ARISTOTLE UNIVERSITY OF THESSALONIKI

OPEN ACADEMIC COURSES

River Water Quality

Section **4**: Monitoring

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Ευρωπαϊκή Ένωση
Ευρωπαϊκό Κοινωνικό Ταμείο

ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΠΡΟΓΡΑΜΜΑ
ΕΚΠΑΙΔΕΥΣΗ ΚΑΙ ΔΙΑ ΒΙΟΥ ΜΑΘΗΣΗ
επένδυση στην κοινωνία της γνώσης
ΥΠΟΥΡΓΕΙΟ ΠΑΙΔΕΙΑΣ & ΘΡΗΣΚΕΥΜΑΤΩΝ, ΠΟΛΙΤΙΣΜΟΥ & ΑΘΛΗΤΙΣΜΟΥ
ΕΙΔΙΚΗ ΥΠΗΡΕΣΙΑ ΔΙΑΧΕΙΡΙΣΗΣ

ΕΣΠΑ 2007-2013
πρόγραμμα για την ανάπτυξη
ΕΥΡΩΠΑΪΚΟ ΚΟΙΝΩΝΙΚΟ ΤΑΜΕΙΟ

Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

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Monitoring

Sampling, Analysis & Biological indicators

Section Goals

- To introduce students to the possibility of using different biota as indicators of water quality

Section Outcomes

- By the end of this course, students should have considered the history of the species life cycle stages, and macroinvertebrates as a pollution indicating system, have studied some of the major taxonomic groups, have investigated methodologies, have considered the comparative value of biotic indices and Europian scores and have reviewed monitoring & modeling

Monitoring

Sampling & Analysis

Section Contents

1. Hydromorphological Parameters, Habitat features & Habitat Evaluation
2. Physical – Chemical Parameters

Hydromorphological Parameters, Habitat features & Habitat Evaluation

- To coordinate a coherent implementation of the Water Framework Directive a common understanding on technical & scientific implications has to be considered
- In Working Group 2.7 (WFD), guidance on establishing programmes of measures is provided. Specific emphasis is given on quality elements, selection & design of monitoring programmes (in accordance with Article 8, 11 & Annex V)
- In many European countries monitoring systems based on habitat description are operational; they cover the ecomorphological status & provide basis for planning activities (engineering, restoration & environmental studies)

Hydromorphological Parameters, Habitat features & Habitat Evaluation

National classification systems for rivers in the EU Member States include many physical elements (Anon, 2002):

- ✓ Quantity & dynamics of flow
- ✓ River Continuity
- ✓ Channel patterns
- ✓ Width & depth variations
- ✓ Flow velocities
- ✓ Substrate conditions
- ✓ Riparian zone structure & condition

- Paradigms are River Habitat Survey (RHS) in UK, Ecological Status River MED [ECOSTRIMED- including IBMWP (macroinvertebrate based) & QBR (riparian habitat quality)] in Spain

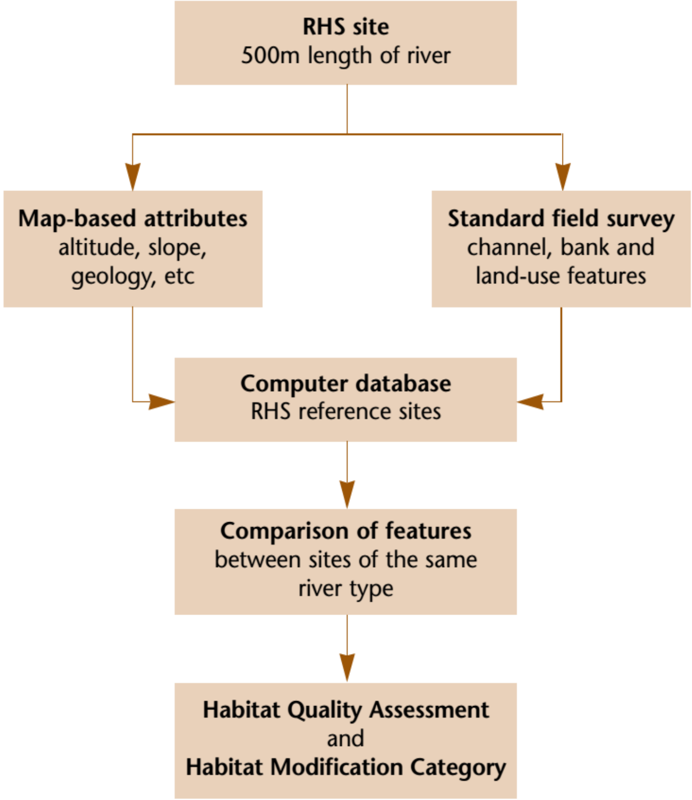
Hydromorphological Parameters, Habitat features & Habitat Evaluation

