Bioautomation, 2005, 2, 70-75 ISSN 1312-451X

Ecotoxicological Assessment of Water and Sediment Pollution of the Iskar River bellow Samokov

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Received: December 14, 2004 **Accepted: March 31, 2005**

Published: April 28, 2005

Abstract: *A system of integral ecological indices has been worked out to assess the level of polution of water and sediments with hazardous substances. A model for the dynamics of the inegral index for water and sediments polution is proposed. This index was applied for ecotoxicological assessment of water and sediments polution of the Iskar river bellow Samokov. A modification method on time series analyzis is applied.*

Keywords: *Integral index, Water polution, Assessment, Model, Hazardous substance*

Introduction

Ecotoxicological assessment of polluted waters is based on the biological testing methods. According to Environmental Protection Agency (EPA) in USA biological testing is realized by the means of 145 test-organisms, including 4650 different tests [9]. Ecotoxicological assessment of polluted water is based on integral approach, which takes into account the total water toxicity. Organisms are exposed on adverse influence of different harmful substances and by the total effect of their action an assessment of the toxic pollution level of the waters could be done.

A strategy for assessment of the harmful substances impact on the water ecosystems has been made [4, 6]. Integration of the biological testing under laboratory conditions, with experiments in microcosms, mesocosms and natural conditions are envisaged.

For assessment and prognosis of the ecological consequences of the pollution with toxic compounds integral functions and structural elements of certain biological level of organization, disturbance of which will cause changes within the population, should be chosen. Based on ecotoxicological investigations with water organisms within the trophic chains, emission and imission standards for the presence of harmful substances in the water body are developed. A combination of factors as lethal and sublethal concentration, chronicle pollution, and water use is substantial to specify such standards. Ecotoxicological assessment of the water pollution is part of water integral ecological assessment [2, 6].

The main objectives of the present work are:

- Ecotoxicological assessment of waters and sediments pollution of the Iskar River before the town of Samokov;

- To develop a model of the dynamic of the integral index for water and sediment pollution assessment.

Materials and methods

Integral index for ecotoxicological pollution assessment

A system of integral ecological indices has been worked out to assess the level of pollution of running waters (I_p), sediments (I_s) and rivers (I_r) [6]. The integral index for pollution level has been determined as a function of index of trophic pollution (I_t), index of pollution with hazardous substances (I_n) and index of microbiological pollution (I_m), or (I_p)=f(I_t)(I_n)(I_m).

The index indicating the level of pollution with hazardous substances is based on the indices for metals (Cd, Cr, Cu, Ni, Pb, Zn, As), organic compounds like aromatic hydrocarbons, phenols, phthalates, chlorine containing compounds, detergents.

The integral index for the ecotoxicological assessment of the overall pollution with hazardous substances is based on the concentrations of the hazardous substances that exceed the admissible limits for a standard water body.

For ecotoxicological assessment of the level of inadmissible pollution above the standard for a certain period of time (month, season, year) is necessary to determine the ratios between the actually measured excess (above the standard) values for each individual parameter and the standard values for a water body that serves as a standard for pollution.

$$\theta_i = \frac{R_{i,j}}{R_{i,0}} \tag{1}$$

where $R_{i,o}$ are the measured excess values of individual parameters; $R_{i,o}$ are the admissible standard concentrations for each individual parameter.

The values of the parameters for hazardous substances lower then the standards will not be taken into consideration.

The integral index for ecotoxicological assessment of the level of the excessive pollution with hazardous substances for a certain period of time shall be determined as a logarithm from the geometric mean of θ_i, following the steps bellow:

- Determining the arithmetic mean of the ratios between above-the measured concentrations and the standards for each parameter θ_i (equation 1);
- Determining the geometric mean of the ratios-θ_i as follow:

$$J = \sqrt[m]{\theta_1 \theta_2 \theta_m} \tag{2}$$

- Determining the integral index as a logarithm from the value of geometric mean J, or:

$$J = log\ J \tag{3}$$

The values of this integral index vary from 0 to 1.

The integral index for the level of pollution with hazardous substances for a certain period of time shall be determined as an arithmetic mean of the ratios $R_{i,j}/R_{i,o}$ as follows:

$$\bar{I}_n = \frac{1}{n}\sum_{j=1}^{n}\sum_{i=1}^{m}\frac{R_{i,j}}{R_{i,0}} \qquad (4)$$

According to this method the temporary order is examined as a sum of the determined component – trend y_t, which describes regularity in development of examined phenomena; the periodical component y_p and the accidental component Et [1]:

$$y = y_t + y_p + \varepsilon_t \qquad (5)$$

The determined component y_t is described by order of Fourier. The accidental component is ignored. Simulative investigation has showed that the model grows adequate results without component ε_t because of that it has taken into account.

