Institutul Național de Cercetare-Dezvoltare pentru Protecția Mediului

INSTITUTUL NAȚIONAL DE CERCETARE-DEZVOLTARE PENTRU PROTECȚIA MEDIULUI
Splaiul Independenței nr. 294, sector 6, 060031, București, România
Tel: (004) 021 305 26 00/ 0372 298 600, Fax: (004) 021 318 20 01, E-mail: incdpm@incdpm.ro, Web: www.incdpm.ro
subunitate:
INSTITUTUL NAȚIONAL DE CERCETARE-DEZVOLTARE "DELTA DUNĂRII"
Strada Babadag nr. 165, 820112, Tulcea, Romania, Tel: (+4) 0240 - 531 520, (+4) 0240 - 524 546 / 524 548 / 524 550, Fax: (+4) 0240 -533 547
E-mail: office@indd.tim.ro, Web: www.ddni.ro

INCDDD

Joint Operational Programme "BLACK SEA BASIN 2007-2013"

Project: **INNOVATIVE INSTRUMENTS FOR ENVIRONMENTAL ANALYSIS IN NORTH WESTERN BLACK SEA BASIN (BLACK SEA e-EYE)**
Cod proiect: **MIS-ETC No 1475**

GA1: Monitoring physical-chemical and biological parameters of surface aquatic systems in North-Western Black Sea Basin

Research initiative 1

Identification and defining physical-chemical parameters and biological parameters (Danube delta)

Danube Delta National Institute for research and Development (DDNITL Partner 1)

Dr.ing. Ion NĂVODARU – Implementation Responsible

Team experts:
dr.ch. Liliana TEODOROF – Senior technical environmental expert
boil. Alexandru DOROȘENCU – Scientific responsible expert
dr. ch. Cristina NĂSTASE – Environment chemistry expert
biol. Cosmin SPIRIDON – Biology expert for phytoplankton
dr.biol. Mihaela TUDOR – Biology expert for zooplankton
biol. Orhan IBRAM – Biology expert for macroinvertebrates
dr.biol. Mihai DOROFTEI – Biology expert for macrophytes
dr. biol. Aurel NĂSTASE – Biology expert for fish
dr.eng. Ion GRIGORAȘ – IT specislist

Tulcea, Romania
March 2014

CONTENT

Introduction 3
1 Identifying and defining of indicators 6
1.1 Physical - chemical indicators 6
1.1.1. General physical-chemical quality elements (thermal, salinity, oxygenation) 6
1.1.2. Nutrients 8
1.1.3. Metals 9
1.2. Biological indicators (Phytoplankton, Zooplankton, Macroinvertebrates) 11
1.2.1. Diversity indices 11
1.2.2. Saprobic systems 13
1.2.3. Species richness 14
1.3. Macrophytes 15
1.4. Fish 17
Conclusions 18
References 19

Introduction

The aquatic ecosystem is constantly being subjected to various kinds of pollution. This system receives a huge quality and quantity of wastes either from point sources such as domestic and industrial discharges or from non-point sources like surface and agricultural runoffs (Yang 2004, Moreno 2006).

Physical- chemical indicators are important indicators of surface water quality. These indicators can affect aesthetic qualities such as how water looks, smells, tastes and also can affect its toxicity and whether or not it is safe to use. Since the chemical quality of water is important to the health of humans as well as the plants and animals that live in and around streams, it is necessary to assess the chemical attributes of water (University 2004).

Biological indicators are organisms which are applied to quantify and characterize the biologically available level of contamination in the aquatic ecosystem. The concept of biodiversity in water quality evaluation has a considerable relevance only when the diversity indices are properly assessed and the usage fully justified by giving prior attention to the number of samples, population size, type of index and the nature of the taxon which is in question (Jiang and Shen 2003, Mihailov et al. 2005).

Solimini (2008) underlined the features considered when phytoplankton was included in the Water Framework Directive monitoring requirements:

- As primary producers algae are directly affected by physical and chemical factors, and changes in the phytoplankton community status have direct implications for the biointegrity of the lake ecosystem as a whole;
- Algae have rapid reproduction rates and very short life cycles, making them valuable indicators of short term (scales of days-weeks) impacts.

Phytoplankton sampling is easy, inexpensive, and creates minimal impact to resident biota. As parameters to be studied, the Water Framework Directive prescribes composition and abundance, biomass and the frequency of blooms. All these parameters are considered to undergo changes along the pressure gradient. Phytoplankton is especially suitable for detecting eutrophication, the impact of excessive nutrient loading.

The responses of zooplanktonic communities, or of the individual organisms, can be monitored in a variety of ways to indicate effects on the ecosystem. Zooplankton, by grazing on phytoplankton and other seston, recycling nutrients and organic material, and serving as prey for vertebrate and invertebrate planktivores, are a key element regarding the structure and functioning of surface aquatic ecosystems (Gannon and Stemberger 1978, Jeppesen et al. 2011).