RHS

- System for assessing the character & quality of rivers based on their physical structure with 4 components:
  - ✓ standard methodology for field survey
  - ✓ computer database
  - ✓ suite of methods for assessing habitat quality
  - ✓ method for describing the extent of artificial channel modification.
- Determination of quality results from occurrence & habitat diversity features, of known value, for wildlife (by comparing observed features with others recorded at sites from rivers of similar typology). High quality is associated with sites of unmodified state
- Success depends on: outputs easy to understand, tried-and-tested field methods based on a representative sample of river habitat features, completeness of database, description & comparison of physical structure & habitat quality at different size scales, acceptability by external organizations, its reference to WFD

Hydromorphological Parameters, Habitat features & Habitat Evaluation

RHS (Raven et al 1998)



Introduction to how RHS Works (Raven et al. 1998)

Hydromorphological Parameters, Habitat features & Habitat Evaluation

RHS

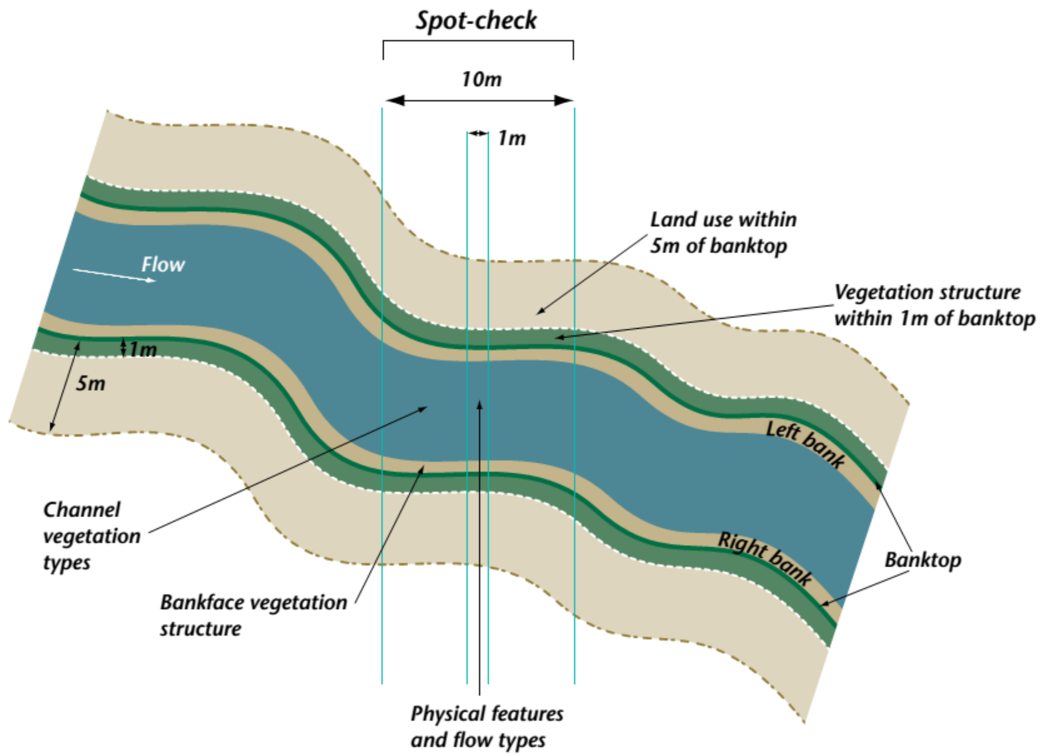
In the field:

- ✓ Measurement of channel depth
- ✓ Measurement of water flow-velocity
- ✓ Calculation of discharge
- ✓ Evaluation of habitat with collection of features associated with the physical structure in 500m sample unit area (Raven *et al.* 1997, Environment Agency 1997)
- ✓ Record of substrate, flow, erosional and depositional features in the channel, morphological, vegetation structure on the banks, land use in the adjacent river corridor (Raven *et al.* 1997,1998, 2002) along with human modifications & induced obstacles