Before one applies this method for modeling it is necessary to check for the presence of trend and to develop a methodology for statistical analysis which enable to check the adequacy of the model [4, 6].

Results and discussion

Water and sediment pollution of Iskar river bellow Samokov with hazardous substances is measured according to the quantity of Cu, Zn, Pb, Cd, Co, Fe, Mn. The water quality in this region is appointed as second category and consequently pollution level is determined according to maximum admissible concentration (MAC) for this category. Waste waters from city of Samokov influence water quality of Iskar river.

Quantity and quality of waste waters after Waste Water Treatment Plant (WWTP) of Samokov is a main factor forming water and sediment pollution of Iskar river till it run into Iskar dam.

According to Water Framework Directive of EU, 2000, it is necessary referent points for assessment of pollution level to be determined.

In the present work pollution level of the river is appointed after maximum admissible concentrations for second category waters. The standards for this category characterize water pollution in referent point.

Bulgaria and the states-members of EU are not adopted standards for sediment pollution, therefore in this case we use Dutch standards for soil pollution. The lower limit of the values for the pollution with heavy metals we use as a basis for assessment of pollution level of the sediments.

For the period 2000 – 2001, quantity of hazardous substances is lower then MAC for second category.

Comparison of the results of the developed model with the experimental data is shown on Fig. 1. Values of the integral index are calculated by equation (4).

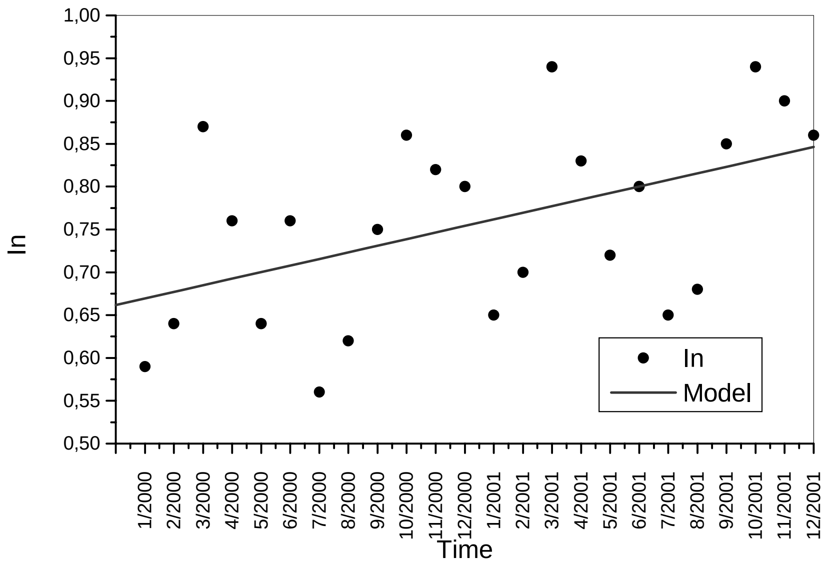

Fig. 1 Dynamics of the integrated index for the level of water pollution with hazardous substances I_n downstream of Samokov.

Values of integral index for the level of water pollution are under 1, which shows that standards for water quality are not exceeded.

The main trend in the dynamics of the integral index for pollution with hazardous substances is described by the linear equation $y=a+bt$. The experimental and theoretical values of the correlation coefficient R^2 are *0.484* and *0.424*.

The model described with linear equation adequately presents the dynamics of index I_n for this period of time. The model adequacy was proved by the values of the coefficients of correlation R^2, the Fisher function and relative error. Values vary from *0.55* to *0.93* and there is a trend of increasing of the values for this period.

Quantity of hazardous substances in the waters varies according to the dynamics of water flow as well as the waster waters coming from the WWTL. Rare cases of exceeding the standards are not observed as well.

By determination of the integral index for ecotoxicological assessment, values of the hazardous substances lower then the standards are not taken into consideration. Since in the observed point exceeding of the standards is not occurring a harmful influence is not expected.
When $I_n < 1$, values of $j < 0$, equation (3).

