THE APPLICATION OF METHODS OF ECOSYSTEM ANALYSIS TO THE EVALUATION OF WATER QUALITY

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Guided by experience and the theoretical development of hydrobiology, it can be considered that the main aim of water quality control should be the establishment of the rates of the self-purification process of water bodies which are capable of maintaining communities in a state of dynamic balance without changing the integrity of the ecosystem. Hence, general approaches in the elaboration of methods for hydrobiological control are based on the following principles:

a. *the balance of matter and energy in water bodies;*

b. the integrity of the ecosystem structure and of its separate components at all levels.

In working out these problems we proceed from the following theoretical premises. 'Water quality' in the ecological sense is the whole ecosystem of a water body, consisting of hierarchical co-ordinative communities. In the applied sense, these are the water characteristics which ensure their utilisation for one practical purpose or another. Self-purification of water bodies is the utilisation of biological or indirectly biological complexes of water body substances entering it from outside. This process must proceed without disturbing the stability of natural ecosystems. In this sense, biocoenoses are organised systems capable of preserving stability by balancing the effects of the external environment and by adjustment to it. Their structure and function must be considered as a whole, together with hydrobiological investigations aimed at controlling water quality.

Thus, in the organisation of water quality control we must take into account special features of the turn-over of matter and the transformation of the energy flow (ie functional characteristics of the ecosystem) and community structure. Such an approach permits an evaluation of the anthropogenic influence on the water body from every source of pollution (effluents, additions from the atmosphere and from the territory surrounding a water body) and likewise, changes in the hydrobiological regime. In other words, ecosystem analysis makes possible a revelation of the whole totality of factors which determine the anthropogenic evolution of a water body. This is necessary for the study of long-term changes in water bodies. The principles of ecosystem analysis of water bodies, together with the creation of their mathematical models, are important because, in future, with the transition of water demanding production into closed cycles of water supply, changes in water bodies will arise in the main through the influence of 'diffuse' pollution (from the atmosphere, with utilisation in transport etc.)

The rate of self-purification processes in water bodies depends on their hydrobiological and trophic type and, likewise, on the nature of the surrounding landscape. Each hydrobiological type of water body (lake, reservoir, pond, river etc.) calls for an individual approach to the elaboration of a standard programme of regime observations.

Organisation of hydrobiological monitoring must be carried out by starting from the special features of a qualitative ecosystem model, taking into account the functioning of the main trophic links (levels) and the dominant species in them.

Depending on the hydrobiological type of a water body and its relationship to the land scape, we can select the primary indices for a rapid method assessment of their state; ie a determination of the degree of ecological well-being. The same methods of control for different types of water body are not acceptable. Such unification can only mask the degree of ecological well-being of a water body. We were convinced of this when anlysing ecosystem changes in Siberian waters, namely, Lake Baikal, the river Angara which flows out of it and the reservoirs formed along its course which are being studied in the Science Research Institute of Biology (7). For example, for fast-flowing rivers the important and trustworthy indices of qualitative changes in water quality are impoverishment in the composition of the rheophile and oxyphile bottom animals and replacement by limnophile animals (with domination by *Tubifex tubifex* in the presence or organic pollution). This was noticed by us in material from the middle section of the river Angara. Utilising these data an algorhithm was worked out for the analysis of macrobenthos samples, based on number and composition (down to species). It turned out that quite limited data were sufficient for the classification of waters into 5 groups. This permits the use of the described procedure as a rapid method for evaluating water quality (12). Thus, if the number of oligochaetes in the sample is 0, it corresponds to the most pure class of water – the 0 class. If oligochaetes are present in the sample, the correlation between the abundance of gammarids and oligochaetes is considered. If gammarids are more abundant than oligochaetes, this is a number 1 class of water. Next, the correlation of abundance between *Naididae* and *Tubifex tubifex* and *Limnodrilus* is compared. If Naididae are more abundant than *T. tubifex* and *Limnodrilus,* taken together, then this is a water of number 2 class. If the abundance of *Tubifex* and *Limnodrilus* in the sample is equal to or greater than 90% of the total number of organisms, this is a number 3 class of water quality. If none of these conditions is fulfilled and only oligochaetes are present, then this is a class 4 water.

For regulated rivers, that is for reservoirs, the degree of ecological well-being is expressed visually in the dynamics of the algal biomass, especially that of blue-green algae. Hence, control of their abundance must be foremost in the evaluation of the water quality of reservoirs and their eutrophication.

