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Problems of the ecological chemistry of aqueous media

The development of chemical industries and technologies during the last decades has led to a catastrophic depletion of the Earth's internal resources. The threat of a sharp decrease in sources of hydrocarbon raw material and helium as well as the amount of the available fresh water suitable for exploitation is realistic. The technogenic harmful waste ejected into the atmosphere and open water-containing areas leads to the poisoning of the Earth and the destruction of the biosphere and entails irreparable losses by eco-systems and their genetic stock. The richest deposits of useful minerals are sometimes converted under the conditions of their extensive exploitation into sources of extreme danger to humanity, as happened in the Astrakhan Gas-condensate deposit. The exploitation of this deposit began because of the deficiency of sulphur in our Country, although many millions of tonnes of this scarce raw material were annually discarded (and continue to be discarded) into the atmosphere in the form of sulphur dioxide by various metallurgical industries and electric thermal power stations. Might it not have been more useful to invest in the development of technologies for the utilisation of sulphur dioxide from gaseous waste than to initiate a "second Chernobyl"?

Humanity is faced by the necessity to adopt many solutions of this type. In face one is dealing with the development of a strategy for humanity's survival under conditions of increasing anthropogenic stresses on Nature and with the creation of the concept of Existence under the conditions of ecological risk. From the standpoint of chemical science, such a concept must include not simply the introduction of low-waste resource-saving and nature-protecting technologies but also the discovery of the permissible limits of the "constraint over nature" in the form of man's economic activity, and adequate justification of the LPC† and LPW‡ norms, the carrying out of necessary geobiochemical surveys with determination of the genesis of the Earth's mineral resources (water, petroleum, gas, ores, coal), and the introduction of norms for the permissible consumption of the resources.

Evidently, in the development of this concept and its application, it is necessary to take into account the common features of the interrelations of all the natural communities and their close unity with the environment. The complex character of the current problems implies that effective solutions to them can be found only by combining the efforts of specialists from different disciplines involving the simultaneous solution by them of their own narrow professional problems. For chemical science and technology, "narrow" problems involve the creation of resource-saving and nature-protecting technologies for the processing of useful minerals, the preparation of new products, and also the development of highly sensitive high-speed methods for the monitoring of the environment. On the other hand, questions concerning the establishment of norms for the permissible amounts of harmful waste (the values of the LPW and LPC) must be solved in coordination with biologists (ecologists, biochemists, macro-biologists, etc.) and the norms for the consumption of natural resources must be worked out jointly with geochemists, geophysicists, geographers, etc.

In view of the acute urgency of the need for nature-protecting and ecological research, it appears essential to combine the efforts of various specialists in the solution of ecological problems, which might be assisted by the publication of appropriate review articles in academic journals with different types of bias. It would be extremely useful to know the views of various specialists concerning the most urgent, from their standpoint, ecological problems, both "narrowly" professional and fairly general.

The Editorial Board of the Journal "Uspekhi Khimii" [Russian Chemical Reviews] has decided to initiate such a programme and invites the Editorial Boards of other Journals publishing review articles namely Uspekhi Fizicheskikh Nauk (Advances in Physical Sciences), Uspekhi Sovremennoi Biologii (Advances in Modern Biology), etc. to take part in this kind of collaboration. We published previously special issues of "Usepkhi Khimii" devoted to new low-waste technological processes (1988, Vol. 57, No. 6) and the problems of the chemistry of the atmosphere in connection with the growing amount of technogenic gaseous waste (1990, Vol. 59, Nos. 10 and 11).

This Collection consists mainly of articles referring to problems of the ecological chemistry of aqueous media, but more general articles are also published. Thus, together with consideration of certain problems of the creation of low-waste technologies based on the extraction of ammonia from liquid waste (ammoniacal water) and the development of highly efficient membrane sensors for the monitoring of the natural environment, S F Timashev's review deals with the general theoretical problems of the relationship between ecology and chemical science. On the basis of the thermodynamics of highly non-equilibrium systems, model ideas concerning the LPC and LPW are introduced. Problems of the modelling of the dynamics of eco-systems and of the influence of mass-exchange processes and chemical reactions, including those in the inner regions of the Earth and in the atmosphere, on the evolution of natural communities are analysed. The concept of the limiting permissible consumption (LPC) of natural resources is introduced, and the role of anthropogenic factors in the initiation of natural catastrophies is discussed.

