Factors Influencing Pollutant Transport in Rivers
Fickian approach applied to the Somes river

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Preventive and corrective measures regarding water quality are very important for the effective management of the river water quality. Such measures need to rely on correct predictions of pollutant distribution. For that reason, the present paper presents: (1) the correlation of pollutant transport to multiple aspects (e.g. river characteristics, hydrodynamics, pollutant characteristics and properties of the releasing source) and (2) the development of the simulation tool (based on the Matlab numerical mathematical model for pollutant transport in the Someş River). Findings in the paper are important not only for their applicability but also due to the presented approach. They address: (1) the concern of minimizing the field effort during model development, (2) a different way to solve ADE compared to existing studies on the Someş River and (3) a comprehensive picture on the phenomena or classes of parameters, which in water quality studies are generally treated as separated and not integrated in comprehensive analyses.

Keywords: advection, dispersion, pollutant transport model, river pollution, Someş River, water quality

This study is a key part of a comprehensive research project regarding the essential issue of water quality in rivers, which aims at creating tools capable to assist professionals in decision making related to water quality remediation through the control of pollutant concentration. Such tools are also useful in training and learning activities. The step preceding pollution control is pollutant transport modelling, a challenging task taking into consideration the complexity of pollutant transport phenomena. Therefore it is widely acknowledged that natural river systems must be simplified during mathematical representation. No model is able to fully represent reality, each focusing on different aspects such as: convection and dispersion for surface flows (Fickian advection-dispersion); the interaction between surface and sub-surface flows (transient storage – TS, [11]); or, temporary storage of material in dead zones along the river (aggregated dead zone – ADZ, [22]. The specific aspects of each approach are represented by model parameterisation, either via measurement or calculation. Consequently an optimum balance between phenomena representation, available experimental data and model complexity has to be considered when modelling a river.

The river stretch investigated in this paper (a part of the Romanian Someş River, presented in figure 1 and described in more detail later on in the paper) is characterized by meanders (usually represented using ADZ approach when small water velocities are involved) in the first third of its length, but also by very steep river bed (see river bed slope in fig. 2) and high velocities, due to the crossed geographical area (mountains followed by hills). The last two thirds are characterised by little meandering, increasing water flows (fiig. 3) and a yearly average velocity of 0.5m/s. However, there could be little or no evidence that the transient storage mechanism plays a significant role in this river stretch. The most reliable mean to address such issue would be the analysis of time series of the concentrations collected from tracer experiments. This kind of data can be obtained through high frequency sampling at many points along such large river stretches. Moreover, time-series data should be collected under a wide range of flow conditions. Unfortunately such an approach requires time and resources and for the majority of case studies it is difficult to carry out.

According to the Fickian advection-dispersion approach (based on the fundamental advection-dispersion equation (ADE) for mass transport in rivers), widely employed for pollutant transport modelling [1-5, 8], pollutants are released at sources (of different geometry and time distribution); they are transported downstream through advection mechanism and spread into the water body by means of dispersion. The ADE approach is based on the lowest number of parameters and it is easier to quantify compared to other approaches describing pollutant transport in rivers, e.g. TS or ADZ. The latter contain parameters that are not as easily related to conventional descriptions of mass transport in rivers. Above mentioned facts are the main reasons why the Fickian approach is preferred in this research over more complicated alternatives using additional parameters that introduce undesired uncertainties in the models.

Additionally, deterministic mathematical modelling is preferred to other techniques, such as artificial neural networks [19], due to the need of detailed representation of the river features, the possibility of testing the relationships between parameters and of investigating factors to influence pollutant transport.

Relying on phenomenology one can conclude that predicting concentrations with the help of ADE models requires pollution sources to be specified, water velocity and dispersion coefficient to be accurately determined and pollutant transformations properly represented. These variables are expressed through model parameters. They have very complex behaviour, cannot be directly measured, and are difficult to estimate based on field data [5]. The importance of river parameters and/or other variables involved in pollutants transport has been underlined in many studies [1, 5, 11] and correlations between them have been done as well [6]. Generally, in existing literature,

phenomena or classes of parameters are treated separately and not integrated in comprehensive studies, as this present paper aims.

Mathematical modelling related studies have been carried out before, some of them even considering different stretches of the Someş River [3, 4, 10]. Despite of the large amount of work there are no studies on the influence of different factors on the transport of pollutant in the case of the Someş River. Moreover, our study is based on a different approach (described later in the paper) to solve ADE compared to existing studies.

Pollutants of concern for this research are the soluble compounds which may be subjected to advection and dispersion. They can be carried downstream in the water body, meanwhile spreading all over the river channel (e.g. soluble organic chemicals, metal ions and other nutrients). They have different behaviour in rivers depending on their properties, e.g.: solubility, density, viscosity, volatility and availability to take part in chemical or bio-chemical reactions. Such properties are taken into account during the calculation of pollutant transport model parameters (e.g. dispersion coefficients, transformation rates). The transformation rates are crucial. The main factors that influence the transformation rates for the most widely investigated processes include: the physical state of reactants, their concentrations, the nature of ttrans-formation process, the temperature, whether or not any "catalysts" are present, and other properties. Comprehensive pollutant transport models take into consideration multiple transformations pollutants may suffer during their transport in water (e.g. physical, chemical, bio-chemical processes). The transformations are usually termed as: (i) sources, when causing pollutant accumulation and (ii) sinks, in case of pollutant loss. The transformations representation could consist of tens of differential equations needed to reflect the complex dynamics of interdependent transformations sometimes involving multiple pollutants (e.g. nitrification and denitrification involving nitrogen compounds). Pollutant transport models taking into account transformations are non-conservative models, while models neglecting pollutant transformations are conservative models. Previous investigations [1] reveal that non-conservative models cater better concentration variability along the stream, providing more accurate prediction of pollutant distribution, while, quite often, non-conservative models cause low prediction accuracy. A comparison between the approaches is presented later on in the paper.

