Guidelines for monitoring of turbidity

1. Background

1.1 Introduction

Turbidity estimates the impact of light scattering due to particles on the level of light attenuation in the water column. It is affected by total suspended solids (i.e., organic and inorganic particles) in the water, and thus differs from water transparency, which is also dependent on the amount of chromophoric dissolved organic matter (CDOM).

Organic particles are mainly autochthonous (phytoplankton, zooplankton, bacterial cells) and thus are related to the trophic state whereas inorganic particles are largely allochthonous (e.g., resuspension, fluvial sediment load). This source of error has to be taken into consideration whenever eutrophication status is assessed using turbidity in the Baltic Sea that is optically classified as a Case II water body (Morel and Prieur 1977), i.e., the body where concentrations of colour producing substances (e.g. phytoplankton, inorganic particles and CDOM) vary independently from each other. For turbidity, this feature is emphasized in coastal areas subject to fluvial impact. The representativeness of turbidity as an eutrophication metrics increases towards offshore areas; here, an increasing share of particles causing turbidity is of autochthonous origin. This has been utilized in the ship-of-opportunity (SOOP) approach.

The scope of this guideline is turbidity, measured either with turbidity meters in a laboratory or with turbidity sensors on board research vessels or in the SOOP and other autonomous systems.

1.2 Purpose and aims

The purpose for turbidity monitoring is to describe spatiotemporal trends in total suspended solids.

Turbidity provides information of total suspended solids that can serve as a diagnostic of eutrophication (with certain limitations mentioned above). It is thus an element of eutrophication monitoring, although only as a supporting parameter.

2. Monitoring methods

2.1 Monitoring features

Turbidity is expressed in formazine nephelometric units (FNU; measurement of diffuse radiation, applicable to water of low turbidity). It measures the radiation back scatter introduced by the total suspended solid content of the sample water against the scatter caused by the formazine polymer suspension of known concentration. Turbidity in FNU is measured with an infrared light source.

Turbidity monitoring is required for the projects including land reclamation or building of transportation / communication infrastructures close to marine protected areas or sensitive habitats when it is important to limit the extent of relocation of suspended matter from not harming the marine life.

2.2 Time and area

Turbidity measurement, probing radiation back scatter that is an inherent optical property of the water, can be done all year round. However, to supplement eutrophication monitoring, it should be monitored during the period of significant biological activity.

The monitored area covers, in principle, the entire Baltic Sea, both the open sea and coastal areas, but only some of the HELCOM Contracting Parties are monitoring turbidity.

2.3 Monitoring procedure

2.3.1 Measuring approach

Diffuse radiation technique is the only quantitative method applicable to natural waters of low turbidity.

2.3.2 Measuring method(s) and equipment

Turbidity of water is measured quantitatively by diffuse radiation using turbidity meters according to guidelines of ISO 7027-1 standard.

2.3.3 Sample handling and analysis

Turbidity of water is measured in the laboratory against the instrument calibration curve from individual water samples. Before starting the measurements, the instrument has to be calibrated according to the manufacturer's calibration instructions. A measurement is performed on a well-mixed sample in accordance with the manufacturer's instructions. The turbidity value is interpreted from the calibration curve.

In situ measurements

Turbidity is measured *in situ* either in the flow-through water within the SOOP systems or in the water column by the CTD systems. The instrument has to be calibrated according to the manufacturer's calibration instructions. The turbidity value is to be read directly from the instrument scale, if the scale has been verified by calibration

2.4 Data analysis

No calculations or conversions required.

3. Data reporting and storage

The results are included in the station data, stored by the Contracting Parties, and reported annually to the COMBINE database hosted by ICES.

Depending on the magnitude of a turbidity value, the results are reported as follows:

- turbidity < 0.99 FNU; report to the nearest 0.01 FNU
- 1.0 < turbidity < 9.9 FNU; report to the nearest 0.1 FNU
- 10 < turbidity < 40 FNU; report to the nearest 1 FNU.

See ISO 7027-1 for Measurement of attenuated radiation by turbidimetry or refer generally to measurement of diffuse radiation by nephelometry.

4. Quality control

4.1 Quality control of methods

Laboratories carrying out turbidity analyses should have established a quality management system according to EN ISO/IEC 17025.

A turbidity meter and a turbidity sensor are calibrated at constant intervals against a dilution series of a traceable commercial standard.

In a laboratory premises, the daily quality control is carried out by commercial gel control samples producing data for X-bar charts. Alternatively, a secondary standard suspension can be used as a daily calibration check, being monitored periodically for deterioration using one of the primary standards.

Repeatability of the measurement is inspected by replicate measurements amongst the sample series.

Contracting Parties should follow the HELCOM monitoring guideline but minor deviations from this are acceptable if the method achieves comparable results. Validation of the adopted method needs to be

performed on the relevant matrix and concentration range e.g. by taking part regularly at inter-comparison studies or proficiency testing schemes.

The correlation between the measured turbidity and the amount of suspended matter *in situ* in the water is not constant due to qualitative variations in the particle content, and hence, in the scattering properties of the sampled water mass. Thus, this correlation can only be fixed for an individual region / location / time period.

4.2 Quality control of data and reporting

For general data reporting guidelines, see HELCOM (2015).

Measurement uncertainty should be estimated using ISO 11352 standard. Estimation should be based on within-laboratory reproducibility, data from proficiency testings, and internal / commercial reference material.

Data must be flagged if normal QA routines or recommended storage conditions cannot be followed.

5. Contacts and references

5.1 Contact persons

Mika Raateoja, Finnish Environment Institute

Jukka Seppälä, Finnish Environment Institute

5.2 References

EN ISO/IEC 17025*: General requirements for the competence of testing and calibration laboratories

HELCOM (2015). Eutrophication Assessment Manual, Annex 3A. http://www.helcom.fi/helcom-at-work/projects/eutro-oper/. Last revision in 2015.

ISO 11352*: Water quality – Estimation of measurement uncertainty based on validation and quality control data

ISO 7027-1*: Water quality - Determination of turbidity - Part 1: Quantitative methods.

Morel A, Prieur L (1977). Analysis of variations in ocean color. Limnology and oceanography 22: 709-722.

* For undated references, the latest edition of the referenced document (including any amendments) applies