RR 2004
3rd European Conference on River Restoration
RIVER RESTORATION 2004
Zagreb, Croatia, 17-21 May 2004

Setting of maximal permissible adverse impact (MPAI) norms for surface water bodies in terms of chemical substances (the Chusovaya and the Sysert rivers as examples)

A. P. Nossal

ABSTRACT: Norms of maximal permissible adverse impact (MPAI) on surface water bodies are essential for normalizing in the sphere of water-related activities concerning surface water bodies. Setting of MPAI norms as water quality status objectives is the most promising approach. This article contains basic methodological approaches to MPAI norms development in terms of import of chemical pollutants and examples of the above norms use in the Chusovaya and the Sysert river basins.

KEYWORDS: surface water, advers impact, water quality, pollutants

Implementation of the society sustainable development concept in the sphere of natural resources, water resources, in particular, integrated use and protection involves adoption of the principle of continuous and regular reduction of adverse impacts upon water bodies.

Norms of maximal permissible adverse impact (MPAI) on water bodies are the basic value for human impact on water bodies. They have to secure ecological good status of a water body whilst maintaining aquatic ecosystem characteristics formation mechanism within the limits of natural variability and satisfaction of practical demands of individual water use types.

MPAI norms are set on the basis of maximal permissible value of human load upon water bodies, long-term action of which would not lead to a water body ecosystem status; and maximal permissible harmful substances mass that could be supplied to a water body and its catchment territory (these two values are the same in terms of chemical substances).

Surface runoff contamination is an integral features of the total status of the catchment territory part where it is being formed, that is physical/chemical characteristics of the surface runoff in indirect form allow for any kind of pollutants supply on the catchment surface. This load often is an original determinant of aquatic ecosystems status deterioration.

Setting of the MPAI norm for pollutants supply to a water body requires preliminary fundamental definition of:

- spatial and time boundaries of the norm action;
- reference (criterion) relative to which MPAI norm would be set.

MPAI norm is set for a calculated plot spatial boundaries of which are to be determined on the basis of natural conditions, water/economic and ecological situation analysis.

MPAI norms are the basic indicators in the process of water/economic or water/protective measure programs development. Taking in account the needed time span for such

programs realization, it is recommended to set the term of MPAI action to be at least 5 years but not more than 10 years.

Water body water quality standard can theoretically represented by the following:

- natural or conventionally natural regional hydrochemical background;
- water quality target indicator or the norm of water body water quality status objective as a numerical expression of pollutants concentration or other hydrochemical indicators measure units, that meet the optimal combination of ecological and social/economic requirements for a specific water body type within a particular time period.

Given the MPAI norms adherence to a certain time period, it would be preferable to take water quality target indicator (WQTI) that is a water quality norm for the calculated period, as the standard. It will be a combined compromised value set for a certain time period. WQTI means the set of water body qualitative characteristics that should be maintained or to be achieved during the preset period of time and should serve the basis for human load regulation, economic activities management and implementation of measures aimed at diminution (prevention) water pollution and negative impact upon aquatic ecosystems.

The said norms of water bodies water quality status must have mandatory regional/ local orientation and be set according the scheme of consequent definition with taking into account the origin of the substance to be normalized, natural regional hydrochemical background and its inter-year variability, physical water quality in the calculated range and the latter position in the general geographic network, as well as economic priorities in water resources use.

Mean concentration value of substances typical to natural environment within the basin boundaries is to be taken as a basis for water body water quality status objective depending on main water content seasons (regional background). The most rigid of MPC values (that for fishery water bodies or sanitary/hygienic value) can be taken as a basis for substances of artificial origin. Water body actual condition is to be compared with the above criteria and, depending on the difference extent water bodies or their parts are categorized in standard, moderately modified and highly modified ones.

On the basis of the ecosystem approach when calculation the MPAI values it is essential to set the upper boundary of the range corresponding to the aquatic ecosystem normal functioning, that is to define maximal permissible concentration of individual ingredients -CDK. The upper limit should be set on the basis of statistic processing of hydrochemical monitoring data with taking into account priorities in water use and actual water quality class on the given range.

Thus, *MPAI norm in terms of chemical pollutants is numerically equal to maximal permissible pollutants mass that can be supplied to a water body front all pollution source provided that the preset norm of the water body status and permissible concentrations in the most unfavorable conditions of water quality formation in the calculate range are observed.*

Due to seasonal variability of both seasonal characteristics of the water body and the pollution sources functioning regime it is expedient to perform MPAI calculation separately for water content seasons for the most unfavorable conditions of water quality formation within these seasons.

It is recommended to calculate seasonal MPAI in terms of chemical substances according to the following formula:

$$MPAI_{season} = C_{дк} W_{уч} - E (C_{нр} W_{ест} + C_{нвх} W_{вх} - C_{нобоспр} W_{обоспр})$$

where $W_{уч}$, is the total seasonal runoff volume on the plot adjacent to the closing range, determining as

$$W_{уч} = W_{ест} + W_{сбрупр} - W_{вх} W_{обоспр}$$

where $W_{ест}$ is the natural runoff volume on the plot (side influxing)

$$W_{ест} = W_{бпр} - W_{ндиф}$$

$W_{бпр}$ is the seasonal side influxing volume on the plots not affected by human impacts;

$W_{ндиф}$ is the seasonal side influxing volume on the plots with uncontrolled diffuse pollution sources;

$W_{сбрупр}$ is seasonal water abstraction volume including point and potentially controlled diffuse pollution sources;

$W_{вх}$ is the seasonal runoff volume supplied from the upper plot;

$W_{сбрупр}$ is the runoff volume supplied with the first order tributaries, separated into autonomous water/ecological plots with their own norms of the water body status;

$C_{нр}$, $C_{нвх}$, $C_{нобоспр}$ are the norms of the water body water quality status for the relevant plots (concentration);

$C_{дк}$ is the permissible substance concentration which the aquatic ecosystem assuredly normally function with.