Other pollutant properties that influence their transport in rivers are density and viscosity. These two properties influence the density and property of the river water, which contains usually multiple chemical species, including pollutants. Density differences in a fluid cause gravity currents, which lead to different transport behaviour with respect to the pollutants having different densities. Density differences also cause physical transformations of the pollutant (e.g. sedimentation) which are usually included in the transport models as zero or first order processes in transformation modules. Heavy compounds with high density (e.g. some heavy metals) are usually identified in sediments distributed downstream the release point. The mix of water and sediments or of other heavy compounds may flow faster than water, because of their higher density [17]. Viscosity also has influence on the velocity distribution and, consequently, on the dispersion coefficient. Its influence on pollutant transport is taken into account through the shear stress (included in the dispersion coefficient). In fully turbulent flows in rough open channels, such as natural streams, the influence of viscosity on D_x is negligible [15].

It is important to mention that the aim of this paper with respect to pollutants it is not to investigate deeply their properties or behaviour, which are available elsewhere [21], nor to present the validation of the mathematical model with the help of pollutant concentration measurements or simulations (delivered by other models). The aim is to offer examples of pollutant features which need specific care during transport modelling.

The objective of this paper is to present: (1) the correlation of pollutant transport to multiple aspects (e.g. river characteristics, hydrodynamics, pollutant characteristics and properties of the releasing source) and· (2) the development of a Matlab numerical mathematical model for pollutant transport in the Someş River. The model development is carried out using a process engineering approach in order to minimize the field effort for this task, as explained later in the paper. This mathematical model for pollutant transport is useful not only devoted to investigate above mentioned relations, but also to predict pollutant distribution along rivers in ordinary situations and also in acute cases (e.g. accidental releases; pollutant runoff due to severe weather), when fast decisions are needed based on reliable information.

Experimental part
Study area and field data

The Someş River Basin is placed in north-eastern Romania, includes a number of 403 water streams with a total length of 5528 km. The investigated river branch is 421 km long (the spring of the Someşul Cald – Someşul Mic – Someşul Mare rivers, up to the Romanian-Hungarian border) and includes 12 monitoring points (marked with circles and numbers in fig. 1), employed by The Romanian National Waters Administration, Someş-Tisa Water Department (DAST) for monthly monitoring.

It is important to mention that many pollution sources exist along the investigated river stretch: six urban settlements, over 100 rural settlements and a large number of industrial and agricultural sites. A study on pollution sources is provided in [2].

Field data employed in the present research has been gathered during years 2001 and 2006. It consists of monthly measurements at up to 12 monitoring points for: (1) the water quality parameters (e.g. species concentration, as

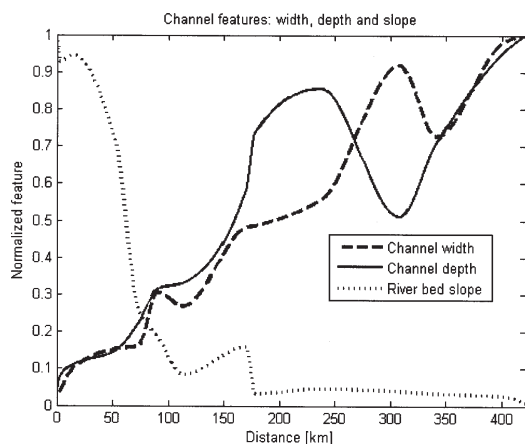Fig. 1. The Someş River Basin map highlighting monitoring points (provided by DAST).

Channel features: width, depth and slope

Fig. 2. Normalized parameters of the river channel
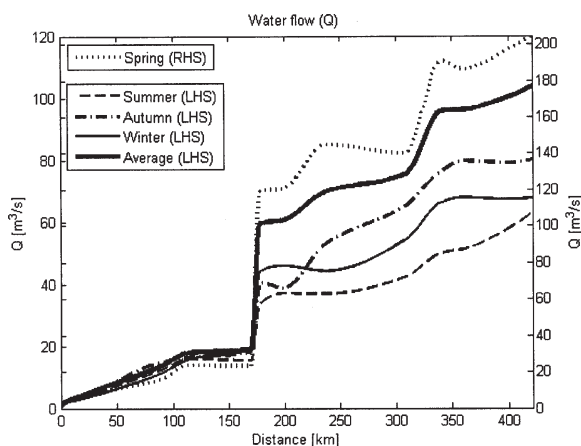
Water flow (Q)

Fig. 3. Annual and seasonal average water flow along the river stretch (LHS – left hand side ordinate axis; RHS – right hand side ordinate axis)

presented in [2] and (2) the channel characteristics [7]. Monitoring has been carried out by DAST.

The normalized values of monitored river bed slope, channel width and water depth are presented in figure 2 for the river stretch. These normalized values have been computed by scaling each parameter with its maximum value measured along the considered river branch.

The parameters illustrate channel non-uniformity along the investigated river stretch in both longitudinal and transversal directions. For example the river bed slope gives information on the geographical area crossed by the investigated stretch: the river has its springs into the mountains, crosses a hilly region, and ends in a plain area. Other parameters show that at short distance before km 200 the transversal profile suffers major changes. This is confirmed by the water flow time series aspect, which shows clearly that around km 178 the investigated river stretch has a large income of water from an affluent, resulting in changes of river features magnitude, as may be seen in figure 3.

Methodology

1D advection-dispersion equation and applicability for the case study

The pollutant transport model developed in the present work describes the evolution of pollutant concentration (c [mg/L]) in time (t [s]) along the river (x [m]) based on the one-dimensional (1D) form of ADE, for longitudinal direction (eq. 1).

$$\frac{\partial c}{\partial t} = -\frac{\partial (cV)}{\partial x} + \frac{\partial}{\partial x}\left(D\frac{\partial c}{\partial x}\right) + S_s \pm S_t \qquad (1)$$

ADE takes into account the pollutant transport expressed by: the convective velocity of water (V [m/s]) and the longitudinal dispersion coefficient (D [m²/s], hereafter referred to as the dispersion coefficient, the parameter responsible for the pollutant spreading along the river channel) and the pollutant sources (S_s [mg/(L s)]) and pollutant sinks (the transformations, S_t [mg/(L s)]). The pollution sources and sinks can be of different origin, such as effluents discharged into the river or pollutant transformations (e.g. chemical or biochemical processes). They have been investigated, along with other aspects of pollutant transport, in multiple studies (e.g. 1, 2, 8, 12, 20, 21]).