- Habitat Quality Assessment (HQA) & Habitat Modification Scores (HMS) are calculated to assess the habitat structure quality & the extent of human alteration of each site. Principal Component Analysis (PCA) is applied to HQA scores (Jeffers 1998) for the comparability with similar sites

Hydromorphological Parameters, Habitat features & Habitat Evaluation

Features recorded at RHS Spot-Checks (Raven et al. 1998)



More for RHS in GB & Ireland (UK) along with the full manual at:
http://www.riverhabitatsurvey.org/?page_id=141

Hydromorphological Parameters, Habitat features & Habitat Evaluation

RHS

- 4 page form easy to fill on a basis of field data collected on a standard 500m length of the channel including map information & channel features (riffles, pools, point bars, vegetation etc.)
- Does not require specialization or expertise since it relies on observational data. Basic training is necessary
- Can be carried out all year long during low flow conditions, but not during high or flood flows because many in-stream features become invisible
- RHS captures the structural variation of rivers relevant to a wide range of organisms, from microscopic algae to fish, birds and mammals expected to be found there

Hydromorphological Parameters, Habitat features & Habitat Evaluation

RHS

- Substrate is estimated visually as percentage occurrence of each particle size category using the Wentworth scale (Wentworth, 1922) & the variance of substrate is calculated with Substrate Diversity Index (De Billy et al. 2000, based on Shannon diversity index)
- Channel depth & water flow are measured with a flow meter, width is measured with a tape measure
- Discharge is calculated by channel dimensions & flow measurement
- Macrophytes coverage is estimated visually as percentage

Hydromorphological Parameters, Habitat features & Habitat Evaluation

Main features recorded during an RHS survey (Raven et al. 1998)

Features recorded	At 10 spot-checks	In sweep-up
Predominant valley form		✓
Predominant channel substrate	✓	
Predominant bank material	✓	
Flow type(s) and associated features	✓	✓
Channel and bank modifications	✓	✓
Bankface and banktop vegetation structure	✓	
Channel vegetation types	✓	✓
Bank profile (unmodified and modified)		✓
Bankside trees and associated features		✓
Channel habitat features	✓	✓
Artificial features	✓	✓
Features of special interest		✓
Land use	✓	✓

Physical – Chemical Parameters

- In situ measurements : Temperature, pH, conductivity, total dissolved solids (TDS), dissolved oxygen concentration (DO), oxygen saturation (DO%) or in mg/L, performed using portable polymeters
- Surface water samples are taken in polypropylene bottles & stored at 4 ^{o}C for laboratory analysis concerning nutrients & TSS. 2 more water samples are collected in 300 ml BOD bottles & sealed in the dark at 20 ^{o}C for 5 days
- In the lab measurements: Water samples are filtered through a 45 μm membrane & analyzed for alkalinity, total hardness & nutrients (PO_4-P, NO_3-N, NO_2-N, ammonia) according to APHA (1985). Total suspended solids respond to the weight of material retained by the 45 μm fiber glass filters after being dried at 104 ^{o}C for 2h (APHA, 1985).

Monitoring

Biological Indicators

Section Contents

1. Conceptual basis of Biological Indicators
2. Saprobic indices
3. Biotic indices & Scores
4. Choice of indicator organisms
5. History & Development of Biological Assessment methods
6. Indicator organism methodology & EU approach using benthic macroinvertebrates
7. Sampling
8. Present status of indicator methodologies & Approaches
9. Current & Future status of Biological Water Quality Indicators (BQI)

Conceptual basis of Biological Indicators

- In all types of monitoring, as referred in section 1, surveillance, operational & investigative, all biological elements characteristic of the water body must be included according to the WFD.
- The results of biological monitoring must be expressed as an ecological quality ratio (EQR, observed values/reference values) for the purposes of classification of ecological status
- The indicator organism concept is a powerful tool in establishing the ecological status of a water body (compared to reference conditions)

Conceptual basis of Biological Indicators

- Different types and amounts of pollution result in changes to the type and numbers of individual species
- So, the use of organisms to detect or *indicate* pollution relate to the detection of changes in community structure
- Observation of the occurrence of specific organisms or of changes in community diversity are the 2 main types to assess the degree of pollution:
  - ✓ Presence or absence of specific indicator-organisms whose degree of tolerance to pollution is known and can be used to assess the level of pollution. These species have a *narrow and specific tolerance* to pollution
  - ✓ Community - diversity changes can show the level of pollution by assessing the relative proportion of the different species & the distribution of individuals between species (*species dominance*). Such changes are assessed by the use of diversity indices & scores

