An approach for solving Danube River water pollution problem

J. Kosturkov, I. Dimitrova
Institute of Water Problems, Bulgarian Academy of Sciences, 1113 Sofia, Bulgaria

ABSTRACT

The pollution tendencies along the length of the Danube river in the up- to middle- and downstream are given. They should be regarded as schematic since the existing data are not representative, reliable and systematic.

It is noted that the restoration and maintenance of water quality could be achieved with the joint efforts of the Danubian countries and the problems should be solved on the basis of well founded scientific programmes and measures. This demands the development of long-term and operative forecasts whose main points are discussed. The forecasting requires the methods of mathematical modelling to be used. The perfection of the water quality monitoring is considered and a concept for it is proposed. An integral management should be applied, economy and ecology being equal partners, in order to take into account all the interests and functions of the Danube river.

DISCUSSION

The river Danube flows across eight European countries and its water resources are an essential part of their water economy balances. The catchment of the river covers regions with developed industry and agriculture and accelerated urbanization so that a great quantity of polluted waters is discharged into the Danube. As a result a great number of negative changes of water quality proceeded and are also in progress now. The hydrochemical parameters for water quality assessment, for which available data exist could be classified in several groups [1,2]:

a. Parameters, characterizing pollution with organic substances. These are BOD_5, COD (with potassium permanganate and potassium bichromate) and dissolved oxygen. This kind of pollution is caused mainly by the industrial and domestic

waste waters, stock-breeding farms waste waters and humus substances washed out from the catchment surface, that are discharged into the Danube. According to a number of research workers the organic pollution shows a definite tendency to increase in a long-term aspect. Such a tendency is also observed along the length of the river in upstream to middle- and downstream direction. Higher values of the organic pollution are registered after the tributaries and larger towns.

b. Parameters, characterizing the biogenic elements pollution. These are the different nitrogen forms: ammonia (NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-) ions, phosphate (PO_4^{3-}) ions and total iron (Fe). The basic source of biogenic elements are the industrial and domestic waste waters as well as waste waters from agriculture (stock-breeding, mineral fertilizers, pesticides, etc.). The biogenic elements content in the Danubian waters exhibits a distinctly expressed tendency to increase in long-term aspect. No clear indications for the biogenic elements distribution along the length of the river in the direction upstream-downstream are observed, except for the parameter total iron (Fe), whose values are rather high in the lower reaches of the river.

c. Mineral substances - sulphate (SO_4^{2-}), chloride(Cl^-), magnesium (Mg^{2+}), calcium (Ca^{2+}), sodium (Na^+), potassium (K^+) and bicarbonate (HCO_3^-) ions; total dissolved solids (ions sum) and insoluble (suspended) substances. The mineralization changes along the length of the Danube indicate a clearly expressed tendency for increase in the upstream to middle- and downstream direction. In a long-term aspect a distinct trend for growth of the parameters after 1960 is observed. The concentration of the calcium and bicarbonate ions does not vary considerably with time, while the concentration of the sulphate, chloride, sodium and potassium ions increases twice according to some investigators. The concentration changes of counted ions along the length of the river follow the alterations of the total mineralization.

The insoluble substances concentration depends on the erosion intensity over the surface of the river catchment, on the flow transportability, on the antropogenous impact. The latter is most pronounced in activities like water reservoir construction, river channel regulation, discharge of waste water with high insoluble substances content. Two periods may be considered for the disbribution of the insoluble substances concentration. Prior to the construction and operation of the hydrotechnical complex "Zheleznivrata" in 1970, the average annual value of the insoluble substances concentration increases in the upstream to middle- and downstream direction. After the complex was put in operation the insoluble substances content in the section from Novo selo to Silistra diminished considerably, that led to increased erosion intensity of the Bulgarian bank of the river. Another reason for this phenomenon is the sharp dynamic change of the water level in the upper part of the mentioned section caused by the hydrotechnical complex. The built water reservoirs

have an advantageous influence since they retain a part of the pollutants.

d. Toxic elements - copper, zinc, manganese, chromium, cadmium, mercury, lead. It is impossible to make an assessment of the concentration of these parameters because sufficient information is not available. These elements are characterized by high toxicity, stability and bioaccumulation ability.

