Report

Ecological Status Classification Schemes for Upper Dnieper in Belarus and Ukraine River basin

August 2016

Project Title : **Environmental Protection of International River Basins Project**

Project Number : Contract No, ENPI/2011/279-666

Countries : Armenia, Azerbaijan, Belarus, Georgia, Moldova, Ukraine

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 : ___________________

Date of report: 5th August 2016

Author of report: Peter Rončák & Romina Álvarez-Troncoso

Acknowledgements: Thanks to William Parr and Paul Buijs for reviewing the draft versions

EC M & E team	___________________	___________________	_______________
	[name]	[signature]	[date]
EC Delegation	___________________	___________________	_______________
	[name]	[signature]	[date]
ENPI Bureau	___________________	___________________	_______________
[task manager]	[name]	[signature]	[date]

Table of Contents

1. INTRODUCTION

The objective of the ecological classification is to assign rivers into five classes of ecological status: high, good, moderate, poor, and bad, Note that in case of AWB and HMWB classification is about the ecological potential, distinguishing four classes.

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.

This new version of the document includes and update for the analysis of the Ecological Status Classification System with more data, more analysis (seasonal analysis) and new historical results for physico chemical parameters.

2. SELECTION OF THE LOCATIONS WITH TYPE SPECIFIC REFERENCE CONDITIONS IN THE PILOT RIVER BASINS

In some of the pilot basin to establish the reference sites is becoming a problem because of the lack of suitable sites, Apart from this situation, there are not enough data from the monitoring program needed to calculate the boundaries, In this new approach of the ESCS data from longest period of the project were used for biological calculation (2013-2016), For physico chemical analysis, historical data for the river basin since 1992-2016 was used in order to calculate the new boundaries,

For the purpose of the JFS and to develop the ecological status classification scheme, three main types of sampling locations were selected in the Upper Dnieper River pilot basin:

- Sampling locations where reference conditions (or insignificant anthropogenic impact) are expected (representing high quality status);
- Sampling locations of lower water quality status, with some human pressure from point and diffuse pollution sources (representing good, moderate, poor and bad status);
- Sampling locations where the river crosses a state boundary,

There are several methods to establish reference conditions such as spatially-based methods, predictive models, palaeo-reconstruction and expert judgement, In the JFSs it was decided to combine a spatially based method with expert judgement, Selection of the potential locations to represent reference conditions involved the following main steps:

- Scoping, using maps and historical literature for preliminary identification;
- Pressure – impact analysis;
- A primary reconnaissance mission by experts (hydrology, hydrobiology, chemistry);
- Sampling for biological elements (macro-invertebrates), hydro-morphological quality elements and physicochemical parameters;
- Reassessment of the selected locations based on the data from earlierJFSs;
- A secondary reconnaissance mission to confirm (or otherwise) the locations of reference sites,

The above steps enabled the selection of sampling locations representative of the specific reference conditions,

The Dnieper River is 2201 km long, Of its entire length, 485 km (22%) are within Russia, 516 km (23%) within Belarus and 1200 km (55%) within Ukraine,

Dnieper River ranks top in size and water content in the territory of the pilot basin, Main tributaries of the Dnieper in Belarus are: on the left – **Sozh** (648 km long, basin area 21700 km^2); on the right – **Drut** (long, basin area 5020 km^2), **Berezina** (561 km long, basin area 24500 km^2), and **Iput** (437 km long, basin area 10900 km^2), In Ukraine, the Dnieper River basin is abundant in rivers: the river density is 0,39 km/km2, Main tributaries of the Dnieper in Ukraine are: **Desna** (575 km long in Ukraine, total basin area 88900 km^2); **Teterev** (365 km long, basin area 15100 km^2) and **Uzh** (256 km long, basin area 8080 km^2),

The Upper Dnieper River basin as defined by the EU WFD, the pilot river basin is composed by these groups of water bodies:

- Large plain river with fine substrata (sand/clay/silt),
- Small and medium-size plain rivers (fine substrata, macrophytes, organic - peaty),

For those groups the reference conditions locations were selected and analysis of the data from JFS was done to develop the ecological status classification schemes (ESCS),

For illustration, photographs from three sampling locations expected to be reference conditions locations are given, see Figs, 1 and 2 ,

Figure 1 Teteriv river, v,Voropaivka, Ukraine

Figure 2 Berezina_Chirkovichi, Belarus

3. METHODS AND DATA: Dnieper River Basin in Belarus and Ukraine

3.1 Sampling methods

A modified multi-habitat sampling method was used, based on the AQEM/STAR methodology, 11 Sub-samples were collected using a net of 30 x 30 cm mouth size and 0,5 mm mesh size, The replicate sites selected after detailed habitat observation according to the ratio of main bottom substrata (pro-rata multi-habitat approach), Both kick-sampling and wash sampling was made, Usually, a 50:50 ratio of kick-sampling and wash sampling was used for the upper part of the river basin and 100 % kick-sampling for the downstream part (alluvial plain), The total area sampled per location was 1 m^2, Samples were fixed with ethanol 80%, stored in a cooling box and delivered to the laboratory for sorting and identification,

Macroinvertebrate samples were collected by experts from the Institute of Biology of Ukraine,