Algae–zooplankton interactions form the basis of energy flux to higher trophic levels. In the majority of lakes, the availability of phosphorus limits algal production and hence also the level of secondary production (Hessen et al. 2006). With enhanced nutrients, the total zooplankton biomass increases, especially the abundance of rotifers, cladocerans and cyclopoid copepods (Vanni 1987).

The relation of community structure to community rates of grazing, nutrient regeneration, and production among aquatic ecosystems of different trophy is, therefore, not known. The principal generalization concerning size structure and lake trophy is that eutrophic aquatic ecosystems are often dominated by smaller cyclopoid copepods, rotifers and cladocerans (McCauley and Kalff 1981, Pace 1986, Jeppesen et al. 2000, Sondergaard et al. 2005).

Although phytoplankton becomes more abundant, their quality as food for zooplankton may deteriorate because the proportion of large, inedible forms of algae increases (Watson and Kalff 1981).

In the absence of fish, large zooplankton species, especially *Daphnia,* have a competitive advantage over small species. Large *Daphnia* are more efficient competitors for resources than small species. They have a higher per-capita filtering rate, a broad diet, lower metabolic demands per unit mass, better resistance to starvation, and they have a high reproductive rate owing to high fecundity attained by large clutch sizes (Goulden et al. 1978, Peters & Downing 1984).

Potentiality of zooplankton as indicator is very high because their growth and distribution are dependent on some abiotic (e.g. temperature, salinity, stratification, pollutants) and biotic parameters (e.g., food limitation, predation, competition) (Beaugrand et al. 2000, Beyst et al. 2001).

Community size of selected major zooplankton can indicate the trophic status of water bodies and also can help to understand the shifts in trophic state.

The major advantages of using macroinvertebrates indicators in biological investigation are:

- the community consists of many representatives from a wide range of faunal orders. It is assumed that such a range of species provides sufficient probability of sensitive species being present;
- spatial and temporal mobility of macroinvertebrates is quite restricted. They can be considered as inhabitants of habitats under investigation;
- organisms integrate environmental conditions over long periods of time.

Some practical considerations that should be kept in mind when collecting macro-invertebrates concern the seasonality of the presence of a large portion of macroinvertebrate species, namely insects in their larval stage of the life cycle. Furthermore, macroinvertebrates exhibit a large variation in spatial distribution at a specific location.

As a result quantitative sampling is considered in some cases to be impossible in routine practice. The use of relative abundances is often applied to get around this problem. Other problems are drift in case of flooding or extreme discharges and migration or colonisation of exotic species.

Macrophytes as indicators of an eutrophication pressure are assessed of regional scale, especially in lakes. It examined effects of scale and typology when classifying macrophytes into eutrophication response classes, and compared different classification methods and trophic indices. Aquatic macrophyte species abundance and water quality data were used.

Two methods to classify tolerant and sensitive species to an eutrophication pressure on different scale levels in order to develop a regional specific response lists were assessed.

The classifications were used to calculate the response of the macrophyte community to a pressure gradient using indices. The short-term time series (2009 - 2013) of both water quality and macrophyte species were used to analyze the response of the macrophyte indices to long term pressure changes.

Fish threats leading to decline and extinction are multiple and often act in synergy: drought, habitat loss and degradation (pollution, eutrophication, damming, channelization, etc,) excessive water abstraction, invasive alien species or predatory are among the main ones. With the often negative aquatic effects of global climate change and ever more extensive agricultural impacts, the threats to ecosystem and individual or population will certainly increase. For fish diversity to persist and prosper is necessary a major effort of the ecological rehabilitation of water bodies and the current EU Water Frame Directive intends that by the end of 2015 all surface waters will be able to fulfill scientific criteria for a “good ecological status”.

1 Identifying and defining of indicators

1.1 Physical - chemical indicators

1.1.1. General physical-chemical quality elements (thermal, salinity, oxygenation)

Water temperature (^{0}C)
Water temperature is a measurement of the intensity (not amount) of heat stored in a volume of water. The solubility of chemical compounds is affected by water temperature that can therefore influence the effect of organic and inorganic pollutants on aquatic life. The temperature increasing accelerated the metabolic oxygen demand, which in conjunction with reduced oxygen solubility, affects many species. The distributions of dissolved and suspended compounds are influenced by vertical stratification patterns that naturally occur in lakes.

Secchi disk transparency (m)
Secchi depth is a measure of light penetration into a water body and is a function of the absorption and scattering of light in the water column. There are primarily three factors or characteristics of surface water which affect the depth to which light will penetrate. One factor is the amount of color, either in true solution or in a colloidal or suspended form in the water. Color-causing materials, the forms (dissolved or colloidal) of which are typically controlled by the amounts and forms of iron present, are often described as "humics." Phytoplankton (algae) in the water column also scatters and absorbs light. Therefore, the presence of high concentrations of algae in a water body reduces light penetration and hence reduces Secchi depth. Third, inorganic clastic (erosional) materials scatter and absorb light, reducing the water's transparency. These materials may be derived from erosion of the shoreline, stirring of sediments into the water column, or erosion in the watershed, and may be transported to the water body by tributaries. The stirring can be due to wind-induced currents and waves, activity of organisms such as carp rooting in the sediments, and/or the activities of man, such as boat traffic, dredging, etc.(Lee, Jones-Lee et al. 1995)