The mathematical model presented in this paper has been developed as a flexible system delineated from outside by an interface (tick line in fig. 4); composed of multiple inter-dependent elements (merged in two sub-systems placed in the central square) and characterized by inputs (left side of the interface) and output (right side of the interface).
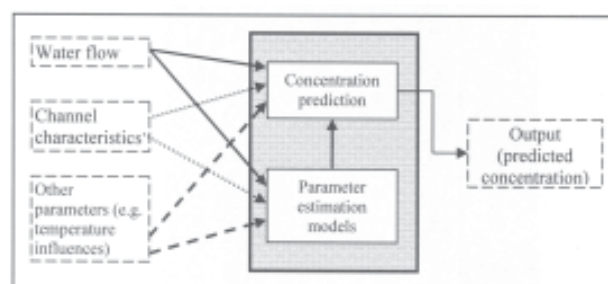

Fig. 4. The mathematical model structure representation

The inputs are time series and scalar data representing: the background pollutant concentration in the river; the water flow rates; the river channel characteristics (e.g. width, depth, slope, roughness); the influencing factors (e.g. tributaries, pollution sources, abstractions) or their characteristics (e.g. location, flow rates, pollutant concentrations); and pollutant characteristics (e.g. molecular weight, transformation rate). Inputs are employed by one or multiple model elements presented in the gray core box of figure . The outputs are represented by the evolution of pollutant concentration in time and space. Consequently, the developed models can be useful for the prediction of pollutant concentration in case of usual and/ or accidental chemicals release, from both continuous and/ or instantaneous sources, under steady or unsteady water flow, depending on the particular case.

The investigation of pollutant transport in the present work has been carried out according to a systemic methodology, applicable to any case study. It has been successfully employed before, based on a different approach for the solution of ADE (analytical solutions in [3], but in this work it has been enhanced and applied to the Someş River as described in following sub-sections.

Processing of field data

Field values of the river stretch parameters are analysed and processed in order to obtain data vectors to be employed as model inputs. Such vectors describe the spatial and seasonal variation of the model inputs based on measurements, as are the data presented in figure 2 and figure 3.

Estimation of parameters

The models for the estimation of pollutant transport parameters have been formulated in this step. The models are based on field data employed by already validated mathematical relationships. The velocity is estimated using

channel characteristics, wetted area and water flow rates, while the dispersion coefficient is estimated with the help of mathematical models available in the literature. The model of [14[(eq. 2) proved to be suitable for the Someş River ([9];

$$D = 2\left(\frac{W}{H}\right)^{1.5}\left(Hu^*\right) \qquad (2)$$

where W [m] is the river width; H [m] is the water depth; and u* [m/s] (eq. 3) is the shear velocity, measuring the water friction with the river bed and river walls; and

$$u^* = \sqrt{gR_hS} \qquad (3)$$

where g [m/s^2] is the gravitational acceleration; R_h [m] is the hydraulic radius; and S [m/m] is the river bed slope. The shear velocity particularly affects the dispersion coefficient [20].

Implementation of ADE in Matlab and model setup
This step consists of putting together all elements developed before in order to simulate concentration evolution in time and space with the help of a numerical mathematical model.

It is well known that based on the structure in figure 4 one can develop two types of mathematical models for pollutant transport: analytical and numerical. The model type is depending on what the core box contains for the concentration estimation: (1) for analytical models – a specific analytical solution of ADE corresponding to each pollution scenario; or (2) for numerical models - ADE itself to account for all pollution scenarios trough initial and boundary conditions accounting for pollution scenarios. Available methods to solve PDEs in order to obtain analytical and numerical solutions are explained in detail elsewhere [16].

The practice confirms that along the Someş River there are many different kinds of pollution sources and pollutants release events. Generally, the sources are characterized according to: location/distribution along the river bank (point or diffuse), geometry (line, point or cubic) and duration of release (instantaneous (bulk) or continuous) [20]. The sources should be carefully taken into account in any pollutant transport modelling work because they affect the model development, structure, complexity and efficiency in representing the real behaviour of pollutants transport, as explained in detail elsewhere[2]. Therefore, this paper presents a flexible model, (1) capable to cater for multiple types of pollution scenarios and (2) allowing for changes of the pollution scenario (e.g. source type or release duration modification) at anytime. Such manageability is possible with the help of numerical models, which have been implemented before for the Someş River by means of the COMSOL Software using another implementation approach [3].

The software used in this work to build the model is Matlab. The Matlab *pdepe* built-in function is employed to implement ADE (the model core), as it allows the model to cater for multiple release types. The model core remains the same, and new elements to be specified are: the source location, its space distribution, release duration, nature of discharge, initial and boundary conditions.

The simulation of an instantaneous (bulk) point release is described by the means of the Dirac delta function ($\delta(t)$ in eq. 4) [5]:

$$\delta(t) = \begin{cases} \infty, & t = 0 \\ 0, & t \neq 0 \end{cases} \quad and \quad \int_{-\infty}^{+\infty}\delta(t)dt = 1 \qquad (4)$$

where t [s] is the time.
The employed initial (eq. 5) and boundary (eq. 6) conditions are:

$$c(x_s,0) = c_{S0}\ \delta(t) \qquad (5)$$
$$c(x,0) = 0 \qquad x \neq x_s$$

$$c(x_{UB},t) = c_{UB}$$
$$c(x_{LB},t) = c_{LB} \qquad (6)$$

where x_s [m] is the pollution source location along the river; x_{UB} [m] is the upper boundary location (upstream end of the stretch); x_{LB} [m] is the lower boundary location (downstream end of the stretch); c_{s0} [mg/L] is the pollutant concentration in the vicinity of the source at the moment of discharge, assuming that mixing takes place instantaneously in the river cross-section; c_{LB} [mg/L] is the concentration at the lower boundary; and c_{UB} [mg/L] is concentration at the upper boundary.

