



Integrated Watershed Management  
- Ecohydrology & Phytotechnology -



APPENDIX





## APPENDIX

**Appendix 1. General considerations of available methods for testing physical-chemical parameters of sediments, recommended holding time and storage conditions of samples**

		HOLDING TIME AND STORAGE CONDITIONS
<b>pH in pore water</b>	measured using an electronic pH metre with glass electrode	-
<b>Ammonia content in pore water</b>	- titrimetric method - ammonia selective electrode method - phenate method	
<b>Total Phosphorus (TP)</b>	After chemical or microwave mineralization - Spectrophotometric method	2 weeks; refrigerate, freeze
<b>Total Organic Carbon (TOC)</b>	- wet oxidation titration - modified titration - combustion after removal of carbonate by addition of HCl and subsequent drying – gas chromatography	
<b>Particle size distribution</b>	Provides information on percent content of sand, silt and clay. - wet sieving - hydrometric method - settling techniques - X-ray absorption	
<b>Percent water content</b>	Measured as a difference of wet weight of a sediment and dry weight after 6 h oven-drying at 105°C	
<b>Conductivity of pore water</b>	Electronic conductivity metre	
<b>Metals</b>	- Spectrophotometric (silver diethyldithiocarbonate) - Atomic Absorbance Spectrophotometry - Atomic Emission Spectrophotometry - X-ray fluorescence - Neutron activation	
<b>Pesticides</b>	After extraction - Gas chromatography/mass spectrophotometry (GC/MS) - Gas chromatography/electron capture detection (GC/ECD)	7 days (until extraction), 30 days (after extraction); refrigerate, freeze
<b>Total sulphides</b>	Common in anoxic sediment, toxic for aquatic organisms - Potentiometric methods ASTM - APHA	28 days; refrigerate or NaOH; pH>9
<b>Sediment oxygen demand</b>	Provides information on dissolved oxygen uptake by sediments in terms of physical and biological processes. - including in-situ - respirometry and laboratory respirometry methods.	
<b>Sediment Biochemical Oxygen Demand</b>	Provides information on the dissolved oxygen consumed by microbial organisms while assimilating and oxidizing a organic matter - respirometry and laboratory respirometry methods in specific conditions	
<b>Sediment Chemical Oxygen Demand</b>	Chemical oxygen demand (COD) is a measure of the oxygen equivalent of organic matter content in a sample that is susceptible to oxidation by a strong chemical oxidant at elevated temperature and reduced pH. - Closed reflux/colourimetric method with dichromate (Cr <sub>2</sub> O <sub>7</sub> ) ions.	
<b>Cation Exchange Capacity of sediments</b>	Provides information relevant to metal bioavailability studies - treating samples with ammonium acetate, digesting with sodium hydroxide and titrating to determine the ammonium ion concentration.	
<b>Redox Potential (Eh) in sediments</b>	Provides information on the oxidation-reduction potential (ORP) of sediments. - Potentiometric measurements of Eh using a millivolt reader with a platinum electrode.	
<b>Alkalinity of Pore Water (freshwater sediments)</b>	Provides information on acid-neutralizing (i.e., proton-accepting) capacity of water. - Titration method with H <sub>2</sub> SO <sub>4</sub>	
<b>Loss of Ignition (organic content)</b>	Provides information on organic content. - Igniting the sediments at 550 ± 10° C	

**Appendix 2. Example of field data sheet for soil assessment**

<b>DRILLING CONTRACTOR</b>				<b>ENGINEERING-SCIENCE DRILLING RECORD</b>				<b>BORING NO.</b> _____	
Driller: _____				PROJECT NAME _____				Sheet _____ of _____	
Inspector: _____				PROJECT NO. _____				Location _____	
Rig Type: _____									
Drilling Method _____									
<b>GROUNDWATER OBSERVATIONS</b>								<b>PLOT PLAN</b>	
WL TOC				Weather _____					
Time				Date/Time Start _____					
Date				Date/Time Finish _____					
Photovac Reading	Sample I.D.	Sample Depths	% Reco-very	SPT	FIELD IDENTIFICATION OF MATERIAL	WELL SCHEMATIC	COMMENTS		
		1							
		2							
		3							
<b>STANDARD PENETRATION TEST</b>									
SUMMARY .....									