Water depth (m)
Measurement of water depth is important to determine the hydrological regime of surface water. Measurement of water level is necessary for water volume calculations in lakes and must be measured at the time and place of water sampling. Water can flow to or from an aquifer which is in continuity with a river, depending on the relative water levels in the river and aquifer. Low water levels in the river can induce groundwater flow to the river, and high water levels can reverse the flow and produce losses from the river to the aquifer.

pH

pH is the measurement of the hydrogen-ion concentration in the water. The ammonia, heavy metals and salts solubilization are facilitated by high pH values. The precipitation of carbonate salts is encouraged when pH levels are high. At low pH values, carbon dioxide and carbonic acid concentrations are increasing. At pH values below 4.5 and above 9.5, water pH has lethal effects on aquatic life.

Chloride

Chloride, a component of salt, is one of the common anions found in freshwater and thus chloride levels are directly related to conductivity. Even slight increases in chloride concentration can have a subtle impact on aquatic ecosystems, but most fish and other large aquatic organisms are not directly affected until concentrations reach 1,000 mg/L or more (**** 2014).

Sulphate

Sulfate occurs naturally in the aquatic environment or it can have an anthropogenic origin. When sulfate naturally occurs in aquatic environments, it can be the result of the decomposition of leaves, atmospheric deposition, or the weathering of certain geologic formations including pyrite (iron disulfide) and gypsum (calcium sulfate). Commenwealth of Pennsylvania Department of Environmental Protection (2012).

Calcium and magnesium

Calcium and magnesium are measure of the amount of dissolved material in the water column. The hardness of water is generally due to the presence of calcium and magnesium in the water body, but other metallic ions may also contribute to hardness. Harder water has the effect of reducing the toxicity of some metals like copper, lead, zinc. Soft water may have corrosive effect on metal plumbing, while hard water may result in scale deposits in the pipes.

Sodium

Sodium (Na) salts are all very soluble and as a result are found in most natural waters.

Filterable residue dried at 105^{0}C

Filterable residue is a measure of the amount of dissolved material in a water column. Sodium, chloride, magnesium and sulphate, called dissolved salts, contribute to elevated filterable residue values. High concentrations of filterable residue limit the suitability of water as a drinking source and irrigation supply.

Anionic detergent active

Anionic detergents active are the most widely produced and used, usually as detergents. Anionic detergents active can exist in surface waters in the dissolved or adsorbed states, as well as in the surface film of water bodies, because they have a pronounced ability to concentrate at the air-water or water-sediment interface. If the Anionic detergents active are not highly toxic, they can affect aquatic biota. Anionic detergents active are responsible for foam formation in surface waters and other pollutants, including pathogens, can become concentrated in the foam. The presence of foam on the water surface makes water aeration difficult, lowering oxygen levels, reducing self-purification processes and adversely affecting aquatic biota.

Dissolved oxygen

Dissolved oxygen is a measure of the amount of oxygen dissolved in water and is essential to the respiratory metabolism of most aquatic organisms. It affects the solubility and availability of nutrients, and therefore the productivity of aquatic ecosystems. The nutrients from the sediments can be release at low concentrations of dissolved oxygen. The dissolved oxygen concentrations in oligotrophic lakes, with low concentrations of nutrients, increase in the hypolimnion (deeper waters) relative to the epilimnion (defined as orthograde oxygen profiles). On the other hand, in eutrophic lakes (with high nutrients concentrations), tend to have decreased concentrations of dissolved oxygen in the hypolimnion relative to the epilimnion (defined as clinograde oxygen profiles).

Biochemical oxygen demand

The Biological Oxygen Demand in five days $(BOD)_5$, is the amount of oxygen consumed by bacteria in the decomposition of organic material present in water bodies. It also includes the oxygen required for the oxidation of various chemical in the water, such as sulfides, ferrous iron and ammonia (Chemical Oxygen Demand. Murdoch et al. 1996).

1.1.2. *Nutrients*

Ammonium

Ammonium is a measure of the reduced inorganic form of nitrogen in water and is consists of dissolved ammonia (NH_3) and the ammonium ion (NH_4^+). Nitrogen is an essential plant nutrient and although ammonia is only a small component of the nitrogen cycle, it contributes to the trophic state of a water body. Excess ammonia contributes to water bodies eutrophication process: prolific algal growths, that have deleterious impacts on other aquatic life, drinking water supplies, and recreation. At high concentrations, ammonia is toxic to aquatic life.

Nitrite

In the nitrogen cycle, nitrite is an intermediate form, an unstable form that is either rapidly oxidized to nitrate by nitrification process, or reduced to nitrogen gas by de-nitrification process. The plants use the nitrite like a nutrient source. Nitrite boosts plants proliferation. For aquatic life, nitrite is toxic at relatively low concentrations.