The continuous time-variant point pollutant discharge from a single releasing source, located at x_s [m] along the river, is described by the following initial (eq. 7) and boundary (eq. 8) conditions:

$$c(x,0) = 0 \qquad x \in [LB,UB] \qquad (7)$$

$$c(x_S,t) = c_{S0}(t)$$
$$c(x_{LB},t) = c_{LB}$$
$$c(x_{UB},t) = c_{UB} \qquad (8)$$

The successful implementation of ADE in Matlab (for both release types) is strongly dependent on the way boundary and inititial conditions are represented. Incorrect initial and boundary conditions lead to the representation of a different pollution event (sometimes hardly noticeable) and to misleading results with respect to the pollutant distribution. The implementation of discontinuous functions expressing boundary or initial conditions (e.g. Dirac) in a direct mode it is not feasible as they are leading to problems in the numerical solution, such as large oscillations or negative values of the concentrations. Such problems also occur during the implementation using other software tools (e.g. COMSOL in [5]). In most situations they may be avoided by representing discontinuous functions as smooth continuous functions of space and/or time.

In the present research initial conditions are implemented using a continuous space dependent function, expressing the background concentration along the river at the beginning of the simulation. At the locations where pollution sources are situated, boundary type conditions have been implemented using the smoothed functions depending on time, in order to express the source concentration [5].

Testing the influence of factors on pollutant transport
This step involves carrying out simulations with the help of the developed model. Details are presented in the following sections of the paper.

Results and discussions
Two different types of pollution sources and pollutant releases are considered: instantaneous point and continuous point. The influence of pollution source features and the influence of pollutant properties are investigated along with hydraulic and mass transport parameters. The reason behind this investigation is related to the need of offering a more comprehensive picture on pollutant transport in the Someş River.
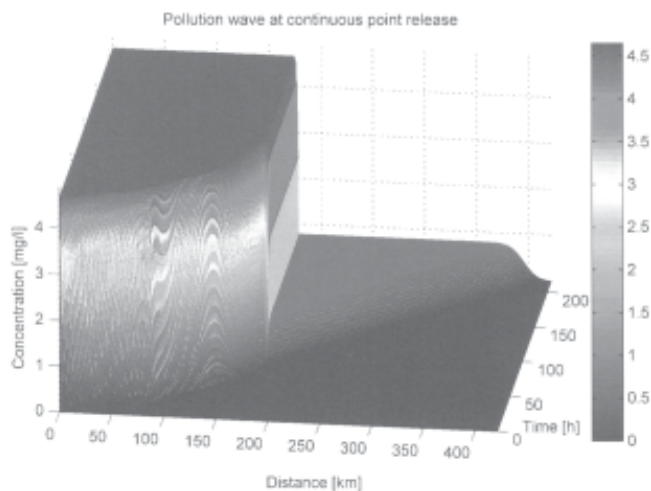
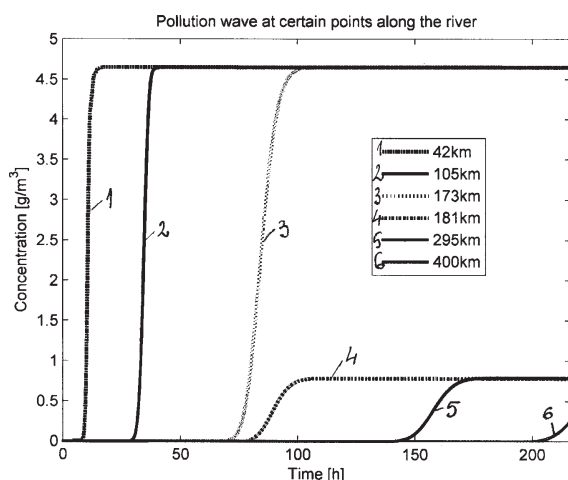Fig. 5. Pollution wave caused by a continuous point release

Fig. 6. Pollution wave caused by a continuous point release: evolution in time at selected locations along the river stretch
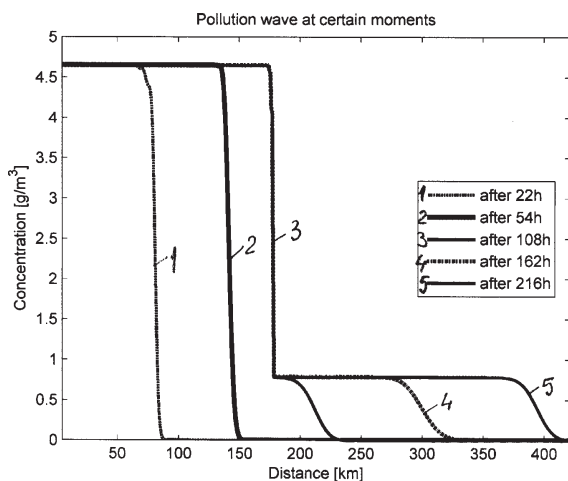

Fig. 7. Pollution wave caused by a continuous point release: evolution in space at selected time moments following the pollutant discharge
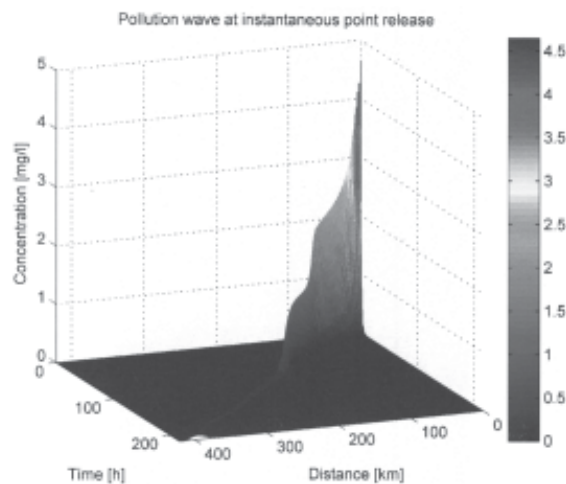