SS=SPLIT SPOON A=AUGERCUTTINGS C=CORED

**Appendix 3. An example of selected parameters from Sediment Chemical Criteria by EPA, Washington, USA. ([http://www.ecy.wa.gov/programs/tcp/smu/sed\\_chem.htm](http://www.ecy.wa.gov/programs/tcp/smu/sed_chem.htm))**

The "no effects" level - the Sediment Quality Standards, WAC 172-204-320 -- used as a sediment quality goal. The "minor adverse effects" level -- The Sediment Impact Zone Maximum Level, WAC 173-204-420; and the Sediment Cleanup Screening Level/Minimum Cleanup Level, WAC 173-204-520 -- used as an upper regulatory level for source control and cleanup decision making.

		<b>SEDIMENT IMPACT ZONE MAXIMUM LEVEL, SEDIMENT CLEANUP SCREENING, LEVEL/MINIMUM CLEANUP LEVEL</b>
	mg kg <sup>-1</sup> dry weight (parts per million (ppm) dry)	mg kg <sup>-1</sup> dry weight (parts per million (ppm) dry)
<b>arsenic</b>	57	93
<b>cadmium</b>	5,1	6,7
<b>chromium</b>	260	270
<b>copper</b>	390	390
<b>lead</b>	450	530
<b>mercury</b>	0,41	0,59
<b>silver</b>	6,1	6,1
<b>zinc</b>	410	960
	mg kg <sup>-1</sup> Organic Carbon (ppm Carbon)	mg kg <sup>-1</sup> Organic Carbon (ppm Carbon)
<b>naphthalene</b>	99	170
<b>benzo(a)pyrene</b>	99	210
<b>total pcbs</b>	12	65
	µg kg <sup>-1</sup> dry weight (parts per billion (ppb) dry)	µg kg <sup>-1</sup> dry weight (parts per billion (ppb) dry)
<b>phenol</b>	420	1200

**Appendix 4. Example of a field form and required analysis for sediment sampling**

<b>NAME OF RIVER/LAKE</b>	<b>DATE</b>	<b>TIME</b>	<b>SITE NUMBER</b>

<b>STATION COORDINATES (GPS)</b>	
Latitude:	N .
Longitude:	W .

<b>DESCRIPTION OF STATION LOCATION</b>	<b>TYPE OF SAMPLER</b>	
	grab	
	core	

<b>SEDIMENT DESCRIPTION</b>	
Colour	
Texture	
Odour/sheen:	
Benthic organisms:	

**Appendix 5. Example of data sheet for physical, chemical and biological examination of lakes and reservoirs**

NAME OF RIVER/LAKE	DATE	TIME	SITE NUMBER

STATION COORDINATES (GPS)	
Latitude:	N .
Longitude:	W .

METEOROLOGICAL CONDITIONS			
Wind velocity		Air temperature	
Wind direction		Precipitation	
Cloudiness			

PHYSICAL PARAMETERS			CHEMICAL PARAMETERS	
depth	O <sub>2</sub> concentration	Water temperature		concentration
0 m			NO <sub>2</sub> -N	
1 m			NO <sub>3</sub> -N	
2 m			NH <sub>4</sub> -N	
..... m			TN	
Secchi disc visibility			PO <sub>3</sub> -P	
pH			TP	
Conductivity			SiO <sub>2</sub>	
			DOC	

BIOLOGICAL PARAMETERS			
Chlorophyll a concentration			
<i>In vivo</i> fluorescence of chlorophyll			
Bacterioplankton biomass			
Phytoplankton biomass			
Zooplankton biomass			
Pelagic fish biomass			

