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POSSIBILITIES OF SOFTWARE EVALUATION FOR THE RIVER COURSE MODIFICATION. CASE STUDY: SIRET RIVER IN BACAU REGION SECTOR

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Abstract

The main purpose of this article is to introduce a method helping us to understand the evolution and changes that occur on a river route. Route transformations on a river flow are usually highlighted by maps or ortophotoplans. However, these are made at a certain time slot and thus they cannot reveal the factors affecting the river route. Therefore, in this article, based on three Siret river routes performed in 3 different time slots, 1954, 1980 and 2010 respectively, was intended to highlight the distribution mode of the flow velocity by using the Ansys-Fluent simulation software. Following the simulation, a series of helpful information revealed the concerned erosion areas, making thus possible the future assessment of the Siret river.

Keywords*: Siret river; Specific geological formations; River margins' expansion and reduction; Preserving the riverbed; Course evolution; Simulation*

Introduction

Rivers are the main agent to shape the Earth surface, by creating different geographical formations. Hydric erosion is one the most significant environmental degradation processes [1-6].

To be able to understand the way in which a river influences the region it flows through, one should consider a series factor, such as [7-19]:

- soil features of the region crossed by the stream;
- weather conditions of the concerned region;
- stream features, such as: flow gradient; flow regime; total suspended solids; variation of flow regime features (flow velocity, identifying swirl areas; fluid pressure over the bank walls).

As a result of the hydraulic erosion process, the river initially changes its route, creating the inflection-generating areas, the meandering area, the area in which the river channels merge or separate, the island's appearance, the channel through which the rivers expand or diminish, even changing the riverbed.

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This article aims to identify the variation of fluid flow's distribution within the channel, this one playing, as stated earlier, a key role in the erosion process [3].

When studying the flow rate of the river, it is extremely important to determine the amount of water existing in the hydrographic network and the time that this quantity crosses the hydrographic system [20-22].

To determine this parameter one can use different methods, such as [23-35]:

- Measuring the fluid's velocity by using different methods and equipment in different spots on the river's flow;
- Acoustic measurement through acoustic pulses on a 20-35kHz broad frequency band, the results being used to dispaly an acoustic tomography [36];
- Volumetric measurement – a method that can be performed for low flow rate rivers and involves an assessment of water flow at a given time [24];
- Float measurement - involves velocity measurement of a flotation object and multiplying the obtained value by the average surface area of the cross-section [1];
- Current measurement - with a meter assessing local velocity of the flow [14, 29];
- Dilution measurement carried out for sodium chloride [25];
- Structural measurement - a correlation is set method that establishes a correlation between river water layer height and river's flow rate [2];
- Slope-area method is the most commonly used - it is based on Manning's equation;
- Analytical measurements of the flow velocity variation [3, 22, 37];
- Using different software to simulate the behaviour of a river [10, 20, 23] .

The flow rate represents a major characteristic quantity playing a key role in modifying a river course. Thus, all researches in the field of soil erosion by flowing waters, regardless of their theoretical or practical character, start by identifying this characteristic quantity.

Within this article, simulation software is used to determine the distribution of the fluid lines and the value of its velocity. This analysis aims to make us understand the mechanisms operating within the rivers' erosion process and be able to envisage the evolution of a river bed.

Materials and methods

The investigation area is situated in Bacau county (Moldova region – Romania), a region within the following coordinates: 450 03' and 470 58' Northern Latitude, and 24º 49' and 28º 02' Eastern Longitude, corresponding to an investigated surface of 47.610 km^2 (Figure 1) [2].