It is clear from the cited examples that only the increase or decrease of biomass is not indeed an indication of unfavourable changes in a water body.

In the selection of criteria for evaluation of water quality the general demands of the elaboration of rapid methods must be taken into account. For example, in the selection of indicator species it is advisable on the one hand to investigate the most massive and easily enumerated species and, on the other hand, to carry out a search for narrowly tolerant, stenobiotic species most sharply reacting to a change in the environment of the habitat. In each water body or part thereof a complex of organisms can react in the same way to pollution. The statistical criteria for the analysis can be the evidence for this. Thus, analysis of the phytoplankton in one of the regions of the Angara showed that application of the method of multiple regression analysis can reveal the changes in the ratios of the biomasses of various algal species which depend on the degree of pollution. A chosen group of algal species permitted the identification of waters according to the degree of their pollution. One can carry out an analogous selection of indicators with the aid of principle component analysis. This was tested by the number of bottom organisms belonging to various physiological groups. It turned out that, in regions influenced by effluents from the pulp and paper industry, the ratio of the investigated groups of microorganisms (cellulose decomposing, putrifying, anaerobic and aerobic heterotrophic, phenol oxidising and sulphate reducing bacteria) changes sharply on four bottoms of varying degrees of pollution. Differences from the unpolluted grounds are expressed above all in the great accumulation of cellulose decomposing, sulphate reducing, phenol oxidising and aerobic heterotrophic bacteria (1).

From these examples it is seen that the application of statistical methodology in community investigations permits the selection of objective indices for the rapid method of evaluating water quality from a considerable mass of data.

Ideas about the structure of aquatic ecosystems are constructed on the basis of classical qualitative methods of collecting plankton and benthos. They are very laborious and are in need of improvement and unification at all stages of collection and processing of hydrobiological information. Organisation of regime observations, carried out by instrumental registration of natural phenomena, is very important for control of water quality. The use of a logarithmic photometer-transparency meter in large stratified waters, automatically recording water turbidity, can be an example of the application of this possibility. This apparatus, of the Newman and Lee construction as modified by V M Kaplin was tested in the Bratsk reservoir conditions and showed the possibility of its use for evaluating the quantity of seston of plant origin (9).

The creation of centralised services is necessary for storage and analysis of hydrobiological material, accumulation and exchange of information and generalisation of the separate results of investigation in a composite programme. A bank of hydrobiological information is the most important task for achievement of this aim.

In the description of the state of water bodies it is necessary to accumulate 'absolute' characteristics, that is truly natural material, not replacing it by 'relative' data codified in the form of indices. Such a conclusion, in particular, can be drawn from the analysis of material obtained in the joint investigations of the Soviet and British specialists based on the regional laboratory of the Severn-Trent Water Authority in 1977. Thus, for example, indices of saprobity, according to Pantle and Buck, of algae from growths on glass slides in the River Dove at Mayfield, where the water is of high nutrient quality and the River Erewash at Toton, where there is an extremely polluted zone, proved to be similar (2.16 and 2.18 respectively) with little difference in all the other investigated regions during this period, whereas each of these zones was characterised by predominance of various dominant species, for example at the two already mentioned stations, by *Cocconeis placentula* and *Synedra ulna.* They do not reveal a consistent regular change depending on the differing water qualities and such numerical indices as those of species diversity of Margalef, Menhinik, Odum, Kantler and Korniker, the Simpson index of dominance, the Shannon index of general diversity, the index of equivalence and index of dominance (11). Earlier, limitation of utilisation of the index of species diversity was shown by us on the basis of phytoplanktonic material from the Angara reservoir (5). Specific data on community content and the size of populations gave more useful information, not only for the evaluation of reservoir state but also for the clarification of the reasons for its change, which is important for prognosis. In this, the observance of a combined approach to the description of phenomena is highly expedient. In hydrobiological control, difficulties are still experienced in the mathematical description of the connections in communities and of their changes. The presence of natural year to year fluctuations of communities complicates their analysis. Statistical evaluation of data permits the revelation of the natural pattern of this or that community change. It is necessary to bear in mind that statistical description of data must precede and accompany any attempt at ecosystem modelling.