Saprobic indices

- Organism on decomposing organic substances as a food source
- Indices: Development of the descriptive Saprobien system proposed by Koltwitz & Marsson early in the last century
- Based on: running water communities show a regular and generally predictable sequence of changes in the presence and abundance of specific indicator species to organic pollution
- Indicator species are assigned indicator or receive saprobic values based on their tolerance to organic pollution.
- The score relates to the saprobic zone depending if the organism is typically present in oligosaprobic, α-mesosaprobic, β-mesosaprobic or polysaprobic zones, respectively.

Biotic indices & Scores

- Systems which combine diversity on the basis of taxonomic groups with the pollution indicator ability of individual species or higher taxa or groups into a single index or score (Tolkamp 1985)
- Generally accepted: polluted waters are generally less diverse than unpolluted ones. The increased degree of pollution “forces” species to be selectively removed in order of their relative susceptibility to the particular form of pollution (Abel 1996)
- A score is given to each indicator organism in accordance with its relative tolerance to pollution. The higher the score, the less tolerant is the indicator
- Each organism is identified to the level at which is can be assigned to a group & get scored

Choice of indicator organisms

- ✓ Results expressible in simplified form
- ✓ Presence/absence of indicator organism must be a function of water quality
- ✓ Organisms must respond to small changes of quality
- ✓ Simple methodology (time- personnel- money efficient) for sampling, sorting, identification, preservation & data processing
- ✓ When biological surveillance is in combination with environmental assessment, the indicator should have commercial, amenity or conservation value

- Benthic invertebrates are currently the most favored indicator organism in current biological surveillance programs in Europe
- In the case of running and standing freshwaters WFD demands all biological elements to be assessed, specifically phytoplankton, phytobenthos, macrophytes, benthic invertebrates & fish

History & Development of Biological Assessment methods

- The history of water quality assessment using the biological indicator organism concept began before the turn of the last century in Germany (Metcalfe 1989) & many have been proposed ever since
- Most were based on quantitative approach yielding an overall score as an indicator of water quality
- Invertebrates collected from all available habitats & identified either to family, genus or species level depending on the type of organism were used in Indices
- The Trent Biotic Index & its development the Chandler Score set the foundation for the development of many more Indices in EU countries as the BMWP in UK (1976), the French Indice Biologique de Qualité Générale (1982), the Belgian Biotic Index (1983) and others.
- The indices differ on their sensitivity, on key groups of organisms used, the values given to indicators, the rating of abundances and/or presence-absence

History & Development of Biological Assessment methods

- The saprobic system, originally developed in Germany, has evolved independently of biotic indices. Many western European countries rejected this approach in favour of biotic indices while others still use saprobic indices
- In saprobic indices there is no fix position for each indicator taxon.No single indicator species will be representative of only one saprobic zone and its distribution will range over a number of zones in relation to its tolerance
- The saprobic index S of a sample is the weighted arithmetic mean of individual saprobic indices of the indicator taxa:

$$S = \frac{\sum_{k=1}^{K} s_k h_k}{\sum_{k=1}^{K} h_k}$$

Where:
K is the total number of taxa
s_k is the value of the saprobity index of taxon k in the sample
h_i is the relative abundance of taxon k (estimated from an approximate scale) in the sample

Indicator organism methodology & EU approach

Saprobic Indices

- Based on the presence of indicator species that are assigned saprobic values in accordance with their tolerance to pollution
- Austria: Env. Programs include the calculation of a saprobic score as an indicator of organic pollution (Birt, 2003) using benthic invertebrates (periphyton & phytobenthos may also be included). Same base with the saprobic index S described, with indicator weighting of each taxon, a sparobic score & a measure of abundance
- Germany: Env. Programs include the calculation of a saprobic score (DIN 38 410) using benthic invertebrates. Use stream type specific saprobic reference conditions and a total number of 612 indicator taxa. Same base with the saprobic index S described, with indicator weighting of each taxon, a sparobic score & a measure of abundance. Additional there is a Microsaprobic Index (S_{Mi}), which evaluates the occurrence of microscopic taxa