Sediment pollution influences the state of macrozoobentos, which is basis for determination of various biological indices for assessment of the river state. Quantity of Cu, Pb, Zn, Cd, Ni, Co and Fe is shown in mg/kg.

Dutch standards for soil pollution are shown on Table 1.

Table 1. Dutch standards for soil pollution with heavy metals, where Ll-lower limit, Hl-higher limit

Indices	As	Cd	Cr	Co	Cu	Pb	Zn	Ni
Ll, mg/kg	29	0.8	100	20	36	85	140	35
Hl, mg/kg	55	12	380	240	190	530	720	210

The lower limit of the values for the pollution with heavy metals we use as a basis for assessment of pollution level of the sediments. Comparison of the actually measured values with standards values of the heavy metals in the sediments shows that's quantity of Cu, Zn, Pb, Ni and Cd is significantly bellow the standards. The integral index for total assessment of the sediment pollution varies from *0.20* to *0.42*. Values of $I_{n,s}$ are much lower then 1, which shows that content of hazardous substances is from *60%* to *80%* lower then the standards ($I_{n,s}=1$).

The main trend in the dynamics of the integral index for pollution with hazardous substances is described by the linear equation $y=a+bt$. The experimental and theoretical values of the correlation coefficient R^2 are *0.484* and *0.424*. There is a trend of slightly increasing of integral index for sediment pollution values for this period.

Results from the developed model for the dynamics of the index for sediment pollution are shown on Fig. 2. The model adequacy was proved by the values of the coefficients of correlation R^2, the Fisher function and relative error.

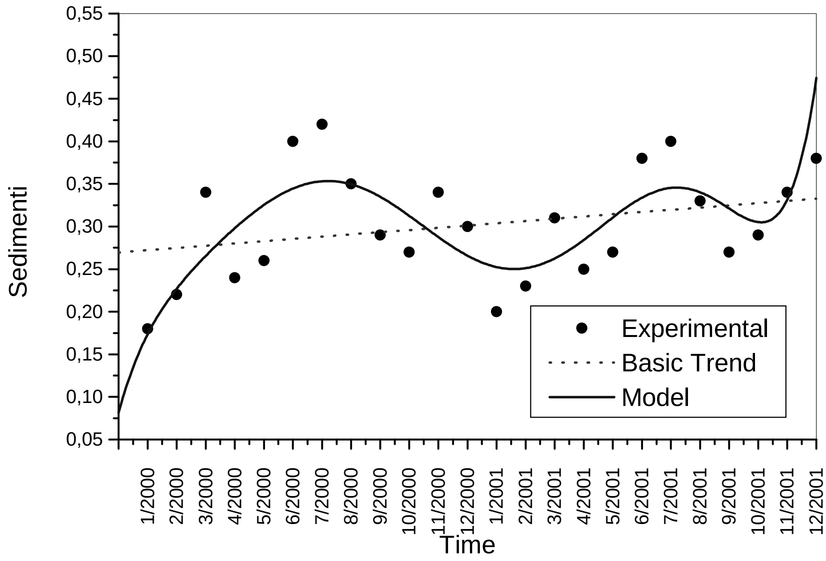

Fig. 2 Dynamics of the integrated index In,s for the level of sediment pollution with hazardous substances downstream Samokov

Dynamics of hazardous substances in the sediments varies according to the dynamics of water flow, the waster waters coming from the WWTL as well as annual river flow and hydrodynamical indices of river flow. Sediment pollution is a source of water pollution. In the case with Iskar river downstream Samokov sediment pollution do not exceed the standards.

When *In* < *1*, values of *j*<*0*, equation (3) and no harmful influence on aquatic organisms is expected.

Conclusions

1. The proposed model can be used for integral pollution assessment of running waters.
2. The developed method gives a possibility to use results from the National Monitoring Network for integral water quality assessment in typical monitoring stations.
3. The proposed model is an initial step to the integrated water pollution assessment.
4. The model provides a possibility to determine the tendencies in the dynamics of the integrated trophic pollution index for a certain period. This tendency provides an opportunity for assessment of the efficiency of the strategy for water quality management.
5. The model of the integral index for assessment of the level of pollution with hazardous substances is an instrument for river water quality management
6. Presence of heavy metals in the water and sediments could badly influence biological processes in the bentos organisms and for river flow remediation.
7. For precise ecotoxicological assessment of sediment pollution within the EU, standards for sediment pollution should be developed. Investigation of the sediments is a priority of “Global change and ecosystems” sub-program of 6^{th} Framework Program.

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