One of the methods of evaluating the state of an ecosystem is the statistical analysis of population numbers, which permits the revelation of their 'normal' and 'abnormal' state. Thus, the discovery of the duration of long-period cycles in the numerical dynamics of Lake Baikal 's plankton permitted a prognosis of the course of long-term changes in the plankton and the revelation of criteria for evaluating the level of plankton growth in specific years. With the help of the main components method, the 'typical' ('normal') seasonal dynamics of the dominant species of the Baikal plankton were determined. These data made it possible to judge the nature and causes of deviations from the 'normal' in the development of the plankton (10).

For the elaboration of measures for nature conservation it is necessary to resolve a problem, namely, by what indices is the stability of aquatic ecosystems to be evaluated? In connection with this question it is necessary not only to examine their energy balance but also their structural peculiarities. In communities which are influenced by anthropogenic factors both the species content and that of higher taxonomic ranks (categories) are changing. The water quality in a water body is altered if the energy balance is disturbed. However, we cannot exclude from consideration the problem of preserving the structural integrity of natural biocoenoses.

It is necessary to mention the following main lines in investigations on nature protection for aquatic ecosystems:

a. the control of natural communities with the aim of conserving their functional and structural integrity and genetic potential;

b. the creation of completely controlled artificial ecosystems using the wastes from economic activities. The purification of effluents, implemented by such ecosystems, must be carried out with the aim of secondary economic utilisation.

The prognosis of water quality changes (including the evaluation of their self-purifying capacity) is only possible by the utilisation of mathematical models which reflect the whole complex of processes taking place in the water body. For example, to this end several mathematical models of Baikal's ecosystem have been constructed. With their help, the intra- and inter-annual dynamics of the main ecosystem components and their dependence on certain abiotic factors have been investigated. Questions relating to the energy balance, species content and temporal and spatial dynamics of the main components of the pelagic ecosystem have been considered. Various mathematical descriptions of the system were used; differential and terminal-difference equations in models based on the law of conservation of matter and energy and a new apparatus of 'uninterrupted' logic in the qualitative ecosystem model.

The initial premise in the construction of mathematical models was the existance of a state of stable equilibrium in the Baikal ecological system. When displaced from this under the influence of external factors, the system returns to the previous state after a certain time following the cessation of this effect. This is a property of ecosystem stability in the given concept and this is largely assured by the presence in the system of an indirect component: detritus. The greatest deviation of the ecosystem from a state of equilibrium is brought about by environmental factors which act on the first link in the trophic chain, namely the phytoplankton.

Models reflect well both the real dynamics of the ecosystem's components and also single out the main environmental factors which regulate these dynamics. For example, numerical experiments with a model showed that, in spring and autumn during the periods of maximal phytoplankton development, absorption of radiant energy is the main influence on the size of its biomass. Apart from this, the magnitude of the maximal vernal algal biomass depends to a considerable degree on the availability of mineral nutrients and that of the autumnal peak, on the thermal conditions before and during the period of maximum. River flows only influence the plankton dynamics significantly in the regions round river mouths (2, 3, 14, 15).

Modelling the Baikal ecosystem shows that, in order to construct representative ecosystem models of this water body, sufficient material has been accumulated during several of the recent decades. At the same time, use of this model revealed certain informational gaps in our knowledge of the ecosystem which will be the subject of further investigations. For example, the energy model of the seasonal ecosystem dynamics of Baikal's pelagial gives grounds for the suggestion that the specific energy content of the zooplankton must alter considerably during the course of the year. The lack of information about links in the chain 'bacteria-dead organic matter' and also of ecophysiological knowledge are especially unfortunate.

The structure of mathematical models permits their successive refinement as new pieces of information appear and also to include them as a whole in the form of blocks in more developed models. These models will form the basis of refined and detailed ones for prognosis of the anthropogenic influence on the Baikal basin. On their basis, the tasks of normalisation of external effects and of management can be set up and, likewise, the planning of observations on the state of the lake.

Proceeding from the concept of hydrobiology as a complex ecological science, one must aim for integration of the methods from other sciences and aim to obtain the maximal possible information about the ecosystem as a whole. However, as mentioned already, it is necessary to separate out the primary methods for controlling the state of the water body today. Biological control of water quality has its own organisational and economic aspects. This concerns especially situations when anthropogenic changes are produced by the influence of 'point' (by comparison with the whole ecosystem) 'perturbating' factors.

