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# EXTENDED ABSTRACT

# Identification of Multiple Pollutant Sources in Rivers in One-Dimensional Domain under Real Conditions

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## 1. Introduction

It is almost three decades that finding the release time and location of pollutant sources in rivers has attracted the researchers' and pundits' attention. In most of the current studies related to finding the release time and the location of pollutant sources, each of the researchers has considered their own specific circumstances in kind of hypotheses and problem solution methods. In a more general study, in previous studies researchers have used three approaches for solving the inverse problem of the pollutant transport equation.

The first approach (simulation-optimization methods) includes characteristics such as combining an optimization algorithm with other numerical methods of solving transport and hydrodynamic equations. The need to use computers with strong processors for solving inverse problem is a type of computational costs that can be counted as a weakness for this method (Mazaheri et al., 2015).

The second approach (probabilistic and geostatistical methods) focuses on using probabilistic and geostatistical distribution. Furthermore, using this method would assist to decrease computational volume for finding inverse problem answers, and finally would reduce number of simulations. So, that is an advantage for this method.

The third approach (mathematical methods) is for solving the inverse problem in a specific way and a mathematical frame. Reducing the numbers of repetitions or removing them and also decreasing the time and computational costs are counted as benefits of mathematical methods.

In the field of the inverse solution, studies that have been done so far, mostly done in the groundwater environment and less attention has been given to surface water resources. Moreover, each done research in the river has considered mainly a simple condition of the flow, the river topography, and pollutant sources. Therefore, introducing a method to propel problem conditions toward real conditions would be more practical and useful. As a result, by considering the selected approach, the present study in decreasing the problem solution time to the least number of runs and also minimizing observations and field costs in the inverse solution domain is accurate and efficient.

## 2. Methodology

In the theoretical background, each step of the problem solution would be analyzed separately considering the equations and their govern rules. The problem-solving steps are forward and inverse solutions which will be discussed further. Generally, the problem-solving process primarily starts with the forward numerical

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solution of two groups of hydrodynamic and transport equations. The second step is the inverse solution of the pollutant transport equation that is being done in order to achieve the final results of the inverse problem.

Actually, the meaning of the forward numerical solution of the pollutant transport equation in rivers is calculating the temporal and spatial distribution of the pollutant concentration with a clear awareness of the location and release rates from the pollutant source. The forward numerical solution of the transport problem consists of two parts; the first part is the numerical solution of hydrodynamic equations (Eq. 1 and Eq. 2) and the second part is the numerical solution of the advection-dispersion equation (Eq. 3). One-dimensional hydrodynamic equations in rivers given by Chaudry (2008) and the pollutant transport equation (ADE) given by Chapra (1997) are:

$$\frac{\partial A}{\partial t}+\frac{\partial Q}{\partial x}=0 \quad (1)$$

$$\frac{\partial Q}{\partial t}+\frac{\partial}{\partial x}\left(\frac{Q^2}{A}\right)+gA\frac{\partial z_w}{\partial x}+gAS_f=0 \quad (2)$$

$$\frac{\partial (AC)}{\partial t}=-\frac{\partial (QC)}{\partial x}+\frac{\partial}{\partial x}\left(AE_x\frac{\partial C}{\partial x}\right)-AkC\pm AS \quad (3)$$

In the above equations, $z_w$ is the water level elevation, $Q$ the flow discharge, $A$ the flow area, $S_f$ the energy slope, $C$ the concentration of the pollutant at downstream points, $g$ the acceleration due to gravity, $x$ the location variable, $t$ the time variable, $E_x$ the longitudinal dispersion coefficient, $k$ the first-order decay coefficient, and $S$ is the source term.

In other words, the outputs of the numerical solution of hydrodynamic equations consist of the flow velocity and the water depth in different times and locations along with the characteristics of pollutant sources (its location and the temporal release rate) and some other parameters are considered as the inputs of the numerical solution of the advection-dispersion equation (ADE). In addition to in the study the application of superposition principle results are used in the forward and inverse solutions of the pollutant transport equation.

## 3. Results and discussion

The inverse model of the study which is the Tikhonov regularization method based on the inverse matrix, would be analyzed in a one-dimensional domain and under hypothetical and real conditions. The first example is a hypothetical example to recover the temporal release rate of a pollutant source using two downstream observation points (Fig. 1). In the second example, the verification of the inverse model would be investigated using real topography data of the Karun River in a real flow regime.

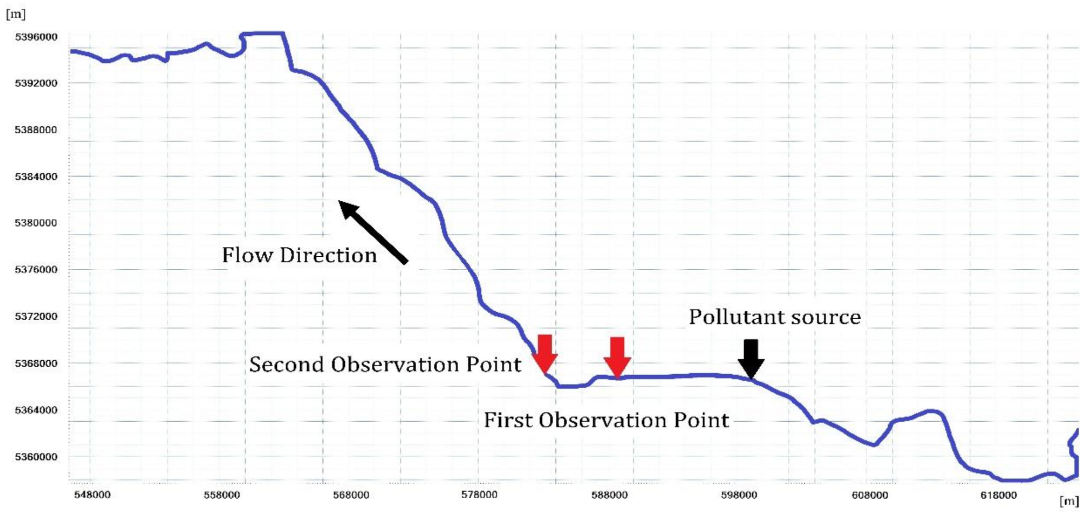


**Fig. 1.** Locations of the pollutant source and observation points in the hypothetical example

## 4. Conclusion

In this section, results for the inverse solution of the transport problem based on a mathematical inverse matrix and Tikhonov regularization method in hypothetical and real flow condition in one-dimensional domain will show. So the following points are some important details of mentioned results:

1. The inverse model is flexible for different conditions related to each pollutant source and observation point. For instance, the temporal frequency of field concentration observations in observation points for each pollutant source can be considered specifically or for all pollutant sources (in multiple sources mode) can be considered equally. But since the objective of the mentioned inverse model, besides the desirable accuracy, is to decrease the number of the field observations to the least, so the first case is suggested.

2. Making decisions that can reduce the number of problem unknowns can also decrease the need to access more field observations. So, decreasing in dimensions of the coefficients matrix can lead to increasing in accuracy of the inverse model.

## 5. References

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