Indicator organism methodology & EU approach using benthic macroinvertebrates

- Benthic macroinvertebrates are the most commonly used indicator organisms in the quality assessment of freshwater in the EU
- Why?:
  - ✓ Large, relatively easily collected
  - ✓ Reasonably sedentary (not migratory)- live on or in the substrate;
  - ✓ Not too difficult to identify many types, reasonably clear taxonomy
  - ✓ Distribution with respect to environmental stress, in particular organic pollution, reasonably well understood
  - ✓ Diverse component of the aquatic environment with a range of responses to stress
- There is a variety of approaches, sampling frequency, cost and biological elements included in the assessment of biological surveillance programmes in standing and running waters in all EU member states

Indicator organism methodology & EU approach using benthic macroinvertebrates

Biotic Scores

- Most biotic scores in EU are based on the UK – **BMWP** Score (Chesters, 1980; ISO/BMWP, 1979)
- Invertebrate families are given a score based on their pollution tolerance. The more sensitive the families representatives are, the bigger the score is.
- The ratio of total BMWP to the total number of taxa gives the ASPT (Average Score Per Taxon obtaining score) being relatively independent of season, sample size & technique
- <u>Advantages</u>: Quick & simple, not developed for a particular catchment, good correlation with other biotic indices
- <u>Disadvantages</u>: No quantification, Open-ended - no maximum score for unpolluted waters
- This observed/predicted ratio is expressed as an Ecological Quality Index (EQI) for both the number of taxa and the ASPT(Environment Agency, 1997).

Indicator organism methodology & EU approach using benthic macroinvertebrates

Biotic Scores - BMWP

Biological Monitoring Working Party (BMWP) Score

	Family	Score
Ephemeroptera (Mayflies)	Siphlonuridae, Heptagenidae, Leptophlebiidae, Ephemerellidae,Potamanthidae, Ephemeridae	10
Placoptera (Stoneflies)	Taeniopterygidae, Leuctridae, Capniidae, Periodidae, Perlidae, Chloroperlidae	10
Trichoptera (Caddisflies)	Phryganeidae, Molannidae, Beraeidae, Odontoceridae, Leptoceridae, Goeridae, Lepidostomatidae, Brachycentridae, Sericostomatidae	10
Hemiptera (Waterbugs)	Aphelocheiridae	10
Crustacea	Astacidae (crayfish)	8
Odonata (Dragonflies)	Lestidae, Agriidae, Gomphidae, Cordulegastridae, Aeshnidae, Corduliidae, Libellulidae	8
Trichoptera	Psychomyidae, Philopotamidae	8
Ephemeroptera	Caenidae	7
Plecoptera	Nemouridae	7
Trichoptera	Rhyacorphilidae, Polycentropidae, Limnephilidae	7
Gastropoda (snails)	Neritidae, Viviparidae, Ancylidae	6
Trichoptera	Hydroptilidae	6
Bivalvia	Unionidae	6
Amphipoda (freshwater sprimps)	Corophiidae, Gammaridae	6
Odonata	Platyctemidae, Coenagriidae	6
Hemiptera	Mesovellidae, Hydrometridae, Gerridae, Nepidae, Naucoridae, Notonectidae, Pleidae, Corixidae	5
Coleoptera (beetles)	Haliplidae, Hygrobiidae, Dytiscidae, Gyrinidae, Hydrophilidae, Clambidae, Helodidae, Dryopidae, Elminthidae, Chrysomelidae, Curculionidae	5

Indicator organism methodology & EU approach using benthic macroinvertebrates

Biological Monitoring Working Party (BMWP) Score

	Family	Score
Trichoptera	Hydropsychidae	5
Diptera	Tipulidae	5
Diptera	Simuliidae	5
Platehelminthes (Flatworms)	Planariidae, Dendrocoelidae	5
Ephemeroptera	Baetidae	4
Neutroptera (Lace wings)	Sialidae	4
Hirudinea (Leeches)	Piscicolidae	4
Gastropoda	Valvatidae, Hydrobiidae, Lymnaeidae,Physidae, Planorbidae	3
Bivalvia (bivalve molluscs)	Sphaeriidae	3
Hirudinea	Glossiphonidae, Hirudidae, Erpobdellidae	3
Isopoda (water or hog lice)	Asellidae	3
Diptera	Chironomidae	2
	Oligochaeta (whole class)	1

Biotic Scores - BMWP

Grade	Description	EQI_{taxa}	EQI_{ASPT}
A	Very good	0.85	1.0
B	Good	0.70	0.90
C	Fairly good	0.55	0.77
D	Fair	0.45	0.65
E	Poor	0.30	0.50
F	Bad	<0.30	<0.50