Nitrate

In water body, the most stable and oxidized form of nitrogen is nitrate. It results from the complete oxidation of all nitrogen compounds. To stimulate growth plants use nitrate as primary form of nutrients. But excessive amounts of nitrogen may result in phytoplankton or macrophyte proliferations. At high levels of nitrate concentrations it is toxic to infants.

Total nitrogen
Total nitrogen is a measure of all forms of nitrogen (organic and inorganic). Nitrogen is an essential plant element and is often the limiting nutrient in marine waters. The importance of nitrogen in the aquatic environment varies according to the relative amounts of the forms of nitrogen present, be it ammonia, nitrite, nitrate, or organic nitrogen.

Phosphate
The inorganic oxidized form of soluble phosphorus is phosphate. This form of phosphorus is the most readily available for uptake during photosynthesis. High concentrations of orthophosphate generally occur in conjunction with algal blooms.

Total phosphorus
Total phosphorus is a measure of the inorganic oxidized form of soluble phosphorus. During photosynthesis, total phosphorus is available for uptake.
High concentrations of total phosphorus generally occur in conjunction with algal blooms.

Chlorophyll "a"
Chlorophyll "a" is the main green photosynthetic pigment found in all plants including phytoplanktonic algae. The concentration of chlorophyll a in estuarine, coastal or marine waters (water column) is used as an indicator of photosynthetic plankton biomass (Goverment 2008).

1.1.3. Metals

Total chromium

Chromium is a naturally occurring heavy metal that is commonly used in industrial processes and can cause severe health effects in humans. Although it can be released through natural forces, the majority of the environmental releases of chromium are from industrial sources. The industries with the largest contribution to chromium levels include leather tanning operations, metal processing, stainless steel welding, chromate production, and chrome pigment production. Chromium can be found in many consumer products, including wood treated with copper dichromate, leather tanned with chromic sulfate, and stainless steel cookware (**** 2008).

Copper
In a water sample, copper is measured in either the total or dissolved form. Copper is essential for all plant and animal nutrition. High concentration of copper makes water distasteful to drink. At relatively low concentrations, copper is acutely toxic to most forms of aquatic life.

Zinc

In a water body, zinc is present in total and dissolved state. Zinc is an essential element for plants and animals as it is necessary for the functioning of certain enzymes. Zinc is relatively non-toxic to terrestrial organisms. It is acutely and chronically toxic to aquatic organisms, particularly fish. Zinc toxicity decreases with increasing hardness, increases with increasing temperature, and decreasing dissolved oxygen.

Arsenic

In nature, arsenic is present in rocks, soils, and waters. In aquatic environment, arsenic compounds tend to accumulate in plant and animal tissue. Geologic and anthropogenic sources are the main way to arsenic introduction in water. Geologically, this trace element is found in the Earth's crust and is incorporated into streams through the processes of weathering, erosion, and deposition. Human activities such as mining and smelting, industrial processes, wood preservation, and agricultural practices can expose the environment to arsenic as well.

Lead

Generally low concentrations of lead are found in water owing to its low solubility. For aquatic life, lead is a toxic element that accumulates in the skeletal structures. The toxic effects of lead to fish decreases with increasing water hardness and dissolved oxygen.

Cadmium

At high water pH value, cadmium precipitates from solution. Cadmium has cumulative and highly toxic effects in all chemical forms. It accumulates in plant cells. Cadmium has been known to have extremely toxic effects on trout and zooplankton. Other heavy metals such as zinc and copper are known to increase cadmium's toxicity.

Total iron

In lakes in which a stratified condition becomes established, water at and near the bottom, might become enriched in organic matter and depleted in oxygen. Ferrous iron can be retained in solution in water of this type to the extent of many milligrams per liter. The iron content of lake water also can be influenced by aquatic vegetation, both rooted and free-floating forms (Hem 1985).

Mercury

In water bodies or in tissue samples, mercury is presented in total form, at very low concentrations. Mercury compounds are highly toxic and have a long retention time in animal cells. Mercury bio accumulates in the kidney and liver and can cause permanent brain damage.

Total manganese

In excessive amounts, manganese is toxic for terrestrial and aquatic biota. It is present in almost all organisms, and often ameliorates the hazard posed by other metals. Manganese concentrations in the environment may be well above the aquatic toxicity levels in effluents originating from base and precious metal mines, municipal sewage and sludge and landfills.

Nickel

Nickel is considered a very toxic heavy metal for aquatic life. In general, alkalinity, salinity, hardness, pH, temperature, complexing agents, humic acids influence the oxidation state, toxicity and availability of the nickel in aquatic life. Natural sources of nickel include weathering of rocks, inflow of particulate matter, precipitation. Anthropogenic sources of nickel include the burning of coal and other fossil fuels and discharges from such industries as electroplating and smelting (E.P.A. 1986).

1.2. Biological indicators (Phytoplankton, Zooplankton, Macroinvertebrates)

1.2.1. Diversity indices

Objective

A diversity index aims at evaluating community structure with respect to occurrence of species. Diversity indices relate the number of observed species (richness) to the number of individuals (abundance). Some diversity indices provide an additional insight by calculating the uniformity of the distribution (evenness) of the number of individuals over the counted species. In some cases, diversity is considered to be the species richness only.