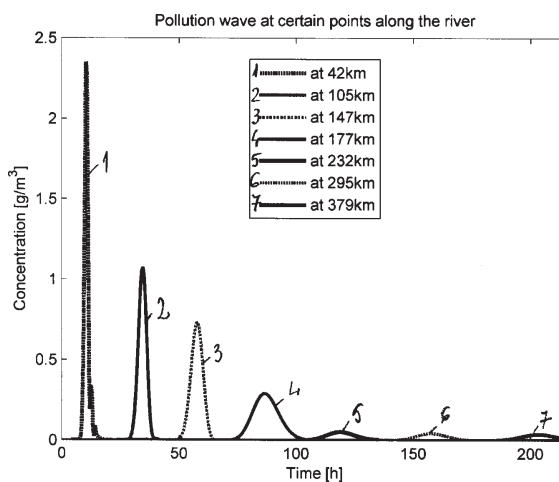Fig. 8. Pollution wave caused by a bulk point release

Fig. 9. Pollution wave caused by a bulk point release: evolution in time at selected locations along the river length
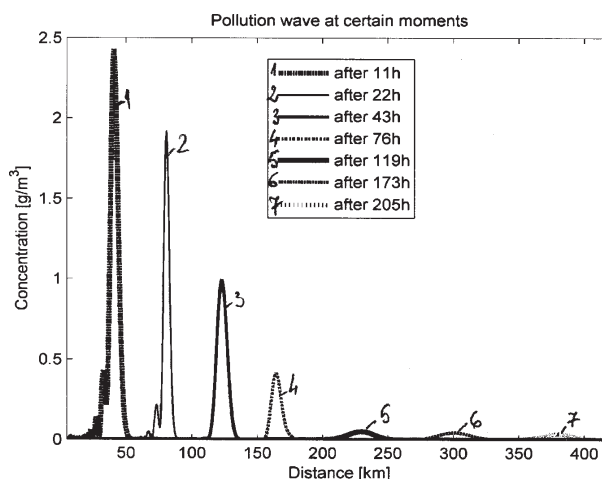

Fig. 10. Pollution wave caused by a bulk point release: evolution in space at selected time moments following the pollutant discharge

Influence of the source type

Two pollution scenarios have been simulated in order to illustrate the pollutant transport from two different sources: a continuous point source (figs. 5-7) and an instantaneous point source (figs. 8-10). The sources are located at the upper boundary, close to the river spring, and release a flowrate of 5 g/s pollutant in the case of continuous release; respectively 4.65 g pollutant in the case of instantaneous release. Both scenarios consider the same estimations for

the river geometry features and the transport parameters (see sections 0 and 0) in order to allow highlighting the effect of the source type on the aspect of the pollution waves.

Figure 5 to 10 show that in both pollution scenarios the pollutant spill reaches the lower boundary after 9 days. As expected, concentrations are higher in the case of the continuous release compared to the instantaneous one. For the two scenarios the pollutant residence time at certain points along the river and the aspect of the pollutant wave
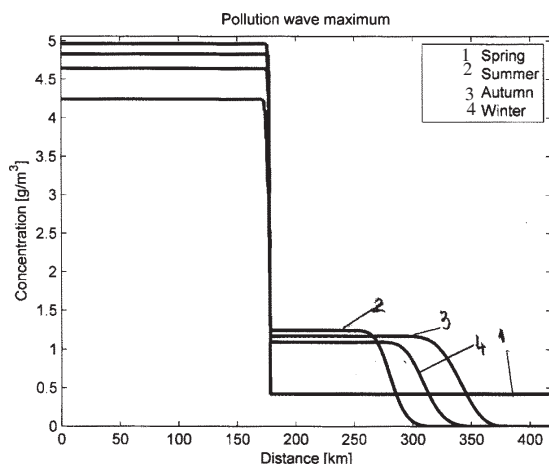
Fig. 11. Pollution wave concentration change, presented comparatively for all four seasons; continuous point release case
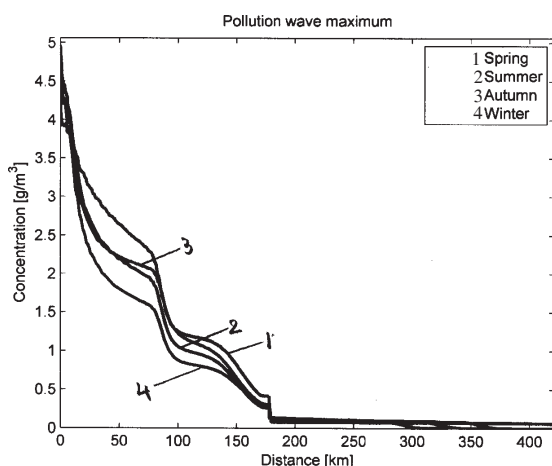

Fig. 12. Pollution wave concentration change, presented comparatively for all four seasons: instantaneous point release case

are different, due to the different nature of the releasing source.

In the case of the instantaneous point release (fig. 8 to 10) the pollution (pollutant spill) has the aspect of a patch (stain) travelling along the river due to advection and dispersion. The dispersion causes the spreading of the pollutant in the river leading to: (1) the dimensional increase of the patch from several centimetres in the vicinity of the source to about 50 km near the downstream border of the stretch (fig. 10); and (2) the concentration decrease with the increase of distance from the release source (fig. 8 to 10).

