HYDROBIOLOGICAL SERVICE FOR OBSERVATIONS AND CONTROL OF SURFACE WATERS IN THE USSR

by

Yu A Izrael, N K Gassilina and V A Abakumov

(The USSR State Committee for Hydrometeorology and Control of the Natural Environment)

Technological progress, having reached in our time an unprecedented speed, is still increasing the rate of mineral extraction, industrial construction, and the mastering of new kinds of energy is growing. Correspondingly the anthropogenic load on the biosphere is increased and that requires the comprehensive development of monitoring the anthropogenic changes in the natural environment.

Among problems resulting from the scientific-technological development, a noticeable place is given to the problem of pure water. Surface land waters proved to be a sensitive link in the natural environment. This fact stipulates the necessity of especially careful control of their state. The latter is the most important function of the hydrobiological service.

The hydrobiological service for observations and control of the surface waters is one of the subsystems of the State/Federal Service for Observations and Control of pollution levels in environmental objects, conducted by the USSR State Committee for Hydrometeorology and Control of the Natural Environment in accordance with the resolution of the Central Committee of the Communist Party of the Soviet Union and of the USSR Council of Ministers, December 29, 1972, "On Strengthening Nature Conservation and Improvement in the Use of Natural Resources". The primary objective of the hydrobiological service for observations and control of the surface waters as a subsystem of the State Service is the acquisition of hydrobiological information and the assessment of the state of the natural environment in the national interest (4).

The deterioration of the state of the ecological systems in individual water bodies and watercourses may not be of vital importance for the estimation of the state of the hydrosphere on the global scale, but it is important for taking national measures.

The main principles of the organisation and goals of the national system of monitoring of the state of the natural environment in the USSR were elucidated at the first USSR/UK Symposium on scientific bases for monitoring of the natural environment state held in Cardington, the United Kingdom, 1976 (2). These principles and goals are, in full measure inherent in the hydrobiological service for observations and control of the surface waters in the USSR. Here we dwell in greater detail on the peculiarities conditioned by the objects of the hydrobiological observations – living biological systems.

Within the framework of the State Service for Observations and Control of pollution levels in environmental objects, systematic observations according to hydrobiological indices were started after 1974. Before 1974 the control of surface water quality was carried out only according to physical and chemical indices. However, the pollutant composition is extremely complex, and comprehensive chemical analysis is extremely expensive and the obtained information on the content of a chemical compound cannot be ecologically interpreted if we do not know its impact on a biocenosis.

As a rule in the aquatic environment intricate complexes of various chemical compounds are concentrated affecting, organisms in a completely different way from individual components. It should be added that, due to better pollutant transformations as well as interactions of numerous chemical ingredients in the aquatic environment, new chemical compounds are formed which are difficult to determine by analysis. Many of them are characteristicised by molecular stability, possessing high toxicity and are expressed in a mutagenic effect, which has been over and over again indicated in the scientific literature. Therefore, the control of the pollution of aquatic objects solely according to physical and chemical indices, even providing for ecologically justified standards for pollutants in natural media, is, at the least, insufficient.

Hydrobiological indices, being the most important elements of the system for surface water pollution control, allow us:

- to estimate the surface water quality as a habitat for organisms in water bodies and watercourses;
- to estimate the integral effect of the combined impact of pollutants;
- to estimate trophic properties of water and in some cases the specific chemistry of its origin;
- to determine the origin of secondary water pollution.

The control of surface waters according to hydrobiological indices is also of high priority in view of a possibility of direct assessment of aquatic ecological systems under the harmful impact of anthropogenic factors. In this respect, hydrobiological indices have a significant advantage compared to indicators of water toxicology, which allows us to make only indirect assessments of aquatic ecological system state by experiments with individual test-objects, when it is impossible to consider fully either peculiarities of the aquatic-object type or its hydrological regime, ie with the help of experiments which are, so to say, indifferent to the real environment of the aquatic-object in question. All this is a good reason for the application in practice of the ecological monitoring of just the hydrobiological indices which provide not only water quality assessment but also give the possibility of a direct evaluation of the states of aquatic ecological systems.