GENERAL OBSERVATIONS

**Appendix 6. Biotests used for analysis of cyanobacterial toxicity**

TESTED ORGANISM	ASSAY	FORM OF ORGANISM	REFERENCES
<b>Mice</b>	Cell damage Lethality test	Cultured organisms	Falconer et al., 1981; Jackson et al., 1984; Yoshida et al., 1997, Tarczynska et al., 2000
<b>Flies</b> <i>Drosophila melanogaster</i>	Lethality test	Cultured organisms	Swoboda et al., 1994
<b>Mosquitoes</b>	Lethality test	Cultured organisms	Kiviranta, 1992; Kiviranta & Abdel-Hameed, 1994
<b>Plant</b> <i>Spirodela oligorrhiza</i>	Growth inhibition	Culture	Tarczynska et al., 1997; Romanowska-Duda & Tarczynska, 2002
<b>Plant</b> <i>Lemna minor L.</i>	Growth inhibition	Culture	Weiß et al., 2000
<b>Microtox®</b> <i>Vibrio fischeri</i>	Bioluminescence inhibition	Freeze-dried bacteria	Marsalek & Blaha, 2000
<b>ToxAlert®</b> <i>Vibrio fischeri</i>	Bioluminescence inhibition	Liquid bacteria Freez-dried bacteria	Mankiewicz et al., 2003
<b>ToxiChromoPadTM</b> <i>Escherichia coli</i>	Enzymatic activity	Liquid bacteria	Marsalek & Blaha, 2000
<b>Protoxkit FTM</b> <i>Tetrahymena thermophila</i>	Growth inhibition	Cysts (dormant eggs)	Tarczynska et al., 2000
<b>Protoxkit FTM</b> <i>Tetrahymena pyriformis</i>	Growth inhibition	Cysts (dormant eggs)	Marsalek & Blaha, 2000; Nalecz-Jawecki et al., 2002
<b>Daphtoxkit FTM magna</b> <i>Daphnia magna</i>	Lethality test	Ephippia (dormant eggs)	Tarczynska et al., 2000, 2001; Nalecz-Jawecki et al., 2002
<b>Daphtoxkit FTM pulex</b> <i>Daphnia pulex:</i>	Lethality test	Ephippia (dormant eggs)	Kyselkova & Marsalek 2000
<b>Rotoxkit FTM</b> <i>Brachionus calicyflorus</i>	Lethality test	Cysts (dormant eggs)	Marsalek & Blaha, 2000; Nalecz-Jawecki et al. 2002
<b>Thamnotoxkit TTM</b> <i>Thamnocephalus platyurus</i>	Lethality test	Cysts (dormant eggs)	Tarczynska et al. 2000, 2001, Törökné 1999 and 2000, Marsalek and Blaha 2000, Nalecz-Jawecki et al. 2002
<b>Artoxkit M</b> <i>Artemia salina</i>	Lethality test	Cysts (dormant eggs)	Kyselkova & Marsalek 2000; Marsalek & Blaha, 2000; Nalecz-Jawecki et al., 2002;
<b>Spirotox</b> <i>Spirostomum ambiguum</i>	Cell deformation	Cryptological form	Tarczynska et al., 2000, 2001; Nalecz-Jawecki et al., 2002
<b>Nematode toxicity test</b> <i>Panagrellus redivivus</i>	Lethality test	Organisms in culture	Marsalek & Blaha, 2000

**Appendix 7. Enzymatic methods used for analysis of cyanobacterial toxicity**

ENZYME	ASSAY	TYPE OF ASSAY	REFERENCES
<b>Protein Phosphatase 1 (PP1)</b>	<b>PPIA</b> (Protein Phosphatase Inhibition Assay)	Colourimetric	An & Carmichael 1994; Ward et al., 1997; Rapala et al., 2002
<b>Protein Phosphatase 1 (PP1)</b> <b>Protein Phosphatase 2 (PP2)</b>	<b>PPIA</b> (Protein Phosphatase Inhibition Assay)	Radiolabelled	Lambert et al., 1994; Fladmark et al., 1998; Flury et al., 2002;
<b>Microcystin conjugate-enzyme</b>	<b>ELISA</b> (Enzyme-Linked ImmunoSorbent Assay)	Colourimetric	Chorus & Bartram 1999; Flury et al. 2002