The presence of enough water of suitable quality is not only an important prerequisite for consideration of the interests of such water consumers as agriculture, potable water supply, electric power supply, industry, navigation, fishing industry, forestry and recreation, but also for the long-term development of the aquatic and terrestrial ecosystems. In order to achieve the basic aim, namely the restoration and maintenance of water quality, the joint efforts of all the Danubian countries are needed (both of government and un-official organizations). As a result of these efforts a programme for the necessary activities should be prepared, that includes the co-ordinated national programmes of the individual countries.

The basic problem, that should be solved in the programme is the development and application of well founded scientific measures, leading to the formation of a multifunctional river system where economy and ecological system are equal partners. This aim demands the application of developed forecasts. It is generally assumed to classify prognoses as long-term (perspective) and operative.

The main purpose of the long-term forecasts is to assess the water quality of the Danube and the possible variants for its alteration in future by the developed recommendations for maximum prevention of the negative effect of the different branches of economy. The basin scheme is most advisable for these forecasts. The long-term prognosis includes a retrospective analysis of information and a characteristic of the present state of water pollution, determination of design values for the water run-off, a forecast for the pollutant discharge from the different branches of the national economy, a forecast for the pollution of the river in single sections and ranges and propositions for optimum prevention and protection. The long-term forecasting suggests that possible discharge of pollutants from different kinds of economic activities which may affect the water quality formation during the regarded period should be taken into account. The income part of the balance should include first of all the pollutant receipts from industrial and domestic waste waters, from the surface run-off of built-up areas, from agricultural waste waters (irrigation, draining, use of chemicals, stock-breeding) as well as from water transport. Methods should exist for the estimation of each of these revenues.

The indispensable information for long-term forecasting includes the results of many years of observation for the degree of the river pollution and the most typical pollutants

in various circumstances supported by the respective hydrological data. Long-term retrospective data for the average month and year typical pollutant receipts from the basic pollution sources are also necessary. These data should be attended by characteristics of the regime and conditions of waste waters discharge, information about their purification effectiveness and the part of waste water subjected to purification.

The basic aim of the operative forecasting is to develop prognoses for short periods (e.g. a week, a month, a season) for taking express measures to diminish the cases or fully prevent inadmissible pollution of the river waters. The most important in operative forecasting is the detection of the unfavourable conditions when dangerous water pollution is possible. The main conditions assigned to this category are as follows:

a. hydrometeorological conditions when dangerous or very dangerous phenomena (levels) of the river pollution occur (increase or decrease of the water quantities to some unfavourable levels, for instance).

b. discharge of pollutants - potential (practically threatening) or realized due to accidents. It is most important to indicate the practically threatening discharges caused by accidents in order to undertake the necessary measures for prevention of the dangerous events according to the results of the prognosis.

The necessary information for the indication and forecasting of the possible unfavourable conditions includes:

a. forecast data about the minimum and maximum values of the water quantities and other hydrological data. This information may be obtained on the basis of long years of hydrological observations.

b. forecast data for the regime of discharge of pollutants with waste waters. These data may be obtained from the production plans and the relevant quantities of waste water.

c. a forecast of the "background pollution" for the regarded period, i.e. the river water quality above the regarded source of pollution as well as a forecast for the self-purification ability of the water in the controlled river section. These predicted data may be obtained on the basis of long years of hydrochemical observations and from the results of the hydrological prognoses.

The reliability of the long-term and operative forecasting depends entirely on the completeness and reliability of the observation system of both the surface waters quality and the quantity and regime of discharge of pollutants into the Danube.

The observation (regime) system of the Danubian water quality in the country consists of 15 observation stations. The observed paramenters are few and besides that the obtained data are not representative, since the water samples for analysis are collected near the Bulgarian bank. The regional environmental inspectorates (REI) gather the information about the pollutants quantity and discharge regime from the sources

of pollution. This information is very scarce, incomplete and inexact. The sources controlled by REI are industrial enterprises and sources of domestic waste waters. The pollution sources from agriculture are not controlled at all although at present they are the major sources of pollution. This is connected mainly with the intensification of agriculture and chemicals application, which are accompanied by receipts of considerable quantities of salts, biogenic elements and pesticides in the water. For this reason one of the main tasks is to develop methods for organization and performance of observations in order to assess the influence of waste waters from agricultural areas.