Unfavorable conditions of individual seasons do not coincide within the limits of a concrete calendar or hydrological year, therefore the most critical MPAI value is to be set for the combined year according to the following formula:

$$ПДВВ_{компгпд} = ПДВВ_{зим. меж. 95\%} + ПДВВ_{л-о. меж. 95\%} + ПДВВ_{вес. пол. 50\%}$$

MPAI norm values for the combined year are an important theoretical value, but in water practice the calculations are performed in conjunction with years of different probability. In order to transfer from the combined year to any year of calculated probability it is recommended to use seasonal transitional indices from basic MPAI values n terms of chemical substances:

$$К_{зр\%} = W_{зр\%} / W_{з95\%}; К_{ло\%} = W_{лор\%} / W_{ло95\%}; К_{вр\%} = W_{вр\%} / W_{в50\%}$$

This article briefly gives the experience of calculating the MPAI values as applied to the Chusovaya and the Sysert rivers within the boundaries of Sverdlovsk oblast.

The Chusovaya River is a left tributary of the Kama River and falls into the Chusovskoy Gulf of the Kama Reservoir at 693th kilometer from the origin. The river total length is 592 km, the catchment area is 23300 km^2, the catchment average height is 347 m, the catchment average decline is 0.5%.

The Chusovaya catchment area at the boundary between Chelyabinsk and Sverdlovsk oblasts is 112 km^2, at the boundary between Sverdlovsk and Perm oblasts it is 11580 km^2. The Chusovaya basin area within the boundaries of Sverdlovsk oblast is nearly 11500 km^2.

Runoff of the Chusovaya and its tributaries is considerably regulated, since 1978 inter-basin water transfer took place. The Chusovaya basin is a major source of domestic and industrial water supply of Yekaterinburg. The river water along almost the whole length, but regions of Pervouralsk and Bilimbay, is suitable for technical water supply.

Industry in the Chusovaya basin is represented with mining, ferrous and non-ferrous metallurgy, machine building, civil engineering and timber. Inhabited localities municipal systems are closely tied with this major water artery. There are totally about 35 surface water intakes on the Chusovaya and its tributaries.

The Chusovaya River and its tributaries excluding the range downstream of the Pervouralsk-Revda industrial region relate to fishery water bodies of the highest fishery category. On the range from Pervouralsk to Bilimbay the river relates to water bodies of the second fishery category.

Waste waters of more than 30 enterprises are discharged after treatment into the Chusovaya and its tributaries. The most tension is observed at the Chusovaya range from the Volchikha Reservoir to Bilimbay, where heavy machine industry, mining and municipal enterprises predominate. Spatial (diffuse) polluting admixture sources are widely spread around the basin.

The Sysert River is a right side tributary of the Iset River. The river total length is 76 km, the catchment area is 1250 km^2, average height is 300 м БС, and average decline is 1.8 %.

The Sysert and some of its tributaries runoff is regulated to the considerable extent: there are 9 reservoirs and ponds on the Sysert proper. Today there are no metallurgy in the Sysert basin, therefore the reservoirs importance as water supply sources is decreased.

Over the past several decades *recreation* became the main type of the Sysert water resources use. *Farming* is highly developed, especially in the downstream of the basin. Industrial and urban waste waters are discharged to the Sysert tributaries. The Sysert River is included into the list of salmon and sturgeon species spawning rivers.

Assessment of contemporary human impacts and the extent of ecological tension at the individual ranges has been performed on the basis of the catchment physical/chemical characteristics and water/economic system analysis, as well as overview of of water bodies pollution sources.

Analysis of comparison of the combined year MPAI norms with the actual import of pollutants mass in respect of the Chusovaya River demonstrates that even nowadays excess of the permissible load is observed in terms of a number of substances at the ranges 2-7. Mostly there are nitrites nitrogen, ammonia nitrogen, BOD, and phosphates phosphorous. Excess of iron, aluminum and chromium 6+ is observed as well. At the same time at the downstream ranges there is a great reserve of the permissible import. In spite of the favorable status of the water body as a whole observation of the norms on the whole water area of the water body is necessary to maintain normal functioning of the formed aquatic ecosystem. This involves taking measures on mitigation of pollutants supply from both controlled and potentially controlled diffuse sources.

To solve adequately the problems in the process of the MPAI values calculation it is necessary to forecast seasonal water quality at the range with taking into account all pollution sources; this has been performed with the specially designed calculation program that takes

into account effects of all pollution sources, their hydrographical location, status objectives and the basin principle.

The developed norms of maximal permissible adverse impacts (MPAI) upon surface water bodies in terms of chemical substances represent the first experience in such norms development in the Ural Region. Methodological approaches to the problem solution actually were worked out in the process of development. Many issues have been yet solved only in the first approximation and the solutions will be revised and updated as they will be applied to practice.

Implementation and control over the observation of the MPAI norms will permit to realize the policy based on the sustainable water use principles within the basin with taking into account regional (basin) features and bearing in mind the task of the preformed aquatic ecosystems preservation without any harm to social/economic and ecological interests of the population.

Author:

A. P. Nossal, Russian Research Institute for Integrated Water Management and Protection (RosNIIVKh), Ul. Mira, 23 Yekaterinburg, Russia