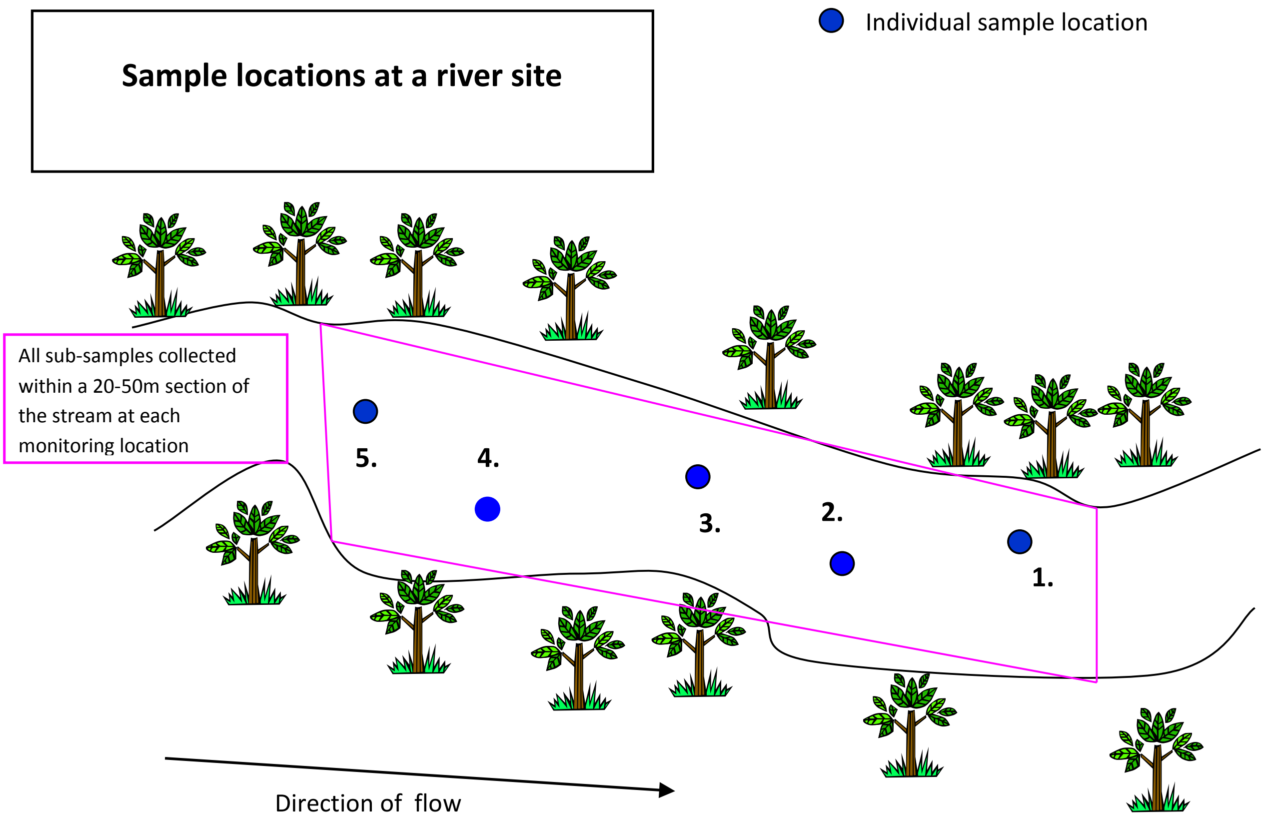

Figure 3 Scheme of the placement of replicate samples within a single river riffle stretch in relation to direction of flow,

3.2 Macroinvertebrates community

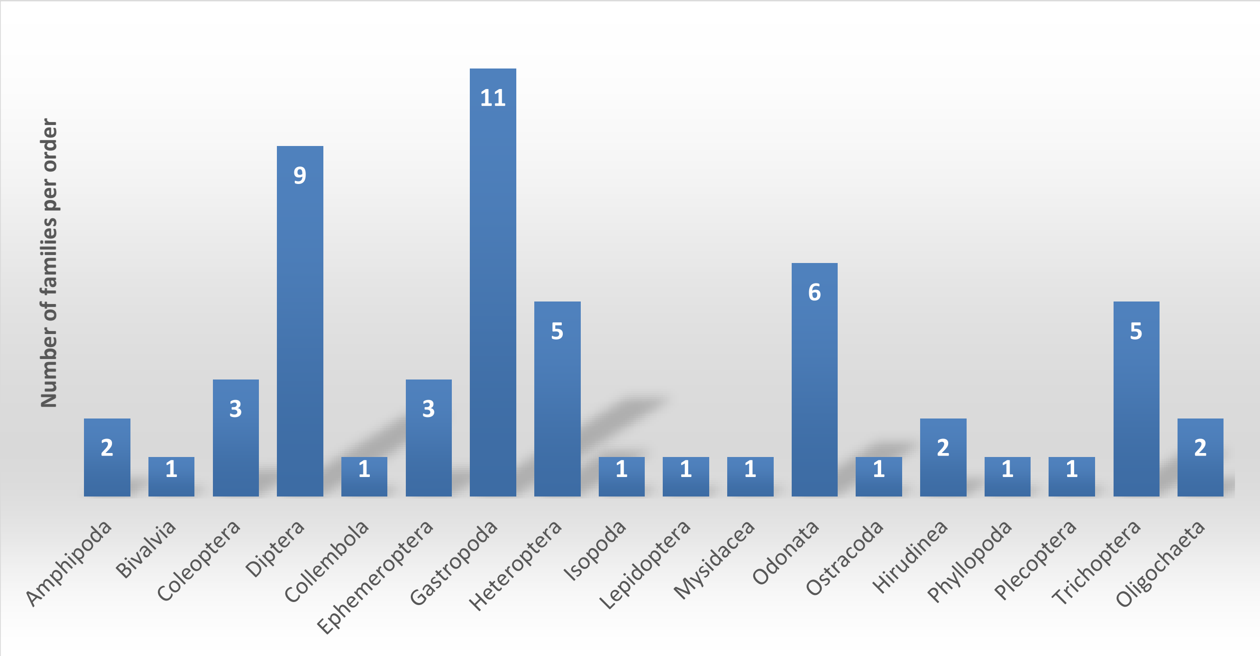

Figure 4 The number of macroinvertebrate taxa in taxonomic groups for the Upper Dnieper RB (UA) River basin River basin identified during the JFS 2016