The above discussed considerations demand the improving of the existing system for observations of the Danube in the Bulgarian section. Scientifically well founded optimum parameters for the system should be determined (a list of the defined parameters, observation stations, ranges and verticals inside the station, observation frequency for each parameter). All sources of pollution should be observed too.

The working scheme, realizing the principle of equal hydrodynamical study at fixed material expenses may be applied for improvement of the system of regime observations. The basic arguments for the necessity of equalizing the study of the water object are considered below.

The changeability of hydrochemical processes is characterized by anisotropy, i.e. the parameter values vary considerably in each of the spatial directions - in downstream, cross-section and depth direction. There is also different changeability in time and space for the individual parameters. The existence of different number of observation stations or ranges and verticals inside the station leads to different degree of study and reliability of the hydrochemical assessments. The different frequency of the observations also leads to different study and reliability of the assessments. This is true to the same degree for the list of the observed parameters. Furthermore, the relations between the network density, the observation frequency and the list of the observed parameters should be co-ordinated and regarded as a complex, since it is impossible to raise the total reliability of the hydrochemical assessments on the account of increasing some observations to the detriment of others.

Another problem arises from the necessity of comparison of the observation systems of the individual Danubian countries. For this purpose the methods for the observations performance should be co-ordinated.

Forecasting, planning, management and control of water quality may be performed on the basis of the collected information from the observation system assessed both by hydrochemical and biological parameters. A description of the hydrodynamic, hydrochemical and hydrobiological processes that are in progress in the system by means of the mathematical modelling and the system analysis methods is necessary for the successful solving of these problems. This affords the possibility to increase

the volume of the registered information and to provide a quantitative assessment for the significance of the individual processes as well as to separate the most substantial factors for the water quality formation. Ultimately, a possibility is provided to forecast the results of different water protection activities and to choose the best ones according to preliminary stated criteria. The method of mathematical modelling plays a substantial role in the regulation of water quality taking into account the actual and predicted condition, considering the ecological reserve, which is finally used for the optimization of the relations between human society and nature.

The collected data from the system for regime observations are not conforming to the requirements of mathematical modelling and improvement of this system. For this purpose special expeditionary investigations should be carried out. The collecting of archival data received from the laboratories of different ministries and departments, scientific expeditions, etc., may also be very appropriate. The developed ecological information system for the basin of the Danube"INFODANUBE" or a similar system may be used as a means for collection, analysis and utilization of the whole information obtained from the observation systems (not only in Bulgaria) as well as from archival data.

Being a part of the total policy for environment, the developed policy for restoration and maintenance of water quality should be directed towards water protection from various kinds of pollution. The first principle of this policy is "the reduction of the source pollution". The emission approach for the different forms of pollution is successfully applied for its realization. The best practical and technical solutions and technologies are required for this purpose.

The international co-operation including information about the national techniques and technologies for pollution decrease, the joint monitoring of the Danube water quality, the collaboration in investigations and the co-ordination of warning in cases of catastrophes are very important factors for the achievement of these ecological purposes. The international co-operation and co-ordination of the efforts should lead to the development and ratification of an international treaty for protection of the Danube from pollution.

The time has come to make a step forward and to leave the phase of irrational use, starting an integral management of the Danube that will provide the possibility to take under consideration all interests and functions of the river. As a more remote aim may be stated the establishment of such an integral river management, which will demand the formation of an administrative system, responsible for the river catchment as a whole.

REFERENCES

1. Buijs, P.H.L., U<unov, Y. and Tzankov, K. "Water Quality

Profile of the Danube River along the Bulgarian-Rumanian Stretch" ICWS-report 92.01, 1992
2. Tzankov, K. and Pechinov D. "Water Pollution of the Danube river" Bulgarian Journal of Meteorology and Hydrology, Vol.1, pp. 79 - 92, 1990