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Assessment of Effects of Sediment Contamination on Water Quality in Reservoirs

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ASSESSMENT OF EFFECTS OF SEDIMENT CONTAMINATION ON WATER QUALITY IN RESERVOIRS

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Objective (not an objective but Introduction)

Many elements and compounds which enter streams, lakes and reservoirs become associated with particulate matter. The particulate matter is carried by water into areas of low flow in the water body where it settles to the bottom. Therefore bottom sediments in lakes and reservoirs can act as a sink or source of nutrients and contaminants. Release and recycling of sediment-associated nutrients and contaminants need to be considered in management and restoration of reservoirs. The protection of water quality in the reservoirs has to include the control of loads of dissolved and particulate nutrients and inorganic and organic contaminants. However, even after the loads become reduced or eliminated, the release of the nutrients and contaminants from the sediments under oxic or anoxic conditions may need application of techniques to control biological and physico-chemical processes, particularly at the sediment/water interface, to prevent release of these compounds into overlying water and to restore the quality of the water in the reservoir. Resuspension of bottom sediment particles and diffusion through the sediment interstitial water are the main pathways of release of nutrients and contaminants from the sediments into the water column. Proper management of sediment quality plays a key role in the quality and treatability of reservoir water. Contaminated sediments can be removed from the reservoir or treated *in situ*. However, biological and physico-chemical assessment of sediment quality needs to be carried out prior to the selection of sediment treatment. The assessment of

sediment quality requires survey of sediment toxicity, sampling and analysis of sediment interstitial water, and physico-chemical analysis of the sediments.

Treatment of contaminated sediments

Assessment of sediment quality

Extensive survey and monitoring are required to assess the extent and severity of sediment contamination, and to evaluate the effects of contaminated sediments on aquatic ecosystems, particularly on water quality; and to prepare a plan for proper remedial action. These activities require sampling and physico-chemical analysis of all compartments of the aquatic system, including the bottom sediments. Bioassessment of sediment quality is becoming very important and commendatory in the evaluation of the quality of bottom sediments.

The first step in the collection of sediment samples is the planning of the sediment sampling program. The program should include listing of analyses and tests which need to be carried out to obtain all necessary data for the characterization of the sediments and/or assessment of sediment quality. Further, the quantity of sediments to be collected needs to be calculated to obtain sufficient material for all analyses and tests, including quality assurance/quality control program. The use of incorrectly collected and analyzed samples may lead to a waste of money and effort and to erroneous conclusions. The importance of, and the relationship among, the individual steps of sediment sampling and analyses in the assessment of sediment quality is outlined in Figure 1. Different sediment sampling techniques and their logistics were described recently by Mudroch and MacKnight (1994) and Mudroch and Azcue (1995).

Sediment removal

Sediment removal by dredging is typically carried out for the maintenance of desired water depth or, in cases where contaminated sediments impair the ecosystem to such degree that an *in situ*

treatment is not economically or environmentally feasible. Modern dredging equipment is relatively efficient in moving large volumes of sediments. However, in areas with high sedimentation rates, repeated dredging needs to be considered. Resuspension of sediment during dredging of contaminated sediments must be minimized to prevent environmental damage. Proper selection of dredging equipment is therefore important to the successful removal of sediment contaminants. Mechanical dredges commonly used are grab-type dredges. One of the disadvantages of these dredges is that they typically create turbidity. Use of silt curtains or a covered, watertight grab bucket can minimize the turbidity in the water during the dredging operations. There are many types of hydraulic dredges suitable for use in dredging a reservoir. Some of the dredges designed for special purposes are suitable for dredging fine-grained or sandy sediments in reservoirs. In case of contamination of littoral sediments in a reservoir, lowering the water level to expose the littoral sediments and removal of the sediments with earth moving equipment may be considered. Many reviews of dredging equipment are available with recommendations for selection of the proper dredging equipment and disposal of dredged material at specific sites (for example, Cooke *et al.*, 1993).

In situ treatment

Different techniques have been developed for *in situ* sediment treatment of contaminated sediments. Chemical, biological and physical techniques have been tested and their efficiency evaluated. Subaqueous capping of contaminated sediments is becoming an accepted, efficient, and economical way of isolating contaminants from the overlying aquatic environment (Zeman, 1994). *In situ* sediment capping is suitable in reservoirs and lakes which do not require dredging for navigational purposes. ~~The method of capping requires that a layer of uncontaminated material be placed as a cover of the contaminated sediments.~~ Clean sand and clay are suitable capping materials that have been proven to effectively prevent contaminants from entering the water column. Prior to

capping, laboratory tests are carried out to determine the relationship of the cap thickness to the effectiveness of capping in preventing movement of contaminants into overlying water and aquatic biota.

Conclusions

Release and recycling of sediment-associated nutrients and contaminants need to be considered in management and restoration of water quality in reservoirs. Biological and physico-chemical assessment of sediment quality needs to be carried out to evaluate the impact of the sediments on the quality of the water. Contaminated sediments which have a negative impact on the water quality can be treated by different techniques, such as *in situ* treatment or removal of the sediments. Selection of the treatment is site-specific, and depends on many factors, such as morphometry of the reservoir, physico-chemical properties and quantities of sediments to be treated, etc. Remediation of the sediments for protection of water quality should include control of loads of dissolved and particulate nutrients and contaminants to the reservoir.