56 families were identified in the Upper Dnieper RB (UA), the most abundant of which were Chironomidae (Diptera), Baetidae (Ephemeroptera), Pleidae (Heteroptera), Planorbidae, Viviparidae and Lymneidae (Gastropoda) and Naididae (Oligochaeta)

The presence of these families suggests that the general quality of the rivers is moderate/good influenced by some organic pollution and eutrophication processes because most of these families are pollution-tolerant, and found in a range of rivers world-wide, The Gasteropora families (Planorbidae, Viviparidae and Lymneidae) are showing the Upper Dnieper lowland parts and huge rivers,

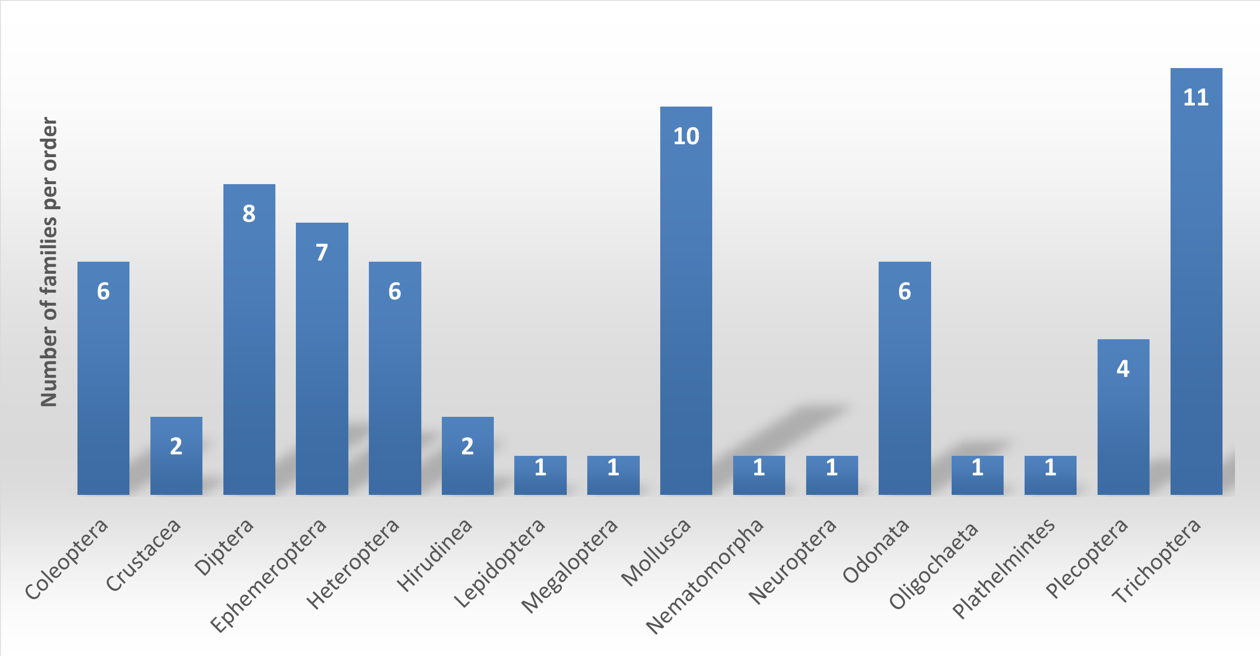

Figure 5 The number of macroinvertebrate taxa in taxonomic groups for the Upper Dnieper RB (BY) River basin River basin identified during the JFS 2016

68 families were identified in Upper Dnieper RB (BY) Similar than other previous results, the most abundant families were Chironomidae and Simuliidae (Diptera), Viviparidae and Sphaeriidae (Molllusca), Gammaridae (Amphipoda), Baetidae and Heptageniidae (Ephemeroptera) and Oligochaeta,

The high diversity (number of taxa) occurs because the area is dominated by a mixed community representing aspects of both large rivers and lakes and areas with no significant pressures and running waters with many different habitats: families such as Viviparidae and Sphaeriidae are typical of shallow lakes and lentic areas or slow-flowing reaches in large rivers; Gammaridae are also found in large rivers and lakes, usually in littoral areas There are other families of Diptera and Ephemeroptera tolerant to the organic pollution in areas with deficient sewage system downstraeam close to populations In general the diversity and abundance found in the basin is very high because of different pressures available in the area that allows to increase the different kind of habitats interesting for different groups

4. ENVIRONMENTAL DATA

All sampling locations were surveyed for basic physico-chemical parameters (Table 1),

Quality elements	**Indicative parameters**
Thermal conditions	*Water temperature*
Oxygen status	*Dissolved oxygen, oxygen saturation* BOD_5 *COD* *Total suspended solids*
Nutrient conditions	NO_3 NH_4 PO_4 *(orthophosphates)*
Salinity	*Conductivity* *Cl* SO_4 *Total dissolved solids (total mineralization)*
Acidification status	*pH*
Heavy metals	*As, Cd, Cu, Ni, Pb, Zn*