UK river classification scheme based upon biological parameters (General Quality Assessment (GQA) Biological Grading)

Indicator organism methodology & EU approach using benthic macroinvertebrate

Biotic Scores

- Spanish BMWP Score: Same basis as the UK BMWP, differs in including new families, changes in some scores & the division of the score into five classes relating to different levels of pollution
- Polish BMWP Score: Same basis Aw the Spanish BMWP but with different scores
- Hellenic Biotic Index: Based on UK BMWP with modifications in families & scores, the relative abundance and relative to the richness of habitats

& many more in other EU countries

Hellenic Evaluation System using benthic macroinvertebrates

- **473 samples** *from clean and polluted sampling sites*
- **Recalibration of some taxa**
- **Separation of substrate into three categories:** coarse *(>70%),* fine-grained*(>70%) & mixed*
- **Each taxonomic group** in order to be inserted in the index should be collected from at least 5 samples of each substrate category
- **Mathematical processing based on the values of the Spanish evaluation system** BMWP‘ & the average IASPT' (AHES) was followed
- The initial scores for the families of **Neritidae** & **Sphaeriidae** were kept

Hellenic Evaluation System using benthic macroinvertebrates

- The relative abundance factor must be taken into account
- The Hellenic Evaluation System is significantly affected by the differences between rivers & seasons, and so
- Necessary to calculate the AHES
- The Hellenic Evaluation System (HESY) is significantly affected by the variability of river habitat, so habitat diversity/richness is taken into consideration

Hellenic Evaluation System using benthic macroinvertebrates

Hellenic Evaluation Score (HES) 1/3

Taxa	Present (0-1% relative abundance)	Common (1.01-10% relative abundance)	Abundant (>10% relative abundance)
α) Capniidae, Chloroperlidae, β) Siphlonuridae, γ) Aphelocheiridae, δ) Blephariceridae ε) Phryganeidae, Molanidae, Odontoceridae, Bareidae, Lepidostomatidae, Thremmatidae, Brachycentridae, Helicopsychidae	100	110	120
α) Leuctridae, Perlodidae, Perlidae, β) Sericostomatidae, Goeridae, γ) Neoephemeridae	90	97	100
α) Nemouridae, Taeniopterygidae, β) Ephemeridae, Heptageniidae, Leptophlebiidae, γ) Leptoceridae, Polycentropodidae, Psychomyidae, Philopotamidae, Limnephilidae, Rhyacophilidae, Glossosomatidae, Ecnomidae, δ) Aeshnidae, Lestidae, Corduliidae, Libelulliidae, ε) Athericidae, Dixidae, στ) Helodidae, Gyrinidae, Hydraenidae, ζ) Sialidae, η) Grapsidae, Potamonidae (Brachyura) θ) Astacidae, (Macrura)	80	86	90

Hellenic Evaluation System using benthic macroinvertebrates

Hellenic Evaluation Score (HES) 2/3

Taxa	Present (0-1% relative abundance)	Common (1.01-10% relative abundance)	Abundant (>10% relative abundance)
α) Potamanthidae, β) Calopterygidae, Cordulegasteridae γ) Stratiomyidae, δ) Hydrobiidae	70	75	78
α) Platycnemididae, Gomphidae, β) Tabanidae, Ceratopogonidae, Empididae, γ) Elminthidae δ) Viviparidae, Neritidae, ε) Unionidae,	60	64	67
α) Caenidae, Oligoneuriidae, Polymitarcidae, Isonychiidae, β) Hydropsychidae, γ) Ancylidae, Acroloxidae, δ) Gammaridae, Corophidae, ε) Atyidae στ) Planariidae, Dendrocoelidae, Dugesiidae, ζ) Dryopidae, Helophoridae, Hydrochidae, Clambidae η) Psychodidae, Simuliidae	50	53	56
α) Ephemerellidae, Baetidae, β) Hydroptilidae, γ) Tipulidae, Dolichopodidae, Anthomyidae, Limoniidae, δ) Haliplidae, Curculionidae, Chrysomelidae, Hydroscaphidae ε) Hydracarina στ) Piscicolidae, Glossiphonidae	40	38	35