Principle

Diversity is a basic feature of the structure of a community or eco-system, both terrestrial and aquatic. The basic assumption is that disturbance of the water ecosystem or communities under stress leads to a reduction in diversity. Pollution, acting as stressor will result in a reduction of diversity to an extent depending on the degree of pollution. The opposite, low diversity as indication for polluted conditions, is however not necessarily true since low diversity may be caused by other stressors like physical conditions in headstreams. For similar reasons, temporal changes in diversity at one station are more significant than spatial changes along the longitudinal axis of the river.

Diversity indices can be applied for most biotic groups present in a river and lakes. Some diversity indices consider only a part of a community, e.g. ratio of Chironomids and Oligochaetes as part of the macroinvertebrate community. A closely related group of indices that provide information on community structure are comparative and similarity indices. These indices determine to what extent two or more biotic communities resemble each other. They can be used to evaluate spatial discontinuities in communities caused by environmental changes or to detect and measure temporal changes between successive samples.

Scope and limitations

The use of diversity indices in many scientific disciplines may be considered as having world-wide acceptance and application. On a global scale, nature conservation strategies have been formulated in terms of biodiversity (in the sense of species richness). In water quality studies diversity indices often are used in evaluating communities in a ‘before and after’ situation, for example upstream and downstream stations of a wide range of disturbances like discharge of toxic substances (acid mine drainage), nutrient enrichment.

Diversity indices have some favorable features:
- they are easy to use and calculate;
- they are applicable to all kind of waterbodies;
- they have geographical limitations;
- they are best used for comparative purposes.

The main objections to diversity indices from the point of view of water management and control are:
- they provide information on the biological status without having a clear ‘assessment endpoint’. Diversity of communities in natural or undisturbed waters can vary considerably within and in between different water types. The method cannot serve broad surveys over wide ranges of watersheds, due to the great natural variation in physical and chemical conditions;
- all species have equal weight, despite known differences in tolerance for pollution, and no information is obtained about the species composition.

Examination of the sensitivity of nine diversity and seven similarity indices shows that the response of the community level indices is dependent on the initial structure of the community, and the manner in which the community is changed. The community level indices may give very misleading biological interpretations of the data they are intending to summarize. Authors state that these indices should never be used alone.

In summary, it can be concluded that diversity and comparative indices are not suitable on their own for routine monitoring of aquatic ecosystems.

Information requirements

Diversity indices can be established by sampling and species identification of a chosen biotic group, macroinvertebrates in this case. The level of identification can vary from species to family level. No specific sampling method or devices are prescribed. It is however essential to use a standard sample and enumeration when comparing impacted sites with a reference site. Sampling strategy concerning density of monitoring station network and sampling frequency is not dependent on a diversity index as such but is related to the biotic group where it is applied.

1.2.2. Saprobic systems

The saprobic index in the saprobic system could be considered a specific form of a biotic index, but is also often treated as a separate group. Because of some distinct differences and the wide spread application the saprobic index will be covered here separately.

A saprobic system aims to provide a water quality classification from pure to pollute by means of a system of aquatic organisms indicating by their presence and vital activity the different levels of water quality.

The saprobic systems are based upon the observation that species composition as well as species numbers is different over a gradient of self purification after organic inputs, ranging from completed oxidation to pre-dominance of reduction processes. As a result, a zonation in the aquatic communities can be distinguished reflecting the degree of saprobity. Every species has a specific dependency of decomposing organic substances and thus the oxygen content. This (known) tolerance is expressed in a saprobic indicator value, which is assigned to a large number of autotrophic and heterotrophic floral and faunal species.

The saprobity or saprobic index is a numerical evaluation of the presence of indicator species and their respective saprobic values. The saprobic index can be part of a saprobic classification scheme with hydrochemical variables like oxygen content, biochemical oxygen demand or ammonia-nitrogen content, and/or microbiological variables or indices of pollution.

According to the Pantle & Buck (1955) method, each indicator species belongs to a certain degree of saprobity. The saprobic index S can be calculated for a particular subsystem of a biocenose using the following formula:

$$S = \frac{\sum (h_i s_i)}{\sum h_i}$$

where
h_i is the quantitative abundance of i-th species and s_i is saprobic value of i-th species (0 = xenosaprobic, 4 = polysaprobic).

An important objection against this formula is the fact that a species is part of one distinct saprobic zone only, whereas the tolerance usually has a normal (gaussian) distribution.

The indicator values for saprobity for all species result from empirical data of research in rivers in Central Europe are available (Sladecek, 1973). At present, the saprobic system is mainly used in two ways that differ in calculation method, i.e. the formula of Pantle & Buck (1955) or the formula of Zelinka & Marvan (1961) and in applied species indicative values.