Table 1 Physico-chemical parameters used in the assessment of the ecological status in the Dnieper river basin in Belarus and Ukraine

Standardised methods were used for the subsequent analysis of the physico-chemical quality parameters,

Hydro-morphological degradation of the streams was based on the hydromorphological field protocol and hydromorphology assessment protocol (see Annex 1) and quantified by the hydromorphology quality score (HMQS),

4.1 Selection of metrics

The normative definitions of ecological status classes given in Annex V of theWFD include five characteristics of river benthic invertebrate assemblages to be considered:

(i) Community composition

(ii) Abundance of taxa,

(iii) The ratio of disturbance sensitive taxa to insensitive taxa,

(iv) The level of diversity, and

(v) The occurrence of major taxonomic groups,

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

In the case of the Upper Dnieper River basin, metrics were calculated with AQEM (Asterics) software and these were used in the selection of candidate metrics, to the extent feasible with the available limited data, 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 references 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,*

5. 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 a combination of these, Reference conditions values from neighbouring countries or catchment areas may also be used, In the case of the Dnieper River basin, the reference conditions values were established from JFS results (2013–2016) for Large plain river with fine substrata (sand/clay/silt) and Small and medium-size plain rivers (fine substrata, macrophytes, organic - peaty) types of river,

5.1 Effect of sampling season

In the Dnieper river basin in Ukraine and Belarus it was possible to test this effect using the data from summer (2013, 2014 and 2015) and 2016 spring samples,

Generally, macroinvertebrate fauna data has differed composition due to seasonal changes as for example between spring and summer, 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 summer data sets for the selected metrics in the Upper Dnieper River basin in Ukraine and Belarus are equal”, As it is presented in Table 2, the results from the analysis have shown that there is significant difference between spring and summer data for the water body group types (p value were higher than 0,05), for BMWP and Margalef’s Diversity index, nevertheless not significant differences were found for the other indexes (BBI, IBE and EPT Taxa), 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,

	BMWP Score	**BBI**	**IBE**	**EPT Taxa**	**Margalef’s Diversity Index**
Dnieper river in Ukraine and Belarus	0,70	0,002	0,007	0,007	0,292

Table 2 Student´s t-test (p values, T2) for the spring and autumn data sets of the selected metrics for the Dnieper River basin (2012 – 2016)

5.2 Variation of selected metrics

Within – type variation

Selected metrics should have low within type variation (less than 30%), In the case of the Dnieper River basin, none of the metrics from reference locations had coefficients of variation equal to or less than 30%, On the other hand, variations of the metrics values in monitoring locations (impacted sites) should be higher to leave scope for metrics values from impacted locations to deviate substantially from those in reference locations in the same water body type (see Table 3), All metrics had higher coefficient of variation than 30% that reflect the ability of selected metrics to cover the whole range of disturbances,

This finding means that the within – type variations are quite high for sampling seasons (2013 -2016) in reference locations, This fact can also indicate the natural unstable conditions, probably due to hydrological and hydraulics conditions of the rivers and also that the selection of reference sites flawed and maybe that all of the impacted sites, subject to about the same type and level of pressure,

In the future JFS it has to be ensure that the quality assurance guidance is followed not only in the field works but also in the preparation of the sampling locations and during the taxonomic identification process,

	All (2013-2014)	All (2013-2016)
BMWP Score		
cv – Ref – Con locations	**0,33**	**0,50**
cv – impacted locations	**0,38**	**0,44**
BBI		
cv – Ref – Con locations	**0,18**	**0,33**
cv – impacted locations	**0,21**	**0,34**
IBE		
cv – Ref – Con locations	**0,28**	**0,38**
cv – impacted locations	**0,47**	**0,35**
EPT Taxa		
cv – Ref – Con locations	**0,5**	**0,93**
cv – impacted locations	**0,57**	**0,74**
Margalef's Diversity Index		
cv – Ref – Con locations	**0,43**	**0,45**
cv – impacted locations	**0,27**	**0,39**

Table 3 Coefficients of variation of the selected metrics for different sampling seasons for the reference conditions locations and impacted locations in the Dnieper River basin in Ukraine and Belarus (2013 -2014 and 2013-2016),

5.3 Detection of impact

Another important aspect of the selected metrics is that their values should be significantly different between reference condition locations and impacted locations, To evaluate such differences Student´s t-tests were applied to the data sets from the Dnieper River basin in Ukraine and Belarus, The analysis shows that there no differences between reference and impacted locations in the river basin in all the 5 selected metrics ($p > 0{,}05$), These results again reflects that the impacted sites are not particularly heavily impacted compared to the reference sites, so more work related with reference site locations definition should be necessary and better site definition of impacts and pressures,

5.4 Metric 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 Table 4, there is a strong correlation with all the indexes except correlation between Margalef index with EPTtaxa and BBI,

	BMWP Score	**BBI**	**IBE**	**Diversity (Margalef Index)**	**- EPT-Taxa**
BMWP Score		**0,744**	**0,799**	**0,892**	**0,792**
BBI	**0,744**		**0,706**	0,600	**0,792**
IBE	**0,799**	**0,706**		**0,741**	**0,720**
Margalef's Diversity Index	**0,892**	0,600	**0,741**		0,696
EPT	**0,792**	**0,792**	**0,720**	0,696	

Table 4 Pearson correlations between selected metrics ($p < 0{,}05$) N =138 (2013-2016) for the lowland rivers in the Dnieper River basin (Correlations ≥ 0,7 or ≤ -0,7 are bolded),