For this purpose, the method of ecological mapping is used with the aim of determining the degree of ecological well-being. In this method the area directly adjacent to the place where the effluents enter is investigated particularly thoroughly. Collection of material is carried out along permanent transects situated opposite the waste pipes and likewise at a definite interval from them. On analogous biotypes outside the zones of influence of effluents a control transect is laid down. Each of the transects, situated perpendicularly to the bank, consists of a series of stations embracing various depth zones and various biotopes. Not less than three samples are taken at each station. The investigations cover both planktonic and benthic communities, including a microbiological investigation of the water and the bottom. The following biological parameters were investigated in the plankton communities: the composition and biomass of the phytoplankton; pigment content; primary production, determined by the oxygen and radiocarbon methods; total numbers of bacterioplankton by the membrane filter method; abundance of the main physiological groups of bacteria; production of bacterioplankton by the method of separated samples according to total number and dark assimilation of ^{14}C; composition, biomass and production of zooplankton, determined by growth and reproductive indices. Sampling was done from standard hydrological horizons with the Juday net and a bathometer. Phyto- and zoobenthos were investigated, taking into account the vertical zonation of the biocoenoses and the composition of the bottom, using quantitative sampling apparatus (Petersen grab) and with the help of divers, who determined the delimitation of bottom cover and those organisms which are poorly accounted for with the usual collecting equipment (4, 6, 8, 13, 16).

The selection both of the spatial and of the temporal 'steps' of the observations are important for outlining the zones of influence of effluents. In selecting the time of observation, it is necessary to take into account the seasonal dynamics of change of state of communities, ie the changing of the biological seasons peculiar to a given water body. This is shown by the presence of various complexes of organisms in one season or another, in the quantitative ratios of species and in the age structure of populations. It is clear that the timing of observations on the state of bioceonoses must be chosen with allowance for the reproduction rate of the population. As plankton populations are represented by more rapidly reproducing species than benthic ones, observations on plankton must be more frequent.

In ecological mapping it is important to take into account the area and the configuration of the section subjected to pollution. For its determination it is necessary to have a bathymetric map of the sector under investigation. In the investigations, contouring the polluted area is carried out on the map with a calculation of depth and distance from the shore. The area of such a sector will not be constant over a year or in various years. Changes in the configurations and dimensions of the polluted sector are related to the influence of hydrodynamic factors (river inflow and runoff of rain, intensity of wind mixing etc.), as a result of which substances of anthropogenic origin can be, in part, retained, dispersed or carried off into the lake's abyssal zone. In addition, the area of bottom occupied by polluted ground is not homogenous in its own characteristics, especially in relation to micro-relief. Therefore, a temporal decrease in the area of a 'point of permanent pollution' (and even more so the change in its configuration) cannot be assessed as a recovery situation in a region of entry of effluents. On the contrary, the fluctuation of the spot testifies to the spread of the pollution over a broader area.

Let us consider the results of using the method of ecological mapping by the example of the evaluation of the influence of effluents from the pulp and paper industry on Lake Baikal. Changes in macrobenthos in such conditions are shown in a change in the numerical ratios of animals both at the level of species and of higher taxons, including types, and in biomass changes. The size of the area occupied by such altered biocoenoses is different in different years. The most notable differences in the macrobenthos, in comparison with the period before the disposal of effluents, are noted on the strongly polluted grounds, where the biomass decreases ten times or more in all the depth zones of the water body. In this, the quantitative correlation in total biomass of the dominant animals — gammarids, molluscs, oligochaetes — is altered materially. Let us consider certain examples of community change in given depth zones. If, at depths of 5 to 20 m in the control transect, molluscs occupy the first place in the biomass, then, in strongly polluted transects, there occurs a decrease in the absolute indices of their abundance and they are in the last place in importance in the total biomass. The biomass of oligochaetes decreases considerably. On the other hand, on such bottoms gammarids become dominant and their biomass does not decrease. Thus the community on such bottoms can be called a gammarid one and, on other categories of bottom in this depth zone, a mollusc-oligochaete community. In the 20 — 50 m zone differences in sediment accumulation are most notably reflected in the biomass and composition of the animal community. On 'strongly polluted' bottoms, gammarids predominate, just as in the 5 — 20 m zone, and the community can be called a gammarid one on other categories of bottom in this zone, an oligochaete community. In the 50 — 100 m depth zone, as in the preceding one, an oligochaete community is transformed on strongly polluted sectors into a gammarid one.