In such pollution scenarios living organisms and plants along the river could survive an accident with increased probability than in the case of a continuous release, as for the latter the exposure is longer and at higher concentrations. For continuous events the pollutant spill has the maximum concentration in the vicinity of the source as long as the pollutant is discharged. With time this maximum concentration extends over larger river length (fig. 7), affecting up to 178km (distance reached after approximately 4.25 days). For the rest of the river length the maximum concentration has lower value due to dilution caused by a large affluent, i.e the Someşul Mare River. In both figure 5 and 8, at about 178 km from the spring, it may be observed how the pollutant wave changes shape quite sharply. The pollutant is significantly diluted and the advance of the leading edge of the concentration wave is diminished. This behaviour shows that the mathematical model fully reflects real behavioural aspects

of the river, which suffers major channel changes at that point because two major river branches meet. It results in sudden increase of the water flow and diminished river bed slope, shown in figure 3 and 2 respectively.

Water flow

The seasonal changes in water flow affect not only the pollutant wave propagation along the river but also its magnitude. For example, figure 11 and 12 show comparisons between the pollutant transport in case of a continuous point release and an instantaneous point release during different seasons of the year, when the flow rate regimes change.

For each release type, all four simulations corresponding to the seasons of the year have been carried out using the same configuration of the pollution source (in terms of quantity and duration) and the same mathematical model settings. Simulations reveal the values of maximum concentration affecting the river length. Differences in water flow rates between the simulations lead to different values of hydraulic and transport parameters (e.g. water depth, velocity, dispersion coefficient). Higher water flow rates (e.g. during spring) result in faster transport of the pollutant and lower concentrations due to dilution, while lower flow rates (e.g. during summer) lead to opposite situation (larger residence times and higher concentrations) allowing the pollutant to cause higher environmental damage.

This behaviour of pollutant transport motivates water quality managers to add unpolluted (fresh) water in damaged rivers, from natural catchments, in order to dilute chemicals, as fighting back measure. Though, such measures work mainly for rivers of small magnitude, where the quantity of the fresh water employed for dilution is not very large and the results justify the effort.

Influence of the channel parameters

The channel parameters are essential features to take into account while dealing with pollutant transport because river channels are non-uniform and influence the pollutant transport in a crucial way. They are involved in the calculation of other parameters of the model (e.g. dispersion coefficient, shear velocity).

In order to highlight the importance of the channel representation in the model, four model runs have been carried out for both continuous and instantaneous releases (resulting from the same source). The river channel features are represented in two approaches: (1) as average constant values along the stretch (a widely used approach, e.g. [9]) and (2) as variable values along the stretch, reflecting river non-uniformity along the stretch. Simulation results reveal different concentration distributions when model employs different representations of the channel features (fig. 13).

For the bulk release (fig. 13) the use of constant channel parameters results in lower values of the predicted concentration, at the beginning of the stretch, compared to the use of variable channel parameters. Downstream the source, at about 100 km (when the channel becomes larger and receives more water from affluents) the simulated concentrations when employing constant parameters are higher compared to the case when variable ones are used, because the channel variability and the increase of water flow (causing dilution) are not represented by the constant parameters. The concentration predictions are also different in the case of the continuous release, when comparing results obtained with constant vs. variable parameters, in terms of the distance covered
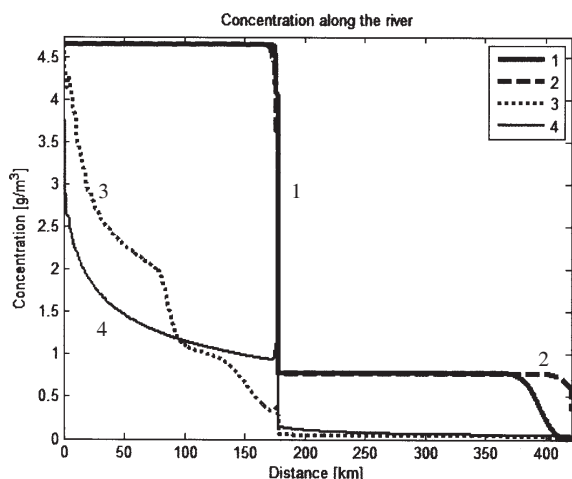
Fig. 13. Pollution wave concentration change (9 days after the release start) in case of using constant vs. variable river parameters: 1 - continuous release at variable channel parameters; 2 - continuous release at constant channel parameters; 3 - instantaneous release at variable channel parameters; 4 - instantaneous release at constant channel parameters
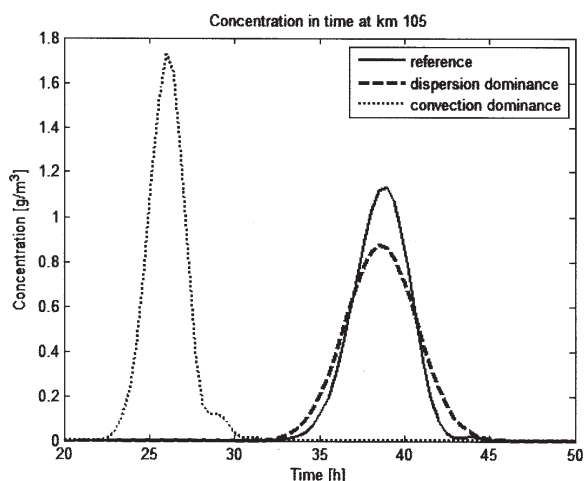

Fig. 14. Illustration of advection-dispersion dominance for a bulk point release: pollutant concentration change in time at 105 km downstream the spring

by the maximum concentration. The use of constant parameters shows that, after 9 days from the release start, the entire river stretch is polluted at maximum concentration, while the use of variable parameters indicates a shorter affected distance (approximately 50 km less). This is because the employment of constant values of the channel features doesn't allow the model to reflect the real river behaviour in an accurate manner. Compared to the real behaviour the average constant channel features employed for the calculation of the convective and the dispersive transport have larger values at the beginning of the stretch and lower values in the second fragment of the stretch. It results in faster transport velocity and a larger river length affected by pollution.