**Appendix 8. Summary of chromatographic methods for determining hepatotoxins (Nicholson & Burch 2001).**

	HPLC			CE	MMPB method
	UV detection	PDA detection	MS detection		
<b>Principle of the technique</b>	Toxins separated by HPLC. UV detection at 240 nm.	Toxins separated by HPLC. PDA detection with UV spectra of analytes.	Toxins separated by HPLC. Detection by MS or MS/MS.	Toxins separated by CE. Detection normally PDA or UV.	Microcystins oxidized whereby Adda side chain is converted to MMPB which is determined.
<b>What it measures</b>	Determines individual toxins, subject to availability of standards.	Determines individual toxins, subject to availability of standards.	Determines individual toxins. May assist in identification of particular toxins, but quantification still subject to availability of standards.	Determines individual toxins, subject to availability of standards.	Gives a sum total of microcystins, as microcystin-LR equivalents if microcystin-LR is used for calibration.
<b>Detection limit and precision</b>	Precision around 5-10%, consistent with robust HPLC techniques. Detection limit depends on concentration factor; 0.02 µg l <sup>-1</sup> estimated for individual toxins using 5 L sample.	Precision around 5-10%, consistent with robust HPLC techniques. Detection limit depends on concentration factor; 0.02 µg l <sup>-1</sup> estimated for individual toxins using 5 L sample.	Precision should be around 5-10%, consistent with robust HPLC techniques. Detection limit depends on concentration factor; 0.02 µg l <sup>-1</sup> for individual toxins using a 5 L sample.	Precision should be around 5-10%, consistent with robust HPLC techniques.	Detection limit of 0.43 ng microcystin. For water samples, detection limit depends on concentration factor.
<b>Current usage and reliability, i.e., is the current usage a research application only and is it amenable to routine use in a commercial laboratory?</b>	Common analytical technique routinely used. Reliability depends on correctly identifying microcystins.	Common analytical technique routinely used. Reliability depends on correctly identifying microcystins. Identification enhanced by spectral data.	Analytical technique becoming more common. Identification of microcystins from mass spectral data much more reliable.	Analytical technique becoming more common but not considered to yet be sufficiently robust for routine use. Even with PDA detection still uncertainties in identifying.	Amenable to routine monitoring. However results not in terms of what is required by guidelines.
<b>Degree of documentation of the method in the literature, i.e., are published standard protocols available?</b>	Well documented and reasonably well standardized.	Well documented and reasonably well standardized.	Not commonly used and therefore not well documented.	CE procedures not that common and therefore not well documented.	Reasonably well documented.
<b>Level of expertise required by the operator/analyst</b>	Moderate level of expertise. High level to correctly identify microcystins.	Moderate level of expertise to operate and to correctly identify microcystins.	Moderate level of expertise to operate and to correctly identify microcystins. Expertise required, should decrease with time.	Moderate level of expertise to operate and to correctly identify microcystins.	Moderate level of expertise.

### Appendix 9. Removal of hepatotoxins (microcystins) by water treatment processes

TREATMENT TECHNIQUE	RESULTS (REMOVAL %)		COMMENTS
	CELL BOUND	EXTRACELLULAR	
Coagulation/sedimentation/ dissolved air flotation	> 80%	< 10%	Removal only achievable for toxins in cells, provided cells are not damaged
Rapid filtration	> 60%	< 10%	Removal only achievable for toxins in cells, provided cells are not damaged
Slow sand filtration	~ 99%	<b>Probably significant</b>	Removal effective for toxins in cells
Combined coagulation/ sedimentation/filtration	> 90%	< 10%	Removal only achievable for toxins in cells, provided cells are not damaged
Dissolved air flotation	> 90%	<b>Not assessed, probably low</b>	Removal only achievable for toxins in cells, provided cells are not damaged
Adsorption – Powdered activated carbon (PAC)	<b>Negligible</b>	> 85%	For adequate PAC doses (>20mg l <sup>-1</sup> ) with a PAC shown to be effective, DOC competition will reduce capacity
Adsorption – Granular activated carbon (GAC)	> 60%	> 80%	For practical EBCTs, DOC competition will reduce capacity and hasten breakthrough, filtration also removes algal cells
Biological granular activated carbon	> 60%	> 90%	See GAC, biological activity enhances removal efficiency and bed life
Pre-ozonation	<b>Very effective in enhancing coagulation</b>	<b>Potential increase</b>	Useful in low doses to assist coagulation of cells; risk of toxin release requires careful monitoring and possibly subsequent treatment steps
Pre-chlorination	<b>Very effective in enhancing coagulation</b>	<b>Causes lysis and release of dissolved metabolites</b>	Useful to assist coagulation of cells but applicable for toxic cyanobacteria only if subsequent treatment steps will remove dissolved toxins and other released metabolites
Ozonation (post clarification)	-	> 98%	Rapid and efficient on soluble toxins provided that DOC demand is satisfied
Free chlorine (post filtration)	-	> 80%	Effective when free chlorine is >0.5 mg l <sup>-1</sup> after > 30 minutes at pH < 8 and low DOC, effect negligible when dose low or pH > 8
Chloramine	-	<b>Negligible</b>	Ineffective. Free chlorine application will yield ineffective chloramines in waters enriched with nitrogenous organic matter
Chlorine dioxide	-	<b>Negligible</b>	Not effective with doses used in drinking water treatment
Potassium permanganate	-	<b>95%</b>	Effective on soluble toxins but only in absence of whole cells
Hydrogen peroxide	-	<b>Negligible</b>	Not effective on its own
UV radiation	-	<b>Negligible</b>	Capable of degrading microcystin-LR and anatoxin-a, but only at impractically high doses
Membrane processes	<b>Likely to be very high (&gt; 99%)</b>	<b>Uncertain</b>	Depends on membrane type, further research required to characterize performance