This revision was based on statistical data analysis of long term biological water quality monitoring. Phototrophic species like algae were excluded because they do not fit into the definition of saproby (heterotrophic intensity). Other criteria for selecting indicator species were: only benthic species are included which reflect the situation of the site; identification at species level should be possible with available keys; the organisms should be spread over Central Europe and finally the saprobic valences should be as narrow as possible. Saprobic systems can differ in the number of distinguished saprobic zones and the index calculation which is used. The system implies more knowledge than actually exists: pollution tolerances are highly subjective and based on ecological observations and rarely confirmed by experimental studies.

Advantages of the saprobic system are:

- quick classification of the investigated community (saprobiological index) can be made on a universal scale from the standpoint of practical use of the water;
- classification of assessment results are suitable for defining water quality objectives or standards and allow clear presentations in colors on a geo-graphical map;
- the saprobic system can be used in testing for compliance with standards.

The Saprobic index can be obtained for several biotic groups: decomposers (bacteria), primary producers and consumers (zooplankton and zoobenthos/macroinvertebrates).

Application of saprobic index requires a qualitative sampling and assessment of abundance of one or more biotic groups. Identification is mandatory at species level because the requirements and tolerances differ for certain species within the same family.

1.2.3. Species richness

Species richness is the number of different species present in an area. The more species present in a sample the 'richer' the area.

Species diversity relates to the number of the different species and the number of individuals of each species within any one community. A number of objective measures have been created in order to measure species diversity.

Measuring species richness is an essential objective for ecological research and monitoring programs. The number of species in a local assemblage is an intuitive and natural index of community structure, and patterns of species richness have been measured at both small and large spatial scale (Gotelli and Colwell 2010).

Limitations of richness/diversity are:

- *Statistical issues in the measurement of biodiversity*. Biodiversity is a fundamental property of ecosystems, but estimating and comparing biodiversity is a non-trivial statistical problem. Sampling all of the species present is an impossible task, except in the most poor of ecosystems, and observed species richness is non-linearly related to sampling effort. Because of this non-linear relationship, comparing species richness among sites and comparing the similarity of species composition among sites requires a robust statistical approach.
- Observed differences in species richness among locations may reflect true differences in species richness as well as differences in sampling effort or dissimilarity in the underlying distributions of species abundance (Wintle et al. 2004).
- Field measurements tend to underestimate species richness Llorente (1993) and short-term snapshots of species richness and composition may not accurately reflect longer term patterns in response to deterministic or stochastic environmental changes (Conroy and Noon 1996, Tyre et al. 2001).
- Sampling rarely continues until all species have been enumerated. As a result, extrapolation methods are needed to estimate the number of undetected species. Recently, many methods have been developed that allow extrapolation from survey data to estimate the true number of species. It is well known that measures of species richness and diversity, and inferences drawn from these patterns, are dependent on the spatial and temporal scale of measurement (Fleishman et al. 2006).

1.3. Macrophytes

Monitoring information requirements should include:

- Classification status of surface water;
- Assessments of changes in status of water bodies;
- Causes of water bodies failing to achieve environmental objectives;
- Compliance assessments with the standards and objectives of protected areas.

A quantification of reference conditions (where they exist) for surface water bodies is necessary for rehabilitations of ecosystems.

Three types of monitoring for surface waters are described in Annex V of the WFD: i) **surveillance**, ii) **operational** and iii) **investigative** monitoring. These types should be supplemented by monitoring programmes required for protected/key areas. The directive specifies quality elements for the classification of ecological status that include hydro-morphological, chemical and physical-chemical elements supporting the biological elements. Concerning the surveillance monitoring, parameters indicative of all the biological quality elements must be monitored. This type of monitoring is to identify long term changes, trends, and inform future monitoring networks. In these water bodies we will undertake the full range of monitoring. We expect this network of surveillance sites to remain fixed. As for operational monitoring, the parameters used should be those indicative of the biological quality elements most sensitive to the pressures to which the body is subject (Table 1.3.1). This type of monitoring to help classify water bodies which are at risk of failing to meet objectives. The monitoring in these water bodies is tailored to assess the pressures and risks identified. The coverage of operational monitoring will change over time. The investigative monitoring is necessary to assess why a water body is failing to achieve its objectives and decide what action is needed. The investigative programme will be designed when we have the initial results from the operational and surveillance monitoring.

Table 1.3.1: Macrophyte species indicators for Danube Delta lakes

GROUP	A Sensitive species	C Tolerant species	B Indifferent species
ISOETIDS	*Elatine hungarica*		
	Eleocharis acicularis		
	Isoëtes echinospora		
	Isoëtes lacustris		
	Littorella uniflora		
ELOIDS	*Elodea canadensis*	*Ceratophyllum demersum*	
	Myriophyllum spicatum	*Elodea nutalli*	
	Myriophyllum verticillatum	*Najas marina*	
	Potamogeton berchtoldii	*Potamogeton perfoliatus*	
	Potamogeton compressus	*Potamogeton crispus*	
	Potamogeton pusillus	*Potamogeton trichoides*	
	Potamogeton obtusifolius	*Potamogeton lucens*	
	Potamogeton mucronatus	*Potamogeton pectinatus*	
	Potamogeton gramineus	*Potamogeton rutilus*	
	Potamogeton acutifolius	*Potamogeton nodosus*	
	Ranunculus peltatus	*Ranunculus aquatilis*	
	Utricularia vulgaris		
	Utricularia minor		
	Utricularia bremii		
	Zanichellia palustris		
NYMPHAEIDS			*Nuphar lutea*
			Nymphaea alba
			Potamogeton natans
			Nymphaea candida
			Trapa natans
LEMNIDS	*Hydrocharis morsus-*	*Lemna gibba*	