As was said above, the objectives of the hydrobiological service under the USSR State Committee for Hydrometeorology and Control of the Natural Environment are concerned with the systematic control of the pollutional state of aquatic objects according to hydrobiological indices, as well as with the determination of aquatic biocenosis variations under an anthropogenic impact. The control of the condition of surface water according to hydrobiological indices is aimed at the acquisition of objective data, the collection of which is necessary for revealing long-term changes in aquatic ecosystems.

The function of the hydrobiological service is to provide national economic organisations with systematic information on water quality and the states of biocenoses, to assess the efficiency of measures aimed at the prevention of water pollution, to plan and implement practical measures for conservation and rational use of surface waters, to develop and outline the unified system of hydrobiological indices for the estimation of aquatic ecosystems pollution.

The hydrobiological control of the state of surface waters, apart from independent functions, is very important for the solution of a number of problems: determination of discharge conditions, character and limits of waste water spread; characterisation of pollutant biotransformations; determination of raw material for a fishery; control of water blooms and

overgrowths of a water body with higher aquatic plants; optimum design of hydrotechnical constructions; potable water supply; recreation; protection of relict forms; control of overgrowths which inflict significant damage to hydrotechnical constructions, etc.

The main principles of the organisation of observations and control of the level of pollution of aquatic objects according to hydrobiological indices are:

1. A great number of hydrobiological observations;

2. Comprehensiveness of observations, ie hydrobiological observations being carried out in combination with hydrochemical and hydrological ones;

3. Unification of scientific-methodical guidance by a network of hydrobiological laboratories;

4. Centralisation of all the hydrobiological information on the control of water pollution and changes in aquatic ecological systems under the impact of anthropogenic factors;

5. Unification and standardisation of techniques for hydrobiological observations and control;

6. Comparability of the hydrobiological indices in regions of the supposed effects of sources of pollution of aquatic objects with the indices in regions where there is no such effect, for example, in water-courses, for the realisation of this principle observations are carried out upstream and downstream of a pollution source.

The only criteria, before the establishment of the hydrobiological service for observations and control of surface waters in our country were maximum permissible concentrations (MPC) of various chemicals. Hydrobiological observations made possible the establishment of ecological norms. In this connection the most important problem defining the scope and the program of hydrobiological observations becomes one of the desired and permissible quality of the natural environment (5). This problem is being solved by a differential approach to natural objects depending on their economic, scientific and aesthetic importance. From this point of view there are three categories of natural objects:

Category 1 — nature reserve areas, unique natural objects;

Category 2 — natural objects undergoing a moderate anthropogenic load;

Category 3 — natural objects with highly modified or artificial anthropogenic ecosystems (3, 6).

Each of the three categories has its own category of maximum permissible state based on ideas of profound qualitative reconstructions of ecological systems under the impact of anthropogenic factors. Under the conditions of environmental pollution both the intensive enhancement of the metabolism of a biocenosis — metabolic progress — and the decrease of its intensity — metabolic regression can occur. The basis of the phenomenon is an intensification or attenuation of the utilisation of energy and matter which is fundamental for the existence of a biocenosis. Depending on the degree of the anthropogenic load there are three general directions of metabolic progress connected with three different paths of change in the ecological structure of biocenoses: complication of ecological structure —

ecological progress; simplification of ecological structure – ecological regression and reconstruction of ecological structure leading to neither complication nor simplification – ecological modulation. In those cases where the environmental pollution level approaches the limit of adaptation abilities of a biocenosis, ecological regression leads to metabolic regression. Each of the mentioned directions of biocenosis change is characterised by a certain complex of common features in relation to their ecological importance. No ecological modifications are permitted for ecological systems of aquatic objects of the first category. For ecological systems of category 2 aquatic objects, ecological modifications leading to ecological regress are not permissible. As to ecological systems of category 3 aquatic objects, ecological modifications leading simultaneously to ecological and metabolic regression are not permitted.

