin were used to classify the sampling locations based on the data from the spring sampling round JFS 2016. After calculation of EQRs for each metric and Multimetrics Index was calculated as mean value from individual metrics. Subsequently, the assessment scheme as illustrated on Fig. 8 was applied and results of classification are presented in Table 20. As it is visible from the ecological status classification of the assessed locations, the results reflects the natural conditions and human activities pressures as well.

Table 20 Ecological status classification of the sampling locations in the Alazani/Ganikh River basin (spring JFS 2016)

River	Sampling location	Class									Impact
		BMWP	BBI	IBE	EPT	*Margalef's Diversity Index*	*Multimetris Index EQR*	Physico-chemical parameters	HM Quality Score	Overall ecological status	
Georgia part											
Batsara	**River mouth**	102	9	8	12	4,1					Location with RC
Alazani	**Omalo**	85	8	8,4	10	2,31					Municipalities and agriculture
Alazani	**Shakriani**	57	7	6	5	2,49					Municipalities and agriculture
Kabal	**Kabalhesi**	111	9	9,3	14	3,61					Location with RC
Bursa	**Kvareli**	26	6	2	1	0,68		N/A	N/A		Waste water from Kvareli
Stori	**Lechuri upstream**	115	8	7,6	14	2,51					Location with RC
Stori	**Lechuri downstream**	87	8	7,6	11	2,19					Municipality and agriculture
Azerbaijan part											
Belakanchay	**upstream RC**										Not classified (high water)
Belakanchay	**downstream**	29	7	N/C	3	0,65		N/A	N/A		Settlements and water abstraction
Meshlek	**mouth RC**	41	8	7	4	0,83					Location with RC
Talachay	**upstream RC**	57	7	8	5	1,16					Location with RC
Talachay	**downstream**	47	7	N/C	4	0,94		N/A	N/A		HM alterations and municipality
Qarabulaq	**Chichixana**										Not classified (high water)
Qarabulaq	**Delichay**	36	6	6	4	1,5					Agriculture and municipality
Bitdili	**Yuxari Chardagli**	77	8	8,4	8	2,48					Location with RC
Qumchay	**Qumkendi**	80	8	9	8	2,71					Location with RC
Gurmukhchay	**Ilisu**	80	8	8	9	1,6					Location with RC
Acchay	**Acchay**	53	8	8	6	1,09					Location with RC
Ayrichay	**Bashdashagil**	19	6	N/C	2	0,68					Location with RC
Ayrichay	**Before reservoir**								N/A		No animals found
Kishchay	**Damarchig**	39	7	N/C	5	1,19					Location with RC

N/A – not applicable

6 CONCLUSIONS AND RECOMMENDATIONS

During the EPIRB Project 2012-2016 many data have been collected in the field and that information was used to develop this first approach of Ecological Status Classification System for the Alazani/Ganikh River basin. The system used methodologies applied in the EU Member State during the implementation of the WFD. Reference condition values were established for 5 metrics (BMWP Score, BBI, IBE, EPT-Taxa and Margalef's Diversity Index) to assess the river benthic community based on the normative definitions of the WFD.

The results of the assessment have shown certain seasonality and also very weak correlations between biotic indices and physico-chemical parameters. This fact can be caused by insufficient data sets and also hydrological and hydraulics conditions (natural conditions) in the pilot river basin and uncertainties of the results from the laboratory analysis (heavy metals variations).

On the other hand, classification system reacted on the human induced alterations in the pilot river basin and classified sampling locations into several classes from high to bad.

This ESCS includes macroinvertebrates for the biological evaluation but it is necessary to include more biological elements as macrophytes and phytobethos in the future.

This is a first approach for rivers but also for other water categories it is necessary to develop a system for classification: lakes, artificial waters and heavily modified water bodies.

7 REFERENCES

1. Hydromorphological River Survey and Assessment. Report SHMI, Bratislava, Slovakia, 2004.
2. Guidance Document No 7: *Monitoring under the Water Framework Directive*, produced by Working Group 27 – Monitoring Common Implementation Strategy for the Water Framework Directive (2000/60/EC), Luxembourg: Office for Official Publications of the European Communities, 2003 ISBN 92-894-5127-0, ISSN 1725-1087 © European Communities, 2003 (153 p)
3. Guidance Document No 13: *Overall Approach to the Classification of Ecological Status and Ecological Potential* Common Implementation Strategy for the Water Framework Directive (2000/60/EC), Produced by Working Group 2A Luxembourg: Office for Official Publications of the European Communities, 2003 ISBN 92-894-6968-4, ISSN 1725-1087 © European Communities, 2005 (47 p)
4. AQEM consortium (2002): *Manual for the application of the AQEM method A comprehensive method to assess European streams using benthic macroinvertebrates, developed for the purpose of the Water Framework Directive* Version 10, February 2002
5. DIRECTIVE 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy Official Journal of the EC, 22122000 L327/1-72 (Water Framework Directive)

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