Hellenic Evaluation System using benthic macroinvertebrates

Hellenic Evaluation Score (HES) 3/3

Taxa	Present (0-1% relative abundance)	Common (1.01-10% relative abundance)	Abundant (>10% relative abundance)
α) Coenagriidae, β) Chironomidae (not red)*, γ) Dytiscidae, Hydrophilidae, Hygrobiidae, δ) Corixidae, Hebridae, Veliidae, Mesoveliidae, Hydrometridae, Gerridae, Nepidae, Pleidae, Naucoridae, Notonectidae, Belostomatidae, ε) Asellidae, Ostracoda, στ) Physidae, Bithyniidae, Bithynellidae, Molaniidae, Ellobiidae, ζ) Hirudinidae, η) Sphaeriidae θ) Oligochaeta (except for Tubificidae)*	30	25	20
α) Chironomidae (red), Rhagionidae, Culicidae, Muscidae, Thaumaleidae, Ephydridae, Chaoboridae β) Lymnaeidae, Planorbidae, γ) Erpobdellidae	20	12	3
α) Tubificidae, β) Valvatidae, γ) Syrphidae	10	2	1

Chironomidae (not red) and Oligochaeta (except for Tubificidae) have the following abundance categories: 0-10% for "present" (P), 10.01-20% for "common" and over 20% for "abundant".

Hellenic Evaluation System using benthic macroinvertebrates

	Macrophyte bed	Natural substrate			Artificial substrate	Slough	Woody Snag
Riffle		Mixed	Coarse	Fine			
Channel margin							
Island margin							
Main channel							
Run							
Channel margin							
Island margin							
Main channel							
Pool							
Channel margin							
Island margin							
Main channel							

Matrix used for the classification of a site as “poor” (white cells) or “rich” (gray cells) as to its habitat diversity, depending on the cross-section of the relevant line and column.

GRADES of HES (X values) and AHES (Y values)

Sample collected from many types of habitats			
HES	X	AHES (Average HES)	Y
>1532	5	>64,72	5
1326-1532	4	54,57-64,72	4
830-1325	3	45,82-54,56	3
341-829	2	31,73-45,81	2
0-340	1	0-31,72	1
Sample collected from few types of habitats			
HES	X	AHES (Average HES)	Y
>1052	5	>55,69	5
756-1052	4	45,18-55,69	4
389-755	3	35,33-45,17	3
167-388	2	27,50-35,32	2
0-166	1	0-27,49	1

GRADES of HES (X values) and AHES (Y values)

Interpretation of the SemiHES values

Semi HES [(X+Y)/2]	Interpretation
5	Very good
4,5	Very good
4	Good
3,5	Good
3	Moderate
2,5	Moderate
2	Poor
1,5	Poor
1	Very Poor

Indicator organism methodology & EU approach using benthic macroinvertebrates

Biological Indices

- Most biological indices in EU are based on the Trent Biotic Index.
- Belgian Biotic Index (BBI) & Indice Biotique Global Normale (French- IBGN) are in common use in their respective countries
- **BBI** was derived from the French Indice Biotique containing a greater number of indicator taxa & having different weights to some indicator groups.
- The groups are ranked in order of increasing tolerance to pollution. The row corresponds to the presence of the most sensitive. The methodology is standardised & the index is independent of seasonal factors
- The values from BBI are grouped in 5 categories

Indicator organism methodology & EU approach using benthic macroinvertebrate

Biological Indices

- **<u>The IBGN</u>** was derived from the French Indice Biologique de Qualité Générale. There is a list of 135 systematic units as a measure of community diversity. Identification to families & for Oligochaeta to class
- The groups are ranked in order of increasing tolerance to pollution. The row corresponds to the presence of the most sensitive. The methodology is standardised & the index is independent of seasonal factors
- The values from IBGN are grouped in 5 categories

Indicator organism methodology & EU approach using benthic macroinvertebrates

Saprobiotics indices *(Q-index, BEOL, K 135)*
(Holland, Germany, Eastern Europe)

Trent Biotic Index
(TBI, England, 1964)

Biological Index
France (IB, 1968)

BΔ General Quality
(IGB, France , 1982)

BΔ Global
(IGB, France , 1985)

Belgian Biotic Index (*BBI, 1983)*

Chandler 's score
(1970, Scotland)

British Index *(BMWP)*
*(*British*, 1978)*

Modified BMWP
(1979, British*) +ASPT*

Iberian *BMWP'*
(1988, Spain)

Extended Biotic Index
(EBI, England, 1978)

Biological Index
(IBE Italy, 1980)

ASPT+BMWP
(Lincoln, ENGLAND)

The Hellenic score
(2000, GREECE)

Sampling Benthic Macroinvertebrates

- In deep rivers: using artificial substrates
- In shallow rivers: quantitatively, using a Surber sampler
- Qualitative sampling: using a net, but may be undertaken (precludes statistical analysis)
- Semi-quantitative sampling: methods like the three-minute kick-sweep method using a standard pond net (amenable to multidimensional analyses) in which sampling time is divided proportionally to the surface of all existing instream habitat types, at each site. Samples are placed in plastic bottles & preserved in 4% formaldehyde or 75% alcohol

✓ Each sample is coded for high or low flow period, the site name, the number of specimen etc.