Certain general approaches to the analysis of eco-systems and evolutionary process in them, based on the employment of a definite form of material inequalities for different levels of initial information, are discussed in N V Sokolov's article. The principles developed make it possible to use, on the basis of material imbalances, various levels of initial information for the monitoring of eco-systems and the planning of nature-protecting measures.

The limits of the "tolerance" of nature to the action of polluting chemical factors are to a large extent determined by the vital activity of the micro-organisms which cleave many of the toxicants entering the environment, by the processes regulating the growth of the micro-organisms, and by their development. Articles with a

† Limiting permissible concentration (Ed. of Translation).

‡ Limiting permissible amount of waste (Ed. of Translation).

biological bias by E S Babusenko, G I El'-Registan, N B Gradova, A N Kozlova, and G A Osipov, in which the principal features of the vitial activity of bacteria, their trophic relationships, and their resistance and adaptation to environmental factors are traced in relation to methane oxidising bacteria and which are aimed primarily at a "chemical audience", were published in this connection.

In the analysis of processes involved in the vital activity of organisms in a wide variety of aqueous media, the discovery of the chemical and biochemical processes associated with the turnover of hydrogen peroxide in natural waters and in biological objects assumes a special role. The processes leading to the formation, transfer, and chemical degradation of H_2O_2 in aqueous media and determining the full biological value of the environment and its capacity for self-purification are examined in the review by E V Shtamm, A P Purmal, and Yu I Skurlatov. The generality and importance of such information for the ecological chemistry of aqueous systems is evident.

A number of articles in the present Collection are devoted to problems of the purification of natural and industrial waters involving the removal of harmful and toxic components. The review of A A Pichugin and V V Tarasov analyses a new and extremely interesting procedure for the creation of nature-protecting technologies associated with the employment of the phenomenon of supercritical extraction. In such virtually waste-free processes, it is possible to achieve effectively the removal of various organic toxicants (phenol, pesticides) from aqueous systems and to regenerate the sorbents used for the extraction of organic impurities from water.

The paper by E V Yurtov and M Yu Korolev discusses the problems of the utilisation of extracting emulsions for the extraction of various substances from aqueous media. It is shown that the efficiency of such processes, which have found applications not only in nature-protecting technologies but also in medicine and in analysis, depends on the properties of the disperse phase and the dispersion medium.

The present state of the removal of boron from soil and natural and waste waters is presented in the review by A I Rodionov, O M Voitova, and N Ya Romanov. These problems are of extremely great current interest because soluble boron compounds are polytropic poisons and, when acting over a long period, can induce chronic intoxication and diseases of the nervous system.

Among fairly new methods used to extract target components from aqueous solutions, including toxic components, reagent ultrafiltration (RUF) is of great interest. Some of the versions of this technology, applied when a freshly prepared sol or chemical reagents, converting the target components into a colloid phase or insoluble forms, are added to an aqueous solution, are presented in the review by A A Svittsov and T Zh Abylgaziev.

The treatment of water to make it suitable for drinking and for technical purposes is apparently becoming a major energy consuming industry because of the destructive utilisation of water and the continuing pollution of natural water-containing areas. It is therefore important to introduce into practice methods of water treatment which involve a relatively low energy consumption and a small amount of waste, including membrane-sorption procedures (see Uspekhi Khimii, 1988, Vol. 57, No. 6; Zhurnal Vsesoyuznogo Khimicheskogo Obshchestva im. D I Mendeleeva, 1987, Vol. 32, No. 6). In the present Collection, the article by V A Shaposhnik, A A Mazo, and P Frölich is devoted to the large-scale problems of the preparation of ultrapure water for the electronic industry, for the elimination from drinking water of the nitrates which enter water containing areas as a consequence of the large-scale employment of nitrate-containing mineral fertilisers, and to the ecological usefulness of membrane technology for such purposes.

S Timashev