	ranae	
	Stratiotes aloides	*Lemna minor* *Lemna trisulca* *Spirodela polyrrhiza* *Salvinia natans*
CHARACEAE	*Chara aspera* *Chara contraria* *Chara globularis* *Nitella flexilis* *Nitellopsis obtusa* *Tolypella prolifera*	

1.4. Fish

Monitoring requirements include:

- Species richness;
- Relative abundance (in CPUE);
- Relative biomass (in CPUE);
- Indicators possible to be investigated is Biodiversity indices, Shannon-Wiener index;

Regarding species richness we will identify all fish species and species richness is the number of different species present in an area. The more species present in a sample the 'richer' the area.

Species diversity relates to the number of the different species and the number of individuals of each species within any one community. A number of objective measures have been created in order to measure species diversity.

Measuring species richness is an essential objective for ecological research and monitoring programs. The number of species in a local assemblage is an intuitive and natural index of community structure, and patterns of species richness have been measured at both small and large spatial scale (Gotelli and Colwell 2010).

Relative abundance and biomass in Catch per Units Effort (CPUE) are two very important parameters for fish measurements. The number of individuals of each species in accordance with used effort for captures, but also grams for each individual of different species reported to the used effort for captures.

Diversity indices used is Shannon-Wiener index. On a global scale, nature conservation strategies have been formulated in terms of biodiversity (initial in the sense of species richness), but actually is relationship between individuals and set of species. In water quality studies diversity indices often are used in evaluating fish communities in a 'before and after' situation, for example upstream and downstream stations of a wide range of disturbances.

Conclusions

First research initiative identified and defined of the physical-chemical and biological indicators that will be monitored and analyzed to assess water quality.

The selected general physical-chemical parameters as quality elements were: water temperature, Secchi disk transparency, water depth, pH, chloride, sulphates, calcium and magnesium, sodium, filterable residue dried at 105^0C, anionic detergent active, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand.

The selected nutrients were: ammonium, nitrites, nitrates, total nitrogen, orthophosphates, total phosphorus, chlorophyll “a”.

Heavy metals included in this study were: total chromium, copper, zinc, arsenic, lead, cadmium, total iron, mercury, total magnesium, nickel.

Phytoplankton, zooplankton and macroinvertebrates are important group of indicators of the structure and function of Danube Delta aquatic ecosystems and their ecological status.

The value of zooplankton as an indicator of ecological conditions stems from their position in the food web between the fish and phytoplankton, thus providing information about the relative importance of top-down and bottom-up control and their impact on water.

Sensitive, tolerant and indifferent species to water pollution have been proposed as macrophytes indicators for analyzing ecological water quality.

Fish biological indicators like richness of species, relative abundance and biomass (in CPUE) and Shannon-Wiener index have been chosen to describe water quality.

References

Beaugrand G., Ibañez F., Reid P.C., (2000). "Spatial, seasonal and long-term fluctuations of plankton in relation to hydroclimatic features in the English Channel, Celtic Sea and Bay of Biscay." Marine Ecology Progress Series 200: 93-102.

Beyst, B., D. Buysse, A. Dewicke, J. Mees. (2001). “Surf zone hyperbenthos of Belgian sandy beaches: seasonal patterns.” Estuarine, Coastal and Shelf Science 53(6):877-895.

Conroy, M. J. and Noon, B. R. (1996). "Mapping of species richness for conservation of biological diversity: Conceptual and methodological issues." Ecological Applications 6(3): 763-773.

Fleishman, E., Noss, R. F., Barry R. Noon, (2006). "Utility and limitations of species richness metrics for conservation planning." Ecological Indicators 6(3): 543-553.

Gannon, J. E., Stemberger, R. S. (1978). "Zooplankton (especially crustaceans and rotifers) as indicators of water quality." Transactions of the American Microscopical Society: 16-35.

Gotelli, J. N. and R. K. Colwell (2010). “Estimating species richness”. Biological Diversity: Frontiers in Measurement and Assessment A. E. Magurran and B. J. McGill. Oxfod, OUP Oxford

Goverment, A. (2008). “Estuarine, coastal and marine habitat-Surface water chlorophyll a concentration”. N. A. a. W. R. Audit: 11.

Grime, J.P., (1979). “Plant strategies and vegetation processes”. Wiley, Chichester, UK.

Hem, J. D. (1985). “Study and interpretation of the chemical characteristics of natural water”, U.S. Geochemical Survey Water-Supply Paper 2264: 263 pg.