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),

Some of the pilot basins present problems for designing the ecological status classification scheme because of the lack of reference sites and data, for example the Upper Dnieper basin,

In consequence, as it is allowed in the WFD, this ecological assessment will be based upon the status of the biological, hydromorphological and physico-chemical quality elements, by comparing data obtained from monitoring networks with the reference (undisturbed) conditions, then deriving an Ecological Quality Ratio (EQR) using the results of other regions that present the same typology descriptors,

For results regarding the boundaries' definition for macroinvertebrates and consequently for ecological status assessment different Geographical Intercalibration Group (GIG) results were consulted, The Central-Baltic GIG successfully completed intercalibration for macroinvertebrates in the first round and the results are included in the first Commission Decision on intercalibration (COM DEC 2008/915/EC) and the work was documented in the 2009 technical report,

The results of the Central Baltic GIG are applicable to both Ukrainian and Belarus Rivers (Dnieper is siliceous),

Type	***River characterisation***	***Catchment area (of stretch)***	***Altitude & geomorphology***	***Alkalinity (meq/l)***
R-C4	*Medium lowland mixed*	100-1000 km^2	lowland, sandy to gravel substrate, 8-25m width (bankfull size)	> 0,4
R-C5*	*Large lowland mixed*	1000-10000 km^2	lowland, barbel zone*, variation in velocity, max, altitude in catchment: 800m, >25m width (bankfull size)	> 0,4
R-C6	*Small, lowland, calcareous*	10-300 km^2	lowland, gravel substrate (limestone), width 3-10m (bankfull size)	> 2

Table 5 LOWLAND RIVERS: DNIEPER BELARUS AND UKRAINE:Overview of common intercalibration types in the Central-Baltic rivers GIG

Lowland river in Ukraine and Belarus Dnieper RB According to the Central Baltic group for Intercalibration process (2012 Intercalibration Technical Report Central-Baltic River Gig – Macroinvertebrates Document), the following EQR boundaries represented the media of the limits calculated in each participant member between the classes:

High/Good	Good/Moderate	Moderate/Poor	Poor/Bad
25^{th} Percentile of reference conditions	0,60	0,40	0,20

Table 6 EQR boundaries for river Dnieper RB in Ukraine and Belarus

6. Establishment of the type-specific reference conditions values

Data for 5 selected metrics from three reference conditions locations in the Upper Dnieper River basin were used to calculate the reference condition 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 often taken into account by setting the High/Good –boundary (see Figure 6) to some percentile (e,g, 25th %tile, 50th %tile) of the distribution of metric values among the reference data from each river type,

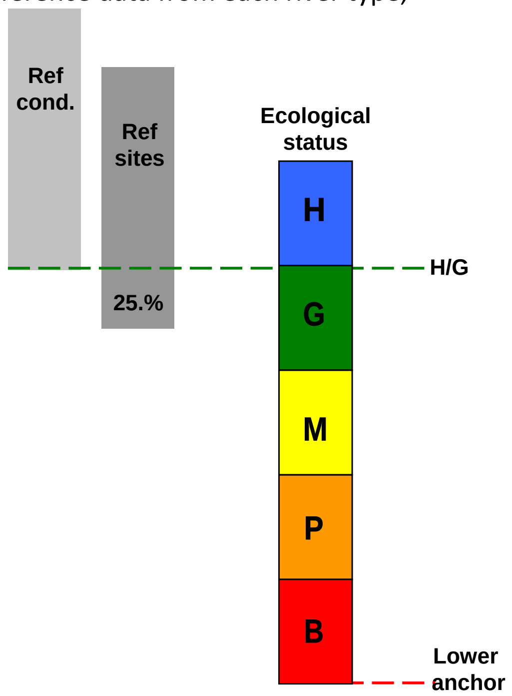

Figure 6 Schematic presentation of the class boundary setting for biological parameters H = High, G = Good, M = Moderate, P = Poor and B = Bad ecological status

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 Upper Dnieper River basin, H/G boundary was set to the 25th percentile of the type-specific reference value distribution, To illustrate the effect of the H/G-boundary value, the50th percentile (median) was also used for comparison for the middle mountainous river type, (For the small mountainous river type, the H/G boundary was set to 25th percentile,) The LA was set to the 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 was set as the 70% of deviation of reference conditions according to the results from Central Baltic GIG, The results are presented in Table 7.

Note: The differences in the boundary values for the ecological status classes between spring and autumn are visible only for the BMWP Score metric, Similarly to the results of the Student´s t-test as described in the chapter above

Due to the low amount of data from the JFS in 2013 -2016, additional data from existent locations in similar rivers in Central Baltic shown in the table 5 were used to calculate the distribution of metric values among the reference locations within a type:

All results from 2013-2016

	BMWP Score	*EQR*	*BBI*	*EQR*	*IBE*	*EQR*	*EPT - Taxa*	*EQR*	*Margalef's Diversity Index*	*EQR*
H/G**	128,00	**0,78**	7,00	**0,79**	7,40	**0,93**	7	**0,64**	4,63	**0,80**
G/M***	98,16	**0,60**	5,34	**0,60**	4,80	**0,60**	6,54	**0,60**	3,45	**0,60**
M/P***	65,44	**0,40**	3,56	**0,40**	3,20	**0,40**	4,36	**0,40**	2,30	**0,40**
P/B***	32,72	**0,20**	1,78	**0,20**	1,60	**0,20**	2,18	**0,20**	1,15	**0,20**
Lower anchor	0		0		0		0		0	

Table 7 ***Class boundaries for BMWP Score, BBI, IBE, EPT – Taxa and Diversity (Margalef Index) for the Dnieper in Belarus and Ukraine River basin (based on GIG Central Baltic) for lowlands river water bodies' type,***

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

6.1 Classification schemes for macroinvertebrates in the Upper Dnieper River basin

Based on the previous analysis of the macroinvertebrates data from JFSs in the Upper Dnieper River basin (2013–2016), classifications schemes were developed for the high-middle mountainous river type and the small mountainous river type, combined data sets (1 result per year in 2013 and 2016) were used in this process.