Source: Adapted from Hrudey et al., 1999;

## ■ GLOSSARY AND MOST COMMONLY USED ABBREVIATIONS

**AEROBES** - organisms that can live only in aerobic conditions as they gain energy from the process of respiration.

**AGGREGATION** - the process of combining smaller spatial units into larger sets.

**ALGAE** - microscopic, usually unicellular, plants. Allochthonous - brought into a water body from outside.

**ALLOCHTHONOUS** organic matter - organic matter transported into a lake or river from adjacent ecosystems.

**ANAEROBES** - organisms living in anaerobic conditions and gaining energy from chemical reactions which are not based on oxygen transformations.

**ANALOGUE MAP** - map printed on paper using graphic symbols to represent features and values.

**ARC** - a line consisting of a series of vertices.

**ATTRIBUTE** - an alphanumeric characteristic of a geographic object (point, line, area) that can be stored in a relational database and linked by an identifier to an object.

**AUTOCHTHONOUS** - produced within a water body.

**BIOASSESSMENT (BIOASSAY)** - Uses biota as the endpoint to represent environmental conditions and assess environmental quality.

**BIODEGRADATION** - the gradual destruction of a material due to natural or artificially induced biological activity.

**BIOLOGICAL** assessment (Bioassessment) - an evaluation of the biological condition of a water body through the use of biosurveys and other direct measurements of resident biota in surface waters.

**BIOLOGICAL CRITERIA (BIOCRITERIA)** - numeric values or narrative expressions that describe the reference biological conditions of aquatic communities inhabiting waters that have been given a designated aquatic life use.

**BIOLOGICAL MONITORING (BIOMONITORING)** - the use of a biological entity as a detector and its response as a measure to determine environmental conditions. Biosurveys and toxicity tests are common biomonitoring methods.

**BIOLOGICAL SURVEY (BIOSURVEY)** - the process of collecting and processing representative portions of a resident aquatic community to determine the community membership, structure, and functions.

**BIOMANIPULATION** - all methods of changing biological structure of an ecosystem in order to improve water quality.

**BIOMASS** - the quantity of living organisms expressed in units of volume or mass, generally related to a unit of volume or area within a water body. Also organic material, usually plant or animal waste, especially used as fuel.

**BIOTEST** - biological test method using animals or plants to provide a measure of total toxicity of a compound.

**BIOTOPE** - populations of all species living in a particular space.

**BLOOMS** - high concentrations of phytoplankton biomass.

**BUFFER** - a zone of given radius around a geographical object (point, line, area).

**CARRYING CAPACITY** - the dynamic equilibrium around which a population fluctuates; regulated by available space and the amount (and quality) of available resources.

**CARTESIAN COORDINATE SYSTEM** - a system of two or three mutually perpendicular axes along which the location of any point can be precisely described by a set of (x,y,z) coordinates.

**CASCADING EFFECT** - transmission of changes within a given trophic level to lower ones.

**CHELATING** - capable of forming a ring-shaped molecular structure and locking a metal ion in place, thereby reducing their activity.

**CLEAR WATER PHASE** - period in spring (frequently in June) characterised by intensive consumption (maximal grazing rate) of filtering zooplankton on phytoplankton. As a consequence, phytoplankton are reduced to very low levels and water transparency increases sharply.