Side by side with criteria, common for each category, for individual groups of aquatic objects within each category are introduced additional particular criteria allowing for the individual requirements of these water-object groups. For example, the additional criterion for river sturgeon will be conservation of the sturgeon stock.

Selection of sites for hydrobiological observations is made according to general principles of siting for observation and control within the system of national environmental monitoring (2). Aquatic objects (or parts thereof) of great economic importance and also subjected to substantial pollution by industrial, municipal and agricultural waste waters are especially carefully controlled. Background observations are carried out at sites in water bodies and watercourses with the least anthropogenic load. The obligatory requirement in the location of a site is how typical it is both in relation to the kind of pollution and the magnitude of the anthropogenic load. At the majority of hydrobiological observational sites, samples are taken on two or more sites. In deep rivers, lakes and reservoirs not only the horizontal but also the vertical extent of the pollution dispersion are taken into account. Observations cover all the main biotopes of an aquatic object. Great attention is paid to the surveying of littoral and stagnation zones of water bodies which impose the greatest effect on the self-purification processes and the quality of surface waters.

The programme of the hydrobiological laboratory network involves a hydrobiological reconnaisance survey of aquatic-objects and regular periodic observations at fixed sites. While making a reconnaisance survey, water bodies and watercourses are studied over their full length. In the course of a survey, the main forms of zooplankton and phytoplankton are identified, information on ichthyofauna is collected, temperature, transparency, and colour of water are determined. The greatest attention is focussed on the littoral vegetation, macrozoobenthos and periphyton. In the latter case, only those microscopic forms are recorded which, during mass development, can be determined by eye or with the help of a simple magnifying lens eg overgrowing: attached forms of rotifers, colonial attached infusoria: *Ophrydium, Carchesium* and *Epistylis,* diatoms: *Gomphonema, Cymbella,* blue-green algae: *Nostoc, Rivularia,* films and overgrowths of sulfur bacteria: *Thiothrix, Beggiatoa,* bacterial Zoogloea ramigera, strands and flocks of bacteria and fungi: *Leptomitus, Sphaerotilus, Nematosporangium* and the like. In the littoral vegetation only dominant flora which is easy to count is identified. In this case, the sub-type of the aquatic vegetation represented by hydro-mesophytes, hydrophytes and hydratophytic species are of definite importance in the assessment of the pollution of the aquatic environment itself, and the subtype of the littoral vegetation, represented by xeromesophytes, mesophytes and hydrophytic species are the diagnostic factors in the assessment of pollution of the bottom by slow-movable and slightly soluble toxic substances. On the basis of a reconnaisance survey, the conditions of the general ecological state of an aquatic-object are determined; typical biotopes are singled out, and recommendations for the siting of fixed observation sites are made.

Hydrobiological observations at fixed sites are carried out according to a biological equivalent system (1). Peculiarities of the temporal organisation of aquatic ecological systems are taken into account in this observational system. Periodical processes of phalanx alternations, representing primary elements of the temporal structure of an ecological system, lie at the basis of the temporal organisation of ecological systems. Each phalanx of one and the same ecological system has its own characteristic, optimum permissible and critical values of the anthropogenic effect (3). In one and the same water body or watercourse one and the same anthropogenic impact may be permissible for some phalanxes and critical for others. In this connection, the agreement between observational periodicity ['P] and phalanx alternation periodicity [P] facilitates in principle the interpretation of observations of variations in the ecological system state under the impact of anthropogenic factors. The equivalence of process periodicities results from a constant agreement between a certain number of P' process periods with a certain number of P process periods. In this case, due to the synchronous character of periodical processes in biological systems, observation periodicity appeared to be equivalent to a broad class of periodical processes in the ecological system in question. Such an observational system is called biologically equivalent one.

At the sites of the fixed network the list of observed hydrobiological indices of surface water quality is mainly determined by the category of the aquatic-object, by its ecological-zonal type, composition and volume of waste water, its toxicity, and by requirements of water consumers. All this stipulates some differences in hydrobiological observation programmes for various sites of the fixed network. Nevertheless, the determination of a number of hydrobiological indices is obligatory for all the sites of a network and they are incorporated in a general programme. They are – zoobenthos, periphyton, phytoplankton and zooplankton.