	Large and small lowland rivers type; Altitude 80–200 m a,s,l,				
Class	**I**	**II**	**III**	**IV**	**V**
EQR	>0,78	>0,60	>0,40	>0,20	≤0,20
BMWP Score	>128,00	>98,16	>65,44	>32,72	≤32,72
EQR	>0,79	>0,60	>0,40	>0,20	≤0,20
BBI	>7,00	>5,34	>3,56	>1,78	≤1,78
EQR	>0,79	>0,60	>0,40	>0,20	≤0,20
IBE	>7,40	>4,80	>3,20	>1,60	≤1,60
EQR	>0,64	>0,60	>0,40	>0,20	≤0,20
EPT	>7	>6,54	>4,36	>2,18	≤2,18
EQR	>0,80	>0,60	>0,40	>0,20	≤0,20
Margalef's Diversity Index	>4,63	>3,45	>2,30	>1,15	≤1,15
Multimetric Index EQR	**>0,79**	**>0,60**	**>0,40**	**>0,20**	**≤0,20**

Table 8 Classification scheme for the high-middle mountainous of water body type in the Upper Dnieper River basin

6.1.1 Comparison of the class boundaries with other regions

Classification schemes established for the Upper Dnieper River basin (BMWP Score) could not be compared with the class boundaries established and used in the Central Baltic GIG group for typologies RC4, RC5 and RC6 because this topology are not using any of the indexes for the intercalibration, The only similar country using some of the is Poland (BMWP) for RC-1,

6.2 Class boundaries for physico-chemical parameters

Based on the pressure and impact analysis organic pollution from untreated waste waters, nutrients from agricultural activities and heavy metals from mining industry in the Upper Dnieper River basin are stress factors, Therefore, BOD_5, COD, O_2, NH_4, NO_3, PO_4 and 6 heavy metals were included in the JFS programme and also to the classification system development (correlation analysis),

6.2.1 Background concentrations

It is important to know the background (natural) concentrations of heavy metals in the river in order to assess the contribution of human activities into the total heavy metals load detected, Background concentrations were calculated using the statistical method based on theoretical log-normal distribution defined by two parameters (mean value μ and standard deviationσ), Data sets of heavy metals available for the upstream part of the Dnieper and tributaries, from the JFs (2013 – 2016) were used in the calculations,

1. 30 sites in rivers in the basin (Berezina, Snov, Usa, Mesha, …) were selected as location with natural, or minimal anthropogenic influence,
2. The whole data set was used to calculate statistical parameters,
3. One value, close to "0" was added to the original data sets (for example detection limit divided by 100 can be used),
4. All values in the data sets were re-calculated as log-values,
5. Both mean value μ and standard deviation σ are calculated from the log-values data sets to create the theoretical log-normal distribution functions,
6. Calculation of the given percentile in the range from 10 to 95-tile was done,
7. Estimation of the background concentration values was made from the log-normal probability curve, as percentile,

6.2.2 Relationship with stressors

To find critical threshold or class boundary values for variables indicative of human induced stress (water quality should support biotic elements (Annex V)) they can be correlated with the estimated biological EQRs or biological status, In this case, Pearson correlation was used to analyse the relation between the BOD_5 and other selected water quality parameters and also between the BMWP Score and selected water quality parameters,

Results from the analysis with the data in the period 1992-2013 have shown that there is weak correlation with all the parameters, Nevertheless, if the long historical data are taken into account, the correlation for BOD_5 with the parameters increases (better correlation for COD, NH_4, NO_3, O_2 and PO_4) (Table 9).

	O_2	COD	NH_4	$N0_3$	PO_4
BOD_5	0,285	0,521	0,323	0,547	0,445

Table 9 Pearson correlations between selected BOD_5 and selected physico-chemical parameters ($p < 0,05$), N = 900 (from 1992 – 2013) for the Upper Dnieper River basin

Using the data in the period 2013-2016, the Pearson correlation have shown that there is weak correlation with all the parameters and the values are showing the same results than the long historical data with similar weak correlation for almost all the parameters with the exception of NO_3 (Table 10),

	O_2	**COD**	**NH_4**	**$N0_3$**	**PO_4**
BOD_5	0,077	0,013	0,226	0,514	-

Table 10 Pearson correlations between selected BOD_5 and selected physico-chemical parameters ($p < 0,05$), N = 100 (from 2013 – 2016) for the Upper Dnieper River basin

The correlation between BMWP Score (see Table 11) is weak with almost all the parameter using all the historical data for biological data (2013-2016) and for physicochemical parameters (1992-2013), In general, tendencies of the relationships between BMWP Score and tested water quality parameters (with few data and long historical data) are towards expected directions (negative for BOD_5, COD and nutrients and positive for O_2).

	BOD_5	O_2	COD	NH_4	NO_3	PO_4
BMWP – RC	,064	0,084	0,052	0,072	0,103	0,067

Table 11 Pearson correlations between BMWP Score and selected physico-chemical parameters (p < 0,05) for the Upper Dnieper River basin River basin

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 for JFS only one sampling round in given year can be used to classify the ecological status. Due to this fact, it was decided to evaluate data (long-term data in the last 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. 7). 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.