**CONTOUR** - a line connecting points of equal elevation (or other attribute).

**CYANOBACTERIA** [also Cyanophytes or blue-green algae] - a group of phytoplankton, some of which can produce toxins, regulate their depth using a gas-vacuole buoyancy mechanism, and/or fix atmospheric nitrogen for use in growth. They often occur in eutrophic waters as a bloom.

**CYANOTOXINS** - toxins produced by cyanobacteria and classified as: hepatotoxins, neurotoxins, dermatotoxins and lipopolisaccharides (LPS).



**DATA** - the basic element of information that can be processed by a computer; may be alphanumeric or graphical.

**DATA MODEL** - a formal method of arranging data to represent an observed environment.

**DATABASE** - a computer file containing data, organized, inter alia, as a set of tables or coordinates of the points and their attendant attributes.

**DENITRIFICATION** - the microbiologically-mediated reduction of oxygenated nitrogen compounds to gaseous nitrogen.

**DENITRIFYING BACTERIA** - the group of bacteria which utilize nitrate in one of three metabolic pathways:

- a) without accumulating nitrite,
- b) with transient accumulation of nitrite, and
- c) in a two-step denitrification process that transforms nitrate into gaseous nitrogen.

**DIATOMS** [also Bacillariophytes] - a group of algae with siliceous walls.

**DIGITAL TERRAIN MODEL (DTM)** - data which depict the relief of a given area of terrain using a grid or irregular triangular network and contour elevations.

**DIGITIZE** - a means of entering geographical data into computerized databases from analogue maps.

**DINOFLLAGELLATES** - a group of phytoplankton with flagella, or whip-like appendages, by which the organisms have limited movement.

**DIVERSITY OF FISH** - the proportion of a given fish species within a sample population. Diversity may be calculated using the Shannon Index (H), where:  $H' = - \sum p_i \ln p_i$ .  $p_i$  is the ratio of each component (the % of a given species) to the total value (all species=100%). The index may be scaled from 0 to 1, where 0 is the lowest possible diversity and 1 is the maximum possible diversity by dividing  $H'$  by  $\ln S$ , where  $S$  is the number of species having the indicated  $p_i$  value (after Odum 1980).

**ECOLOGICAL INTEGRITY** - the condition of the biotic (biological community) and abiotic (non-biological; water chemistry and habitat) components of unimpaired water bodies, as measured by assemblage structure and function, water chemistry, and habitat measures.

**ECOREGIONS** - a relatively homogeneous area defined by the similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables.

**ECOTONE** - the transition zone between two different types of ecosystems, such as a river and a meadow, characterized by very high biodiversity; ecotones may play an important role as buffers, modifying and limiting flows of nutrients and pollutants between ecosystem components.

**EFFICIENT INFILTRATION** - the amount of precipitation water, which passes (percolates) from the unsaturated zone into the ground water. Efficient infiltration is sometimes called recharging infiltration.

**EH** - ecohydrology (see: chapter 2.A).

**ELISA (enzyme-linked immunosorbent assay)** - sensitive biochemical method for detecting compounds that interact with specific antibodies; useful for rapid sample screening for microcystins.

**ENTITY** - a discrete geographical object represented as a digital data structure.

**EX SITU** - removed from its original location.

**FEATURE** - a representation of a geographical object as a point, line, or polygon.

**FILTER** - a small matrix (mask) containing coefficients used for modifying pixel values in a raster image on a map using a variety of mathematical procedures.

**FLUORESCENCE** - the process whereby light is absorbed at one wavelength and almost instantaneously emitted at new and longer wavelengths by an organic molecule, as in the case of photosynthetic pigments.

**GENERALIZATION** - the reduction of the volume of geographical data; such reductions are usually used to construct a better graphical representation on a map or in image enhancement.

**GEOGRAPHIC OBJECT** - a user-defined part of the real world that can be represented using geographical features and attributes.

**GEOREFERENCE** - the relationship between raster data and cartographic coordinates.

**GREEN ALGAE** [also Chlorophytes] - a group of algae which are usually a good food for zooplankton.

**GRID DATA** - the structure of data used to represent geographical objects, composed of square cells of equal area, arranged in rows and columns.

**HEAT BALANCE** - balance of all energy fluxes entering and leaving an ecosystem or landscape.

**HPLC (high performance liquid chromatography)** - analytical method for separation and quantification of compounds in liquid solvents.