Present status of indicator methodologies & Approaches

Phytoplankton

- Valuable biological indicators, easily sampled with understood respond to nutrient enrichment. Difficult to identify, not clear response to other sources of pollution
- No phytoplankton-based systems are currently in use in relation to the assessment of running waters
- One saprobic phytoplankton index (SPI) had been developed in the Netherlands with 7 phytoplankton group indicators of oligo- meso- poly- saprobic conditions

Present status of indicator methodologies & Approaches

Phytobenthos & periphyton

- Valuable biological indicators, relatively easily sampled from the substrate, relatively well understood its response to nutrient enrichment
- Like phytoplankton, difficult to identify, not clear response to other sources of pollution
- Saprobiological quality of rivers, with reference to organic pollution, is assessed in the Austrian Index which calculates the phytobenthos
- Similar indices comprising phytobenthos for the ecological classification system have been developed in Germany & Czech Repuplic
- Diatoms can support the functionality of ecological indices like the IBD (Biological Diatom Index, AFNOR 2000) which is in use in France

Present status of indicator methodologies & Approaches

Macrophytes

- Valuable biological indicators, Response to nutrient pollution reasonably well understood, Relatively easily identified, Relatively easy to sample
- Disadvantages: few species are present in eroding running waters & oligotrophic standing waters. Not clearly understood their relation with other pollutants
- Macrophyte Index in France - Indice Biologique Macrophytique en Riviéres (IBMR) to assess organic pollution and eutrophication of running waters. Is a function of overall tolerance to nutrient enrichment weighted by the relative abundance of contributing taxa

Present status of indicator methodologies & Approaches

Fish

- Being at the top of the food chain they reflect changes in the community
- Well understood response to pollution
- Being at different trophic levels provide an integrated indication of ecosystem health and water quality
- Their long life cycle provide indications of ecosystem health & water quality over an extended time period
- Easy identification
- Have high value from recreational & economic point of view
- ➢ difficult and expensive in labour to sample
- ➢ Their mobility may make them not characteristic of the area under ecological assessment

Present status of indicator methodologies & Approaches

Fish

- The French Indice Poisson National (IPN) is an index utilizing fish which combines types of measures (Oberdorff *et al.* 2002):
  - ✓ Total number of species as a measure of taxonomic richness
  - ✓ Number of rheophilic & lithophic species as a measure of habitat guild
  - ✓ Tolerant species as a measure of sensitivity to stress
  - ✓ Invertivorous & omnivorous species as a measure of trophic guild
  - ✓ Total density as a measure of abundance
- The ratio of observed & predicted values calculate combined probabilities
- The existence of several types of measures that individually provide different responses to stress allow the Fish Based indices to be applied to rivers of differing traits

Present status of indicator methodologies & Approaches

Fish

- The Belgic Index of Biological Integrity (IBI) can be applicable in small & medium streams of North West Europe
- The IBI integrates six types of measure belonging to one of three categories: species richness, indicators of water quality and indicators of physical habitat quality
- The total IBI score is the sum of the score of the six measures. Variations in scores may be affected by different biogeographical traits. Differentiation in measures & weighing may be necessary

Current & Future status of Biological Water Quality Indicators (BQI)

- Benthic invertebrates are the most commonly used group of organisms used as biological indicators in the assessment the ecological status of rivers and streams in EU member states
- Phytobenthos (diatoms) & macrophytes as indicators are in use or under development in several states
- Fish & phytoplankton as indicators are in an early stage in the vast majority of states
- Saprobic indices & scores for biological water quality assessment are in use in central and some eastern European countries
- Integration of methods & the further development of biological indicator methodologies will be based on the members states' preference
- The saprobic valency & indicator status of particular taxa may vary between member states. Biotic indices rely on the assignment of scores to particular taxonomic families