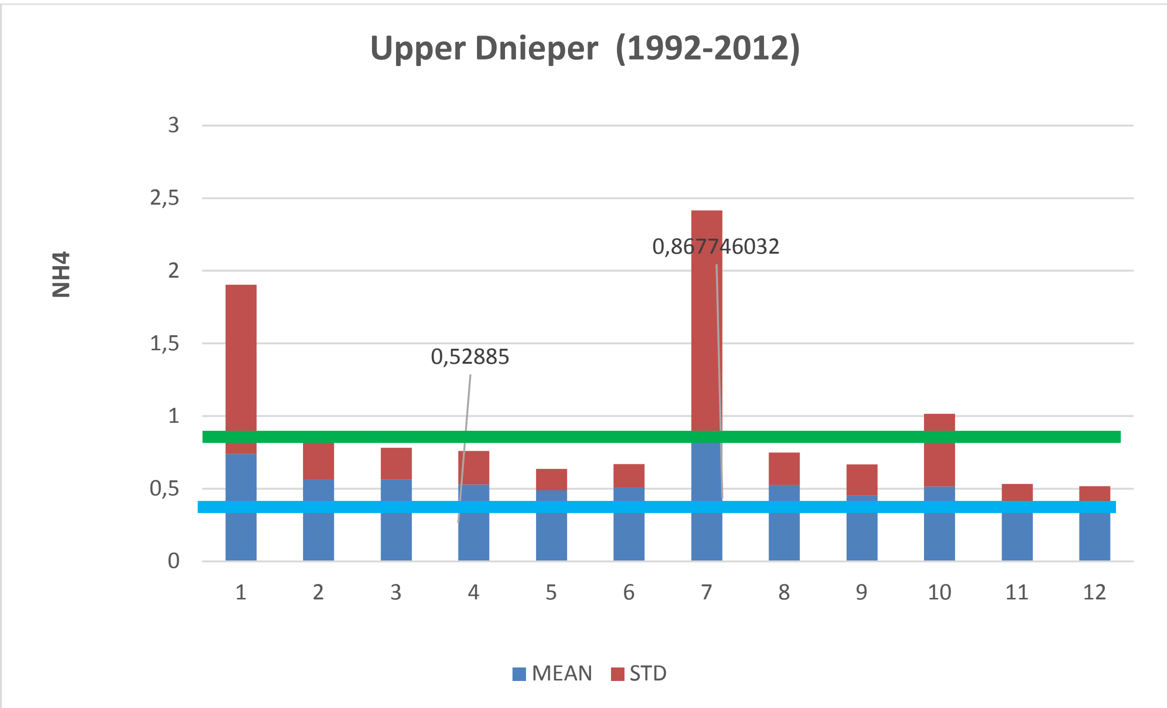

Figure 7 Long-term monthly mean concentrations and standard deviations of NH_4 (blue line is High status and green line Good status limit values).

Due to weak correlations it is not possible to indicate the association between the pressure variables and metrics, Therefore, it was decided to use historical data from 1993-2016 and also expert judgement in setting the EQR boundaries of the selected pressure variables (see Table 12),

Parameter	unit	I	II	III
Temperature	**°C**	<20	<27	≥27
Conductivity	**µS/cm**	<300	<500	≥500
pH	**--**	(7,0; 8,5)	(6,0;	≤ 6,0
			7,0>	or
			or	≥ 9,0
		8,5-7,0	<8,5; 9)	
Dissolved oxygen	**mg/l**	>9	>7,5	≤7,5
BOD5	**mg/l**	<3	<6	≥6
COD-Cr	**mg/l**	<10,0	<25	≥25
N-NH_4	**mg/l**	<0,4	<0,9	≥0,9
N-NO_3	**mg/l**	<3,5	<8	≥8
N-PO_4	**mg/l**	<0,2	<0,5	≥0,5

Table 12 Classification scheme for general physico-chemical parameters

Parameter	unit	I	II	III
Cu	µg/l	<4	<20,0	≥20,0
Zn	µg/l	<20	<40,0	≥40,0

Table 13 Classification scheme for other specific pollutants relevant for the Upper Dnieper River basin

6.3 Class boundaries for 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 hydromorphological quality elements (HMQE) assessment system in the EPIRB project is used for the classification in the pilot river basins (see Table 14), This preliminary Hydromorphological Quality Score system (HMQS) was used in Slovakia to classify the water bodies (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	

Table 14 Preliminary boundaries of the hydromorphological quality classes

6.1 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, 8), 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,

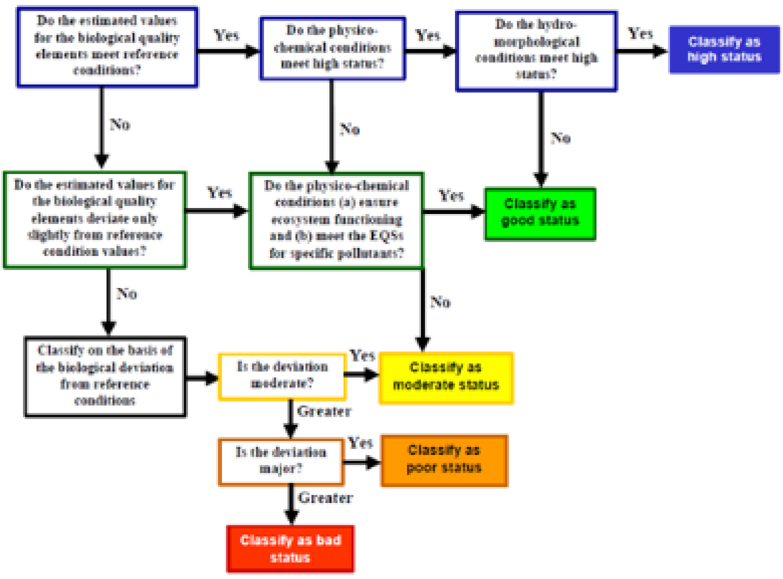

Figure 8 Assessment of the ecological status (reproduced from WFD CIS Guidance documents 10 and 5)