**IMAGE** - a graphic representation of an object produced by an optical or electronic device. An image is stored as raster data in the form of pixel values.

**IN SITU** - in the original location.

**IN VIVO** - in living organisms.

**INFILTRATION** - the slow passage of water (percolation), which comes from precipitation, rivers, water reservoirs and condensation of water vapour on soil, through the unsaturated zone to the saturated zone.

**INFILTRATION UNITS** could be:  $l\ km^{-2}$  or  $mm\ year^{-1}$ .

**INTERPOLATION** - making predictions based on measurements done only in a certain area.

**IWM** - Integrated Watershed Management.

**KRIGING** - an interpolation technique based on a theory of the semivariogram.

**LAYER** - a logical set of thematic data covering one subject.

**MAP PROJECTION** - a set of mathematical equations for converting geographical coordinates to Cartesian plane coordinates. The equations allow the depiction of spherical, three-dimensional objects on a flat map.

**METRICS** - a characteristic that changes in some predictable way with increased human influence (e.g., a scoring system).

**MIDSUMMER DECLINE** - sudden midsummer decrease of large, filtering zooplankton (mainly *Daphnia* spp.) biomass.

**MODEL** - a simplification and abstraction of reality. Models can be seen as a data set representing the structure of geographical objects, as well as a set of logical expressions and mathematical equations used to simulate processes. Models may also be physical representations of geographic features.

**MULTIMETRIC APPROACHES** - an analysis technique using several measurable characteristics of a biological assemblage.

**MULTISPECTRAL** - the remote sensing technique for obtaining images over a number of distinct narrow bands of the electromagnetic spectrum.

**MULTIVARIATE COMMUNITY ANALYSIS** - statistical methods (e.g., ordination or discriminant analysis) for analyzing physical and biological community data using multiple variables (quantitative or nominal).

**NODE** - the end points of a line.

**NON-POINT SOURCE POLLUTION** - pollution entering water bodies from diffused sources, including surface and subsurface runoff, nutrient leaching, and erosion, mainly from degraded landscapes (e.g., landscapes degraded due to agriculture, deforestation, etc.).

**NUTRIENT CONCENTRATION** - the amount of a nutrient in a given volume of water.

**NUTRIENT LOAD** - the amount of a nutrient transported into a water body by rivers, sewage discharges, etc., over a given period of time, calculated as concentration multiplied by discharge.

**NUTRIENTS** - chemical elements necessary for growth and development of vegetation. The main nutrients are phosphorus, nitrogen, and carbon. Increased nutrient concentrations stimulate the process of eutrophication in aquatic ecosystems.

**PH** - phytotechnology (see chapter: 2.B).

**PHOSPHATASE** - a group of hydrolytic enzymes liberating the orthophosphate ion from organic compounds.

**PHYCOCYANIN** - a photosynthetic pigment characteristic of cyanobacteria.

**PHYTOEXTRACTION** - removal of chemical substances by plants.

**PHYTOPLANKTON** - the algal component of plankton, which are free-living organisms within an aquatic environment.

**PHYTOREMEDIATION** - removal of contamination through the natural process of plant uptake.

**PIEZOMETER** - a pipe-like trap for ground waters with perforated ends, placed in water bearing layers to measure ground water elevations; when placed in fields, ground water flows can be measured using tracers.



**PIXEL** - one picture element (or cell) in a set of grid data.

**POINT SOURCE POLLUTION** - pollution entering water bodies from concentrated outflows (e.g., pipes transporting municipal and industrial sewage, water from purification plants, irrigation channels, etc.).

**POLYGON** - a vector representation of an enclosed area written as a set of vertices or given by a mathematical function.

**PPIA (protein phosphatase inhibition assay)** - sensitive biochemical method that uses biochemical activity to measure the presence of microcystin and nodularin toxins.

**PYROLYSIS** - the breaking apart of complex molecules into simpler units by the use of heat.

**RADICAL ZONE** - the surface layers of the soil within the reach of plant roots.

**RASTER** - a computer readable format used for representing images or grid data.

**RASTERIZATION** - the process of converting data from vector format to raster format.

**REFERENCE CONDITION** - the chemical, physical, or biological quality, exhibited at either a single site or an aggregation of sites, representing a semi-natural or reasonably attainable condition at the least impaired reference sites.