Consequently, parameter calculation may seriously affect the result of concentration estimation along the river. Such information is employed as basis for decisions in the water quality management, especially in the case of accidents, when information regarding pollutant spill arrival time, its maximum concentration or the residence time is very important for taking prevention and counteraction measures. Therefore, the accurate representation of the channel parameters is of high importance.
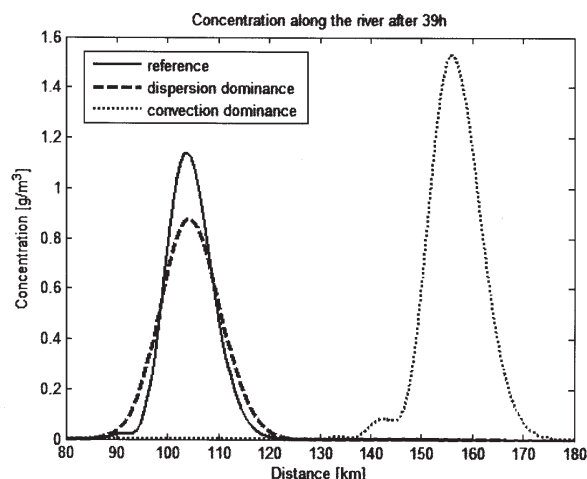

Fig. 15. The illustration of advection-dispersion dominance for a bulk point release: pollutant concentration change in space after 39h of travel time along the river

Advection vs. dispersion dominance

The relationship between transport mechanisms (advection and diffusion) causes (along with other phenomena, e.g. transformations) the complex behaviour of pollutant in rivers. The contribution of advection and diffusion to the transport is variable in time and space along the river: e.g. in mountain regions, where river channels are very steep, the advection is characterized by large velocities which make it more important compared to the diffusion; while in plain areas the advection is characterised by smaller velocities. Such issues translate into the advection-dispersion dominance possible cases: (1) one of the transport mechanisms can have larger magnitude (advection or dispersion is dominant); or (2) mechanisms have equal influence and importance during the pollutant transport. They are illustrated in figure 14.

The advection-dispersion dominance is shown by the distribution of concentration curves in space and time but also by the value of Peclet number (Pe), a dimensionless number to investigate the transport phenomena in fluid flows. In the case of assessing the longitudinal mixing, for a distance x [m] along a river, and a time t [s] after release start *Pe* can be calculated with the help of velocity (V [m/s]) and dispersion coefficient (D [m²/s]) as follows:

$$Pe = \frac{xV}{D} \qquad (9)$$

$$Pe = \frac{V^2 t}{D} \qquad (10)$$

The Peclet number should be computed when working with unsteady flows. When advection and dispersion have the same importance Pe equals one and the concentration curve is considered as reference (black continuous lines in figure 14 and 15). At dominant dispersion (represented by dashed line in figure 14 and 15) the concentration curve is flattened (has lower peak values) and wider (pollutant spill covers more distance along the stream) compared to the reference wave, because pollutant cloud spreads in the stream faster than it is transported downstream (Pe << 1). At dominant advection (blue dotted lines in figure 14 and 15) the concentration curve is sharp (has larger peaks) and narrow (pollutant spill covers less distance) because the pollutant is transported downstream very fast and has less time to spread (Pe >> 1). It may also be noticed that in this latter case peaks arrival times and centroid travel times along the river are lower compared to the other two situations (fig. 14), because the pollutant travels faster along the river.
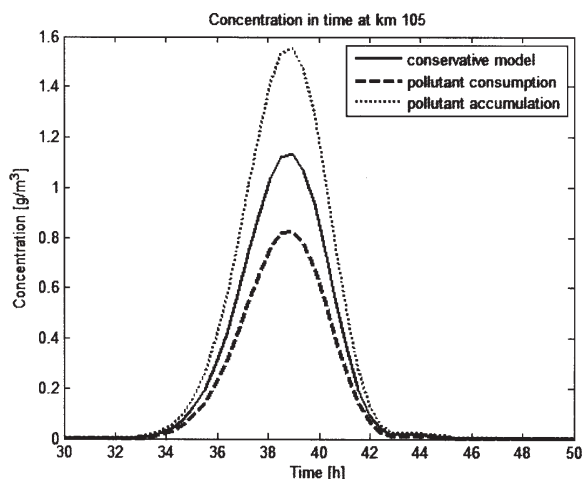
http://www.revistadechimie.ro

Fig. 16. A bulk point nitrate release applied to the Someş River stretch: the concentration prediction in case of different approaches for pollutant transformations

Pollutant properties

The aim of this section is to offer an example on how pollutant related features need specific care during transport modelling. Choosing one of the available approaches to represent the sources (a conservative model vs. a non-conservative model) may result in the underestimation or the overestimation of the pollution level in the river. The wrong choice may lead to inappropriate decisions related to the water quality management. An illustrative example is presented in figure 16 for a bulk release of nitrate, which has been revealed by previous studies [2] as an important pollutant along the Someş River. The pollutant is simulated using three kinds of settings for the mathematical model presented above: (1) as conservative (no transformations); (2) as non-conservative with nitrate consumption (larger denitrification compared to nitrification); and (3) as non-conservative with nitrate accumulation (nitrification and other processes causing the increase of nitrate concentration are more intense, compared to nitrate consumption, e.g. by denitrification). The model employs transformation rate constants from [18].

Generally, in the water quality pollution management, intensive monitoring and remediation plans should be made according to model results. In the case of pollutant transformations based on erroneous specifications such measures may become totally wrong. The situations of lower predicted values of pollutant concentration (due to underestimation) guide decision factors towards less effective measures with respect to counteraction measures, compared to the situations when higher values of concentration are predicted (due to overestimation). Therefore, the transformations representation in pollutant transport models is a very important component, not only because the models, as decision support tools, should be reliable, but also because the result of water management activities should meet legal standards and conditions for flora and fauna to be preserved in safe conditions [13].

Conclusions

The need to offer relevant and accurate information for the dependence of pollutant transport in rivers with respect to river geometric and hydraulic characteristics, mass transport parameters and/or transformation processes is constantly increasing. Today, fulfilling the task of making sustainable environmental management of the rivers involves using the mathematical modelling and simulation.