Thus, in the 5 — 20 m zone, the biomass decrease on strongly polluted bottoms occurs, in the main, at the expense of the disappearance or considerable decrease in the biomass of molluscs and oligochaetes and, in the 20 — 100 m zone, of oligochaetes. Gammarids experience the least change of biomass. However this animal group too does not remain without change; there is an evident impoverishment in species. Thus the percentage content of gammarids in this or that region is an indicator of its pollutedness and can be used for the purpose of rapid determination of the influence of effluents.

Reconstruction of the biocoenoses proceeds also on less polluted bottoms. It is of interest that, in certain depth zones, the macrobenthos biomass on these grounds becomes even higher than on 'conditionally unpolluted ones' and a control sector. In the 5 — 20 m depth zone this proceeds at the expense of increased abundance of molluscs, but, in the 20 — 50 m depth zone — of oligochaetes. However, in the 50 — 100 m depth zone, the zoobenthos biomass also decreases on less polluted bottoms. This is especially marked as regards the biomass of oligochaetes. In such depth zones even relatively slight pollution of the bottom leads to a more unfavourable effect than at lesser depths. Undoubtedly, it is necessary to take account of this in the prognosis and evaluation of the distribution of pollution in the lake's abyssal zone.

Examination of data of investigations in the interannual aspect leads us to one more conclusion. Just after the start of entry of effluents there is observed an increase in benthos biomass but the biomass on 'conditionally unpolluted' grounds and on the control transect differs quite insignificantly. One may suppose that the first influence of effluents causes an eutrophication of the region subjected to their influence.

Comparison of the enumerated data permits us to make a supposition about the process of community change in time under the action of effluents. Clearly, at the start, the community biomass increases, although also with insignificant reconstruction of its composition but, with continuing accumulation of effluents, it decreases and the composition of the community undergoes a substantial change, showing itself differently in different groups. The effect of effluents is expressed to a greater degree on organisms whose life is closely connected to the bottom (oligochaetes, turbellarians, molluscs) and to a lesser degree on nekton-benthic ones (gammarids).

A similar community reconstruction on polluted bottoms also takes place in the mesozoobenthos. The abundance of the harpacticids, nematodes and cyclopoids which are dominant in the mesozoobenthos decrease very substantially. Rotifers almost disappear, and the abundance of ostracods decreases sharply and the rhabdocoels and tardigrades become less common. A reduction in the mesozoobenthos biomass on polluted grounds is accompanied by a tenfold decrease in species diversity.

The bottom algae inhabiting the littoral undergo a lesser change. Also their biomass in different years shows considerable fluctuations but neither in time nor in space are they connected with the direct effect of effluents. Their influence is displayed only in the mass appearance of epiphytic organisms on macrophytes. The mass appearance of epiphytes, among which vorticellids are dominant, is a sign which can be utilised in the rapid determination of pollution.

Thus, the method of ecological mapping permits us to demarcate a region where radical reconstruction of biocoenoses is taking place, ie a sharp decrease in biomass and a change in the organism content even at the level of higher taxonomic ranks. This region can be called the 'spot of stable pollution'. The last is confirmed by an analysis of the number of bottom microorganisms. The area where their number markedly (10 – 100 times) exceeds that of the control is considerably greater than that where a reconstruction of the zoobenthos is noted.

The above permits us to express several general considerations about the influence of effluents on bottom biocoenoses. The region of influence of effluents can be subdivided into several zones which differ in their special features and in the tempi of the reconstruction of the biocoenoses and by the intensity of the self-purification processes.

1. The zone of stable reconstruction of biocoenoses.
   The transformation of entering substances is carried out more slowly than their accumulation. The accumulation of anthropogenic sediments leads to a marked impoverishment of the zoobenthos biomass and to a change in its community composition, even at the level of higher taxonomic categories. The most noticeable reconstruction of bottom communities in this zone takes place on sectors with reduced micro relief and at depths where enrichment of the water with oxygen by photosynthesis and aeration proceeds slowly.

2. The transitional zone of unstable community change.
   Here, the above mentioned signs can be noticed sporadically. Under the influence of hydrodynamic factors pollution is less massive than in the first zone, periodically being dispersed. Thanks to this, the restoration of the previous appearance of the biocoenoses is possible.

It is difficult to demarcate the first and second zones, because each of them is not a unity in area. The influence of pollution in the second zone difficult to distinguish from natural community fluctuations.

3. The zone of intense self-purification.
   Here the active processes of the re-working of effluents take place. This zone is characterised by the high numbers and intense life processes of micro-organisms.