**REFLECTANCE** - the ratio of energy reflected by a surface to that incident upon it.

**RETENTION TIME** [also Water retention time, WRT] - the ratio of volume and flow of a reservoir or lake.

**RETENTION TIME, WATER RETENTION TIME** - the ratio of volume and flow of a reservoir or lake.

**RTS** - (river type-specific species) - criterion reflects the fish fauna naturally occurring in a specific type of river, excluding species not native in a given area (e.g., country, ecoregion) and not autochthonous for that river.

**RUBBER SHEETING** - the procedure for adjusting the geometry of an image by non-uniform transformations.

**SCALE** - a relationship between the distance on a map and in reality.

**SCANNING** - the process by which analogue maps are converted to raster format by an optical device.

**SEMIVARIOGRAM** - a graph showing the relationship between variance and separation for a pair of data points.

**SHELTERBELT** - a row of trees and shrubs planted in the midst of a cultivated field.

**SHOAL** - a large number of fish swimming together.

**SPATIAL INTERPOLATION** - the procedure of estimating values in certain areas using existing observations.

**SSP** - species criterion reflects the type-specific fauna (RTS-species) composed of species meeting the following minimum criteria: the species are self-reproducing, thus juvenile fishes occur, and maintain, at least a minimum population size.

**STABILIZATION** - a process designed to limit the mobility of toxic chemicals.

**STREAM MICROHABITAT SYSTEM** - the distribution of pools, riffles, and runs, having relatively homogenous substrate types, water depths, and velocities, within a stream course.

**STREAM ORDER** - the dendritic arrangement of channels of a river throughout its drainage basin. The most popular hierarchy is defined such that first order streams are those having no tributaries, second order streams are those formed by the union of two first order streams, third order streams are those formed by the union of second order streams, and so on.

**STREAM POOL-RIFFLE-RUN SYSTEM** - a subsystem of a reach having characteristic bed topography, water surface slope, depth, and velocity patterns. In a natural meandering watercourse, the shallow zones or riffles and the deeper zones or pools lie in a regular pattern connected by runs. The distance between two neighbouring riffles or pools is approximately one half of the wavelength of one full meander, or about 5 to 7 times the width of a watercourse. In-stream habitats at this level are complex hydrological units.

**STREAM REACH** - a length of stream or a stream segment lying between breaks in channel slopes, local side slopes, valley floor widths, riparian vegetation, and bank materials.

**STREAM SEGMENT** - the portion of a stream system flowing through a single bedrock type and bo-

unded by tributary junctions or major waterfalls.

**STREAM SYSTEM** - all running surface waters in a watershed and standing waters within stream systems that may be wetlands or lakes depending upon their depth, hydrologic conditions, soil types, and vegetation cover.

**SUCCESSION** - is a widely-accepted, biological concept implying a sequence in which species or group of species dominate a plant community.

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**SURFACE** - a representation of geographical object as a set of continuous data (also a data field).  
Surface runoff - surface flow caused by rainfall, transporting solids, nutrients, and pollutants downhill into aquatic systems.

**THE SATURATED ZONE** - is the zone below the groundwater table where all pores are filled by water.

**THE UNSATURATED ZONE** - is the zone immediately below a land surface and above a water table where pores contain both water and air and are not totally saturated with water. The unsaturated zone is sometimes called the vadose zone.

**TOPOLOGY** - the spatial relationship between nodes, lines, and polygons.

**TREATABILITY STUDY** - a study to determine the efficiency of one or more potential treatment methods or processes for a given remediation problem.

**VECTOR** - a data structure in which lines are represented as a list of ordered coordinates.

**VECTORIZATION** - the process of converting data from raster to vector formats.

**VERTEX (VERTICES)** - a point or series of points with given coordinates on a line.

**WATER BALANCE** - balance sheet of all water fluxes entering and leaving an ecosystem or landscape.

**WATER DEFICIT** - difference between evapotranspiration and water supplies (precipitation and water retention) within agricultural landscapes.

**WETLAND** - a natural or constructed system, permanently or periodically flooded, that can act as water purification systems or nutrient sinks. Purification is enhanced by the activity of vegetation and variety of microbiological and biogeochemical processes taking place within the substrate of the wetland. Wetlands are defined by the presence of hydric soils, characteristic types of vegetation, and a high water table.



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