Zoobenthos most clearly reflects the water quality and the state of the ecological systems in watercourses. Due to the prolonged life cycle of many bottom animals, their communities provide reliable characteristics of changes in the aquatic environment during prolonged periods of time. Zoobenthos indices, depending on the sampling site, allow us to obtain both integral estimates of watercourse quality and the degree of pollution of the bottom sediments themselves, which is necessary for the determination in general state of aquatic-object pollution.

Periphyton indices are used for the estimation of the average quality of aquatic-objects for a considerably long pre-observational period. Periphyton permits the identification of the pollution of aquatic-objects which occurred earlier, even if at the moment of observation the water is fully purified.

Zooplankton indices are fairly reliable indicators of water quality in slow-flowing water-bodies, lakes, reservoirs and ponds. Zooplankton indices are most important when comparing pollution levels of different water bodies or sufficiently large parts of rivers, large lakes and reservoirs. The zooplankton of the marginal vegetation of small rivers is very important for the assessment of the state of an aquatic ecological system. Zooplankton indices are usually used for the acquisition of water quality characteristics at sites for relatively short periods of time.

Phytoplankton indices, as well as zooplankton ones, characterise the quality of the water mass in which this development took place. Therefore, in watercourses they are used for obtaining information on pollution levels in the parts located upstream of the site. In addition to water quality assessments by indicator organisms, phytoplankton allows us to estimate water quality by indicators of primary production. Indicators of primary production and chlorophyll, taken separately, far from always unambiguously reflect an aquatic-object pollution, but they are required for calculating the assimilation number of chlorophyll which is an important indicator of the photosynthetic activity of phytoplankton which strictly depends on the extent and quality of water pollution.

Side by side with the above listed indices, at some sites microbiological and littoral vegetation indices are used. The importance of microbiological indices is especially great in those cases when the assessment of water quality is required at the moment of sampling. Vice versa, littoral aquatic vegetation characterises water quality for long periods of time. Such very important features of littoral aquatic vegetation as interzonal ones and the wide geographical spread of many species allow us to use its indices for the comparison of the degree of aquatic-objects pollution over vast areas.

On sites of the hydrobiological service for observations and control of surface waters, the work is carried out in accordance with manuals and guidance and technical recommendations developed at the Institute of Applied Geophysics which conducts scientific-methodical guidance of the hydrobiological service for observations and control of surface waters in the USSR. The unity of the observational methods and in the processing the data allows us to obtain comparable hydrobiological information from the whole country. Final processing of the hydrobiological information, as well as generalisation of the obtained results, are also accomplished at the Institute of Applied Geophysics. The combination in one and the same centre of the functions of scientific-methodical guidance and centralisation of hydrobiological information allow us to make rapid and operational corrections for the network activity for the increase of information quality. Alongside scientific-methodical guidance and generalisation of hydrobiological information, the perspectives of the hydrobiological service for surface waters are outlined and research in the field of the environmental protection is carried out at the Institute of Applied Geophysics.

Likewise, there are hydrobiological laboratories at regional scientific research institutes of the USSR State Committee for Hydrometeorology and Control of the Natural Environment. The main objectives of the hydrobiological laboratories of regional institutes are the research on those regional peculiarities of the biology of aquatic-objects, which are important for the assessment of permissible anthropogenic impacts as well as the adaptation of hydrobiological methods for the control of surface-water quality to peculiarities of aquatic-objects of their region in allowing for biogeographical peculiarities of the aquatic flora and fauna composition, geographical and vertical zoning.

General guidance and coordination of the State Service for Observations and Control of the environment pollution level of external environmental objects, which includes, besides surface-water pollution monitoring, monitoring of marine pollution, air pollution, and soil pollution is made by the USSR State Committee for Hydrometeorology and Control of the Natural Environment.

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