7. CLASSIFICATION EXERCISE

In the next page one first approach of the classification exercise is presented, More accurate exercise will be done later (classification schemes will be applied on the JFS results),

Table 15 **Ecological status classification of the sampling locations in the Upper Dnieper River basin in Belarus (spring 2016 JFS data used)**

SITE	River	Location of sampling site	BMWP	BBI	IBE	EPT	*Margalef's Diversity Index*	*Multimetris Index EQR*	Physico-chemical parameters	HM Quality Score	OVERALL ECOLOGICAL STATUS
1,	Volches	vil, Ustye	143	9	8	16	6,341	High	COD	High	**GOOD**
2,	Ut	vil, Tereshkovichi	90	9	8	11	4,093	Good	COD	High	
3,	Greza	vil, Vyazma	98	7	7	10	4,095	Good	COD	Good	**GOOD**
4,	Vabich	vil, Barsuki	140	9	7,4	13	4,876	High	COD	Good	
5,	Usha	vil, Usha	102	8	7	7	4,196	Good	COD; NH4	High	**GOOD**
6,	Berezina	vil, Uglata	125	9	8	11	5,433	Good	COD	High	**GOOD**
7,	Berezina	vil, Chircovichi	63	5	6	4	2,593	Poor	COD	High	**POOR**
8,	Gayna	vil, Sutoki	98	8	6,4	10	4,608	Good	COD	High	**GOOD**
9,	Plissa	t, Smolevichi	54	6	6	6	3,017	Moderate	Conductivity; COD	Moderate	**MODERATE**
10,	Plissa	t, Borisov	134	8	8	13	5,144	High	COD; NH4	High	**GOOD**
11,	Zhadunka	vil, Studenec	133	8	8,4	7	5,354	High	COD	Good	**MODERATE**
12,	Uza	vil, Bobovichi	29	3	3,4	1	1,373	Bad	COD, Conductivity	Good	**BAD**
13,	Ola	vil, Plesovichi	110	8	7	7	5,031	Good	Conductivity; COD	Moderate	**MODERATE**
14,	Lipa	vil, Lipa	87	8	7	5	3,778	Moderate	CDO	Good	**MODERATE**
15,	Drut	t, Rogachev	154	6	8	15	6,488	Good	COD	High	**GOOD**
16,	Rova	vil, Semenkovichi	82	7	6	7	2,583	Moderate	COD	Good	**MODERATE**
17,	Drut	vil, Belynichi	131	9	9	15	5,302	High	COD	Good	**GOOD**
18,	Vyacha	vil, Nelidovichi	121	8	9	8	4,958	Good	BOD	Good	**MODERATE**
19,	Iput	t, Gomel	94	7	6	7	2,236	0,53	COD	Poor	**POOR**
20,	Реста	vil, Poteryaevka	68	7	6	5	3,164	0,52	COD	High	**MODERATE**

Table 16 **Ecological status classification of the sampling locations in the Upper Dnieper River basin in Ukraine (spring 2016 JFS data used)**

Number of Site	**River/Sampling site**	**Location**	**BMWP**	**BBI**	**IBE**	**EPT**	***Margalef's Diversity Index***	***Multimetris Index EQR***	**Physico-chemical parameters**	**HM Quality Score**	**Overall ecological status**
site 1	Suhyi Vyr	Gribova Rudnya	76	7	7,6	3	3	Moderate	pH, O2, COD	Good	**MODERATE**
site 2	Snov	Sedniv	106	7	6	7	5	Good	O2,BOD, COD	Moderate	**MODERATE**
site 3	Zdvizh	Fenevich	80	6	6.6	3	4	Moderate	COD	Good	**MODERATE**
site 4	Teterev	Voropayevka	22	4	4,4	0	1	Poor	BOD, COD, NH4	High	**POOR**
site 5	Mesha	Rudnaya	81	7	7.4	6	4	Good	pH, COD	Good	**MODERATE**
site 6	Nemelnya	Border BY/UA	107	8	7,4	8	5	Good	COD	Moderate	**MODERATE**
site 7	Dnieper	Border BY/UA	65	5	6	1	4	Poor	COD	Good	**POOR**
site 8	Desna (Десна)	Upper Chernigiv (выше г. Чернигов)	53	4	4,4	2	3	Poor	COD	High	**POOR**
site 9	Desna	Below Chernigov 10 KM	89	5	6	2	5	Moderate	COD	High	**MODERATE**
site 10	Dnieper	Zagadka village)	27	4	2	2	2	Bad	COD	Good	**BAD**

8. CONCLUSIONS AND RECOMMEDATIONS

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 Upper Dnieper in Ukraine and Belarus 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.

9. REFERENCES

2012 Intercalibration Technical Report Central-Baltic River Gig – Macroinvertebrates

2013 Aplicación de los sistemas de evaluación del estado ecológico desarrollados para ríos en la aplicación de la Directiva Marco del agua en la Demarcación Hidrográfica del Cantábrico