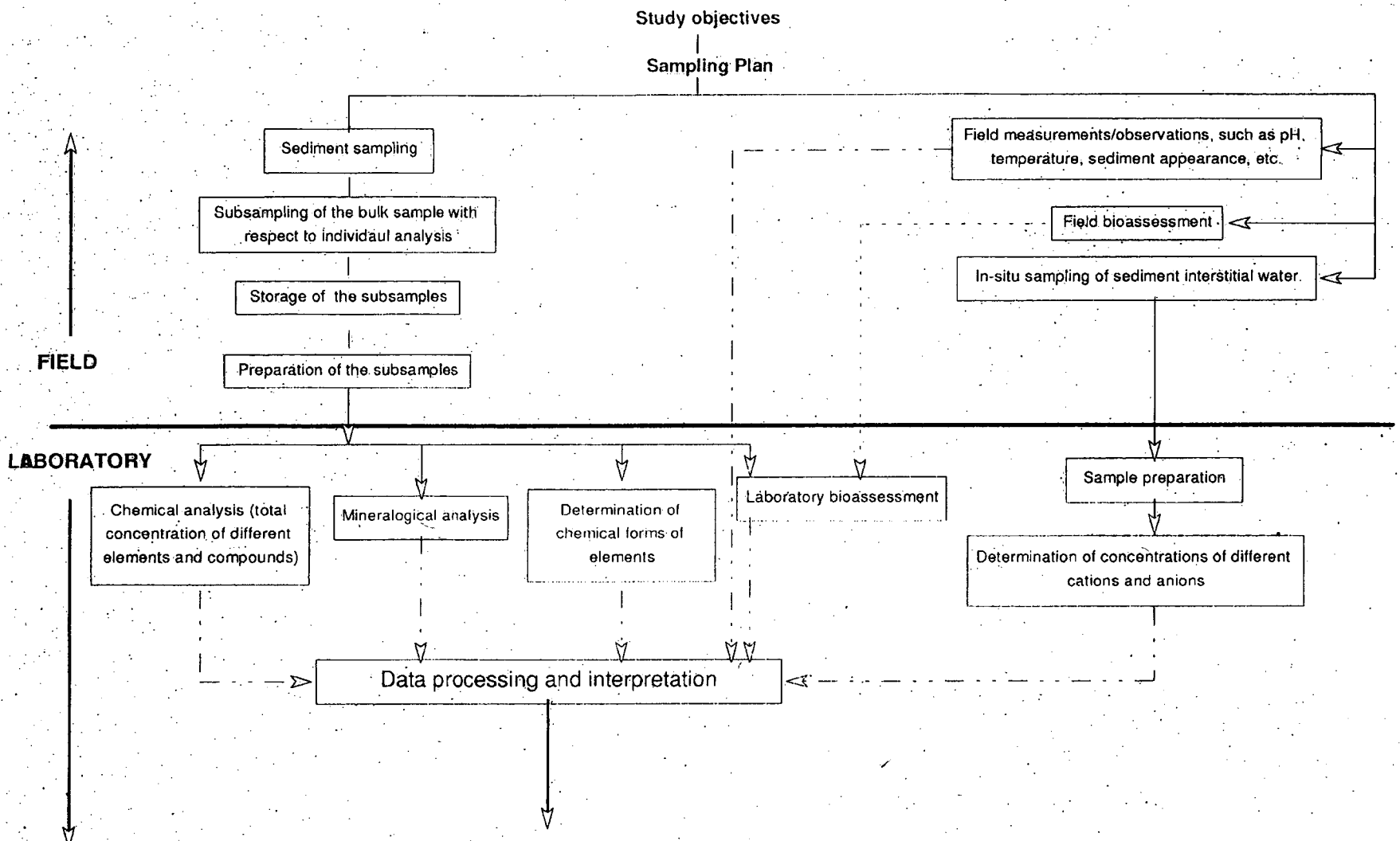
References

Cooke, G.D., Welch, E.B., Peterson, S.A. and Newroth, P.R. (1993). Sediment Removal. *In* Cooke, G.D., Welch, E.B., Peterson, S.A. and Newroth, P.R.: *Restoration and Management of Lakes and Reservoirs*, Second Edition, Lewis Publishers, Boca Raton, Florida, U.S.A., pp. 451-533.

Mudroch, A. and MacKnight, S. (1994). *Handbook of Techniques for Aquatic Sediments Sampling*. Lewis Publishers, p. 236.

Mudroch, A and Azcue, J.M. (1995). *Manual of Aquatic Sediment Sampling*. CRC Press Inc., p. 219.

Zeman, A. J. 1994. Subaqueous capping of very soft contaminated sediments. *Can. Geotech. J.* **31(4)**: 570-577.


Study objectives
Sampling Plan
Sediment sampling
Subsampling of the bulk sample with respect to individaul analysis
Storage of the subsamples
Preparation of the subsamples
Field measurements/observations, such as pH, temperature, sediment appearance, etc.
Field bioassessment
In-situ sampling of sediment interstitial water
FIELD
LABORATORY
Chemical analysis (total concentration of different elements and compounds)
Mineralogical analysis
Determination of chemical forms of elements
Laboratory bioassessment
Sample preparation
Determination of concentrations of different cations and anions
Data processing and interpretation
Assessment of sediment quality as stated in the objectives
Indicates transfer of sub-samples for additional testing
Indicates flow of data from completed analyses

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