In this zone we can distinguish two sub-zones. In the first sub-zone self-purification proceeds simultaneously with reconstruction of the qualitative composition of the biocoenoses. In the second sub-zone no such reconstruction may be noted and self-purification depends on an intensification of the life processes of a natural complex of organisms and this leads to an increase of biomass.

The influence of effluents is felt to a lesser degree in the open water than on the bottom and the greatest change in the water quality of the pelagial can be traced in the microbiological data. Such a phenomenon is worth paying attention to. The sector distribution of micro-organisms is very heterogenous. In direct proximity to the point of entry of the effluents, bacteria are comparatively few but, moving some distance away (a distance which differs for different physiological groups), the bacterial numbers rise to a maximum and then fall again to values characteristic of natural waters. This forces us to conclude that the intensity of the self-purification processes in open water can be highest on the margin of the 'spot of stable pollution'. Circumscription of such margins and qualitative evaluation of the intensity of self-purification are complicated by the great mobility of the water mass.

In recording the special features of the open water, it is necessary to underline the fact that the effluents influence the phyto- and zooplankton less markedly. It is difficult to separate out and delineate the boundaries of the influence of the effluents from the background of year-to-year and seasonal fluctuations typical of the plankton itself. Neither the species content of the phyto- and zooplankton nor, likewise, the trophic and age structures of the latter undergo discernable change. There are no stable deviations in the chlorophyll a content. The primary production rate increases up to 30 – 50% in the zone of intense self-purification. One can only testify to certain phenomena. For example, the appearance of species not natural for the water body, among which are rotifers and protozoans – inhabitants of purification works; a heightened percentage of dead Copepoda (5) and a more marked admixture of bottom organisms into the plankton.

Comparing the indicators we have used in relation to their significance for evaluating water quality and degree of deviation from the background ('normal') condition, we can arrange them in the following sequence: bottom communities of soft bottoms (bacteria and zoobenthos) – bacterioplankton primary production – zooplankton – phytoplankton – communities of stony littoral bottoms (especially phytobenthos). In the above-mentioned matter concerning the river Angara, the most indicative data proved to be those about the zoobenthos and the composition and numerical ratio of the phytoplankton species; the amount characterising productive–destructive processes in the open water changed in the least regular manner.

An important indicator for revealing a polluted zone is a quantitative correlation of representatives of different ecogenetical and trophic groups of organisms. Inasmuch as the degree of influence of pollution on biocoenoses depends on the ecological peculiarities of the organisms, one can use for control of water quality a numerical correlation of species which differ in their modes of life, among which are: in nutrition; in connection with the bottom; in relation to oxygen etc. Thus, ecological mapping is one of the methods of evaluating water quality. This approach cannot be replaced by other methods of control – ecophysiological, ecotoxicological, ecogenetical – despite the importance of the experimental revelation of the effects of the influence of pollution (among which are mutagenic and toxic substances) on hydrobionts. The experimental revelation of the influence of effluents on the viability of hydrobionts does not permit us to take account of the effect of the accumulation and transformation of substances in the water body. In this, the role of the oxidising capacity of the water, the magnitude of its 'hardness', the water body's temperature regime, composition of the bottom and other environmental factors are important. Substances not giving rise to a lethal outcome or, in general, harmless in an experiment, can show a negative effect on communities under natural conditions. Results obtained in experiments with individual populations cannot be completely extrapolated to natural communities because the influence of external agents is displayed in different ways in the first and second situations. Individual substances and their different combinations, as is well known, likewise act differently on organisms, and the number of these 'permutations' is very great.

In the experimental determination of the influence of pollution on hydrobionts, it is important to find out the mechanisms of the influence of one component or another of the pollution on hydrobionts and to reveal organisms capable of utilising this or that substance.

The problem of mutagenic or toxic substances deserves special attention. Their action, which has proved to be harmless to an investigated object can, in the remote future, manifest itself upon utilisation by organisms of succeeding links in the nutritional chain, including man.

So experimental determination of the influence of anthropogenic substances in implementing water quality control cannot replace hydro-biological analysis. In working out methods of controlling water quality it is necessary to utilise the results of ecosystem analysis, permitting us to pool our knowledge of natural objects, to describe them and to forecast their changes. Ecosystem analysis, expressed in the creation of mathematical models, permits us both to carry out control and also to give a prognosis and manage anthrogenic influences, and this ensures the rational utilisation and conservation of water bodies.

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