Jeppesen, E., P. J. Jensen, M. Sondergaard, T. Lauridsen, and F. Landkildehus. 2000. “Trophic structure, species richness and biodiversity in Danish lakes: changes along a phosphorus gradient”. Freshwater Biology, 45:201-218.

Jeppesen, E., P. Nõges, T. A. Davidson, J. Haberman, T. Nõges, K. Blank, T. L. Lauridsen, M. Søndergaard, C. Sayer, R. Laugaste, L. S. Johansson, R. Bjerring, and S. L. Amsinck. 2011. Zooplankton as indicators in lakes: a scientific-based plea for including zooplankton in the ecological quality assessment of lakes according to the European Water Framework Directive (WFD). Hydrobiologia 676:279-297.

Jiang, J.-G. and Shen, Y.-F. (2003). "Application and validation of a new biotic index using data from several water systems." Journal of Environmental Monitoring 5(6): 871-875.

Lee, G. F., Jones-Lee A., (1995). Secchi Depth as a Water Quality Parameter. R. o. G. F. L. Associates. El Macero, CA

Llorente, J. (1993). "The use of species accumulation functions for the prediction of species richness." Conservation biology 7(3): 480-488.

McCauley, E. and Kalff, J. (1981). "Empirical relationships between phytoplankton and zooplankton biomass in lakes." Canadian Journal of Fisheries and Aquatic Sciences 38(4): 458-463.

Mihailov G., V. Simeonov, N. Nikolov and G. Mirinchev (2005). "Multivariate statistical assessment of the pollution sources along the stream of Kamchia River, Bulgaria." Water Science & Technology 51(11): 37-43.

Moreno, J. L., C. Navarro, and J. De las Heras. 2006. Abiotic ecotypes in south-central Spanish rivers: Reference conditions and pollution. Environmental Pollution 143:388-396.

Murdoch, T., Cheo, M., and O'Laughling K., (1996). "The Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods Adopt-a-Stream Foundation". Michigan, 296 p.

Pace, M. L. (1986). "An empirical analysis of zooplankton community size structure across lake trophic gradients." Limnology and Oceanography 31(1): 45-55.

Pickett S.T.A. and White P.S., (1985). "Patch dynamics: a synthesis". The ecology of natural disturbance and patch dynamics (eds) S T A Pickett and P S White (Orlando: Academic Press) pp 371–384.

Pantle, R., Buck, H. (1955): Die Biologishe Uberwaschung der Gewasserund die Daestellung der Ergebnisse. GWF, 96, 603 pp.

Solimini, A. G., A. C. Cardoso, J. Carstensen, G. Free, A.-S.Heiskanen, N. Jepsen, P. No˜ges, S. Poikane & W. van de Bund, (2008). "The monitoring of ecological status of European freshwaters. " Quevauviller, P., U. Borchers, C. Thompson & T. Simonart (eds), The Water Framework Directive: Ecological And Chemical Status Monitoring. Wiley, Chippenham, Wiltshire: 29–60.

Sondergaard, M., Jeppesen, E., Jensen J.P., (2005). "Pond or lake: does it make any difference?" Archiv fur Hydrobiologie 162(2): 143-165.

Tyre, A. J., Possingham, H. P., Lindenmayer B.D., (2001). "Inferring process from pattern: Can territory occupancy provide information about life history parameters?" Ecological Applications 11(6): 1722-1737.

Watson, S., Kalff, J. (1981). "Relationships between nannoplankton and lake trophic status." Canadian Journal of Fisheries and Aquatic Sciences 38(8): 960-967.

Wintle, B. A., McCarthy, M. A., Parris M. K., Burgman M., (2004). "Precision and bias of methods for estimating point survey detection probabilities." Ecological Applications 14(3): 703-712.

Yang, L., Ma, K. M., (2004). "Impacts of the urbanization on waters non-point source pollution." Huan Jing Ke Xue 25(6): 32-39.

**** (1986). E.P.A.. "Ambient aquatic life water quality criteria for nickel". O. o. R. a. D. U.S. Environmental Protection Agency, Environmental Research Laboratories. Dullith, Minnesota, Marragansett, Rhode Island, 93pp.

**** (2004). University, W. J. "Exploring the environment water quality." from http://www.cotf.edu/ete/modules/waterq3/WQassess3.html.

**** (2008). U.S. Department of Health and Human Services. "Toxicological Profile for Chromium." Georgia: Agency for Toxic Substances and Disease Registry."

**** (2012). Commenwealth of Pennsylvania Department of Environmental Protection, B. o. p. a. n.-p. s. m.. "Rationale for development of ambient water quality criteria for sulfate protection of aquatic life use ", fromiles.dep.state.pa.us/PublicParticipation/Public%20Participation%20Center/PubPartCenterPortalFiles/Environmental%20Quality%20Board/2012/EQB%20%20April%2017,%202012/Triennial%20Review/11%20TR13_Rationale-Sulfate_Criteria.pdf.

**** (2014). "Water quality monitoring data parameters." from http://www.watershedcouncil.org/learn/water%20terminology/.