In this paper, in order to investigate pollutant propagation in the Someş River and its dependence to key factors, a model for the pollutant transport is developed taking into account morphological, hydrologic and hydrodynamic river characteristics, along with pollutant transformation processes. The paper presents: (1) the model development employing a new implementation compared to frequently used approaches; and (2) a comprehensive picture of the influence of different kind of factors on the propagation of pollutants.

The model caters for multiple pollutant release types, which are implemented using specific boundary and initial conditions. It is suitable to predict dynamic distribution of the pollutant concentration along the river in any conditions (e.g. time changes in the pollution source, variable water flow due to different meteorological conditions, or when other river features change). Two different types of pollution sources and pollutant releases are illustrated in the paper: an instantaneous point release and a continuous point release. Furthermore, the influence of pollution source features and pollutant properties on pollutant propagation is investigated along with hydraulic and mass transport parameters change. Results show that the representation of the source geometry and the river channel features (e.g. variable vs. constant parameters along the channel) is essential for realistic process modelling. They significantly influence the pollutant transport and consequently are directly involved in the calculation of pollutant transport characteristic parameters employed in the modelling (e.g. dispersion coefficients should be considered with special care). Such issues, along with other aspects (e.g. dispersion-advection dominance, pollutant transformations, water flow variability), affect not only the form of the pollutant wave but also its magnitude along the river. The assessment of the chemical or biochemical involved processes revealed by the investigated aspects become valuable tools for the river quality management and sustainable development.

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review

Daniel A.Vallero and Trevor M.Letcher
Unraveling Environmental Disasters, 2013
Elsevier Inc., Waltham, MA,USA,Oxford UK., Amsterdam, The Netherlands,
500p.(ISBN 978-0-12-397026-8)

Most engineering and science leaders agree that "*disasters are low probability events with high value consequences.*" Problems become disasters when risks not properly managed. Result significant physical damage to human life, ecosystems and materials. This explanation calls attention to anthropogenic aspects of disasters, as results of human decisions.

This book has been written by two prominent scientists:D.A.Vallero ,professor of Environmental Engineering at Pratt School of Engineering, Duke University, Durham,N.C., USA and T.M.Letcher, emeritus professor of Physical Chemistry, University of KwaZulu-Natal, Durbam,South Africa. The authors "began this book as a conversation between two colleagues", intended to consider why a disaster occurred from a scientific perspective.

As authors explain in **Preface** , this book is a developing of D.A Vallero 2005 work *Paradigms Lost:Learning from Environmental Mistakes and Misdeeds* (ISBN 0750678887) which included some explanations of environmental failures, but primary focus was on miscues that led to these failures.

The book is structured into 17 interrelated chapters:
1.**Failure**(32,19) 2.**Science**(24,18)3.**Explosions**(14,20)4.**Plumes**(27,18)5.**Leaks**(26,14) 6.**Spills**(31,15)7.**Fires**(18,13)8.**Climate**(37,46) 9.**Nature**(13,15) 10.**Minerals**(38,14) 11.**Recalcitrance**(22,34)12.**Radiation**(21,23) 13.**Invasions**(35,44)14. **Products**(22,41) 15.**Unsustainability** (9,15)16.**Society**(33,45)17.**Future**(15,14).After chapters title in the brackets are done the number of allocated pages and of the corresponding references/notes for each chapter. A **Glossary of Terms** with the meticulously selected by the authors operational definitions(37pg)and **Index**(23pg) clue the book.

Further, I will detail only the principal titles for four selected chapters to demonstrate the fine authors analysis :
1.**Failure:** Events;Disasters as Failures; Types of Failures; Types of Disasters; Systems Engineering. 9.**Nature**: Hurricanes; Floods; Drought; Ecosystem Resilience.

12.**Radiation**: Electromagnetic Radiation; Nuclear Radiation; Nuclear Plant; Nuclear Power Plant Failure; Meltdown at Chernobyl; The Fukushima Daiichi Nuclear Disaster; Three Mile Island Nuclear Accident; Radioisotopes and Radiation Poisoning; Carbon Dating; Nuclear Waste Disposal.

15.**Unsustainability:** Oil**;** Phosphates; Helium; Platinum Group Metals; Lithium;Other Metals; Biomass; Methane; Carbon Dioxide.

Each chapter of the analyzed book is illustrated with images, tables and photographs used in interpreting the wealth of data, related with the specific environmental disasters, that have been occurred over the past 5o years. The International System of Units has been used throughout.

Authors include solutions and specific recommendations , along with a summary in Chapter 17 of the lessons that need to be heeded,of the actions that "could make a difference" in responding to and preventing future environmental disasters.

It is obvious that the book can be read "from cover to cover" or choosing the chapter, which concern a particular reader.

This genuine treatise on disasters will be, surely, a **reference book** for such motivated readers as scientists and engineers, but should be read also by lawmakers,parliamentarians,representatives, nongovernmental organization members and others, which must inform the public.

I have been read this book, property of the Clement C. Maxwell Library from Bridgewater State University, MA, USA,with a great pleasure,remembering the good working time of late '90 years. Then, together with the principal researchers: Ph. D. Rodica Stanescu Dumitru from National Institute of Public Health (Bucharest) and Ph.D Valentina Chiosa, now at Research Center for Work Hygiene(Montreal)we have been searched useful data preparing the book :Metode fizico-chimice aplicate la masurarea noxelor in mediul profesional/*Physical-chemical methods used to measure noxes in occupational environment /* (Ed. Academiei Romane,2003, ISBN 973-27-1031-4) and the course: Relatii intre Structura, Proprietati si Activitate Biologica aplicate la Poluanti Industriali /*Relationships between Structure,Properties and Biological Activity applied to Industrial Pollutants/* (Ed.Universitatii Bucuresti,2003, ISBN 973-575-725-7). The nominated course is comprised in the actual Curricula for section Science of Environment at Faculty of Chemistry from Bucharest University.

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