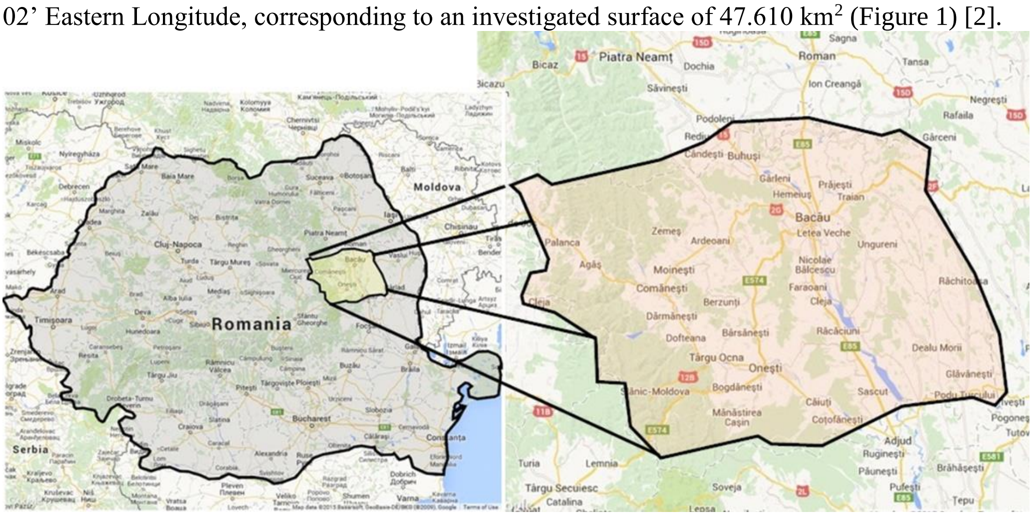

Fig. 1. Siret river course, Bacău County region [38].

These coordinates correspond to Siret river route, crossing Bacau County from border to border, on a 92.2 km length.

The investigated area is part of Siret river basin, and geographically speaking is part of the Central Moldavian Plateau.

To carry out this survey on the changes of the Siret river route, three different river routes have been investigated, in different periods: 1954, 1980 and 2010.

Since the changing process of a riverbed is very complex and requires time, one cannot emphasize the factors generating these changes.

For part of these factors, we used a finite element analysing software (ANSYS-FLUENT) that can emphasize the variations of the fluid's (water) flow velocity, as well as the pressure over the banks [39].

In order to carry out the simulation of a watercourse flow, the following simplifying assumptions have been made:

- a two-dimensional pattern (2D);
- the refernce flow rate and river's flow velocity were measured in in 2010 at Dragesti monitoring station (0.8 m/s);
- the river suspended matter has not been considered;
- the used pattern does not require the analysis of the entire watercourse. By the help of the finite element analysis software, we analysed only the river segment that had not undergo damming works, and where the flow is natural, meaning more than half of Siret river flow on Bacau County territory.
- the influence of Siret river's tributaries on the analysed flow has not been considered.

Given these simplifying assumptions, the following working stages have been performed (Figure 2).

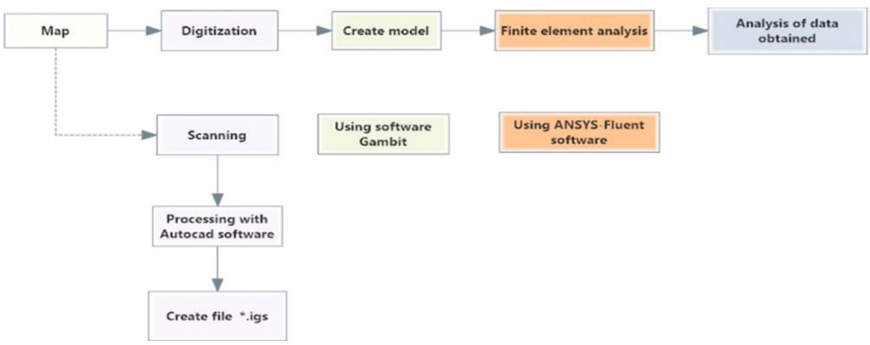

Fig. 2. Working scheme.

For the analysed patterns, 3,000 iterations have been carried out.

In conclusion, Fluent software can present a series of parameters, among which:

- pressure: static, dynamic, total;
- velocity: linear, angular, radial, tangential;
- tracking a solid particle displacement in the fluid channel.

For the analysed case, we only monitored the variation of the watercourse linear velocity depending on the flowing channel profile and dimension.

Results and discussions

After carrying out simulation with Fluent software on fluid's flow through Siret watercourse profile, we obtained the following distribution of fluid's linear velocity:

- For Siret river route in 1954 (Figure 3);

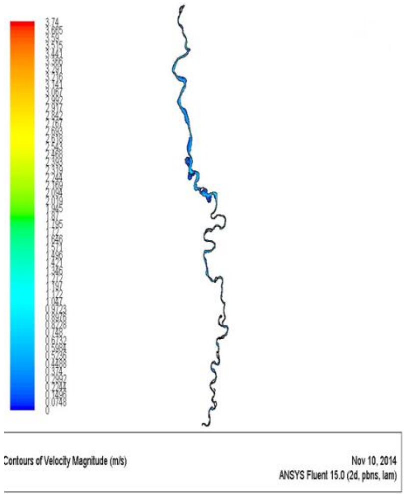

Fig. 3. Linear velocity variation for Siret river profile in 1954.

For a better emphasis of the river's flow velocity variation, a series of pictures have been taken for different sections of the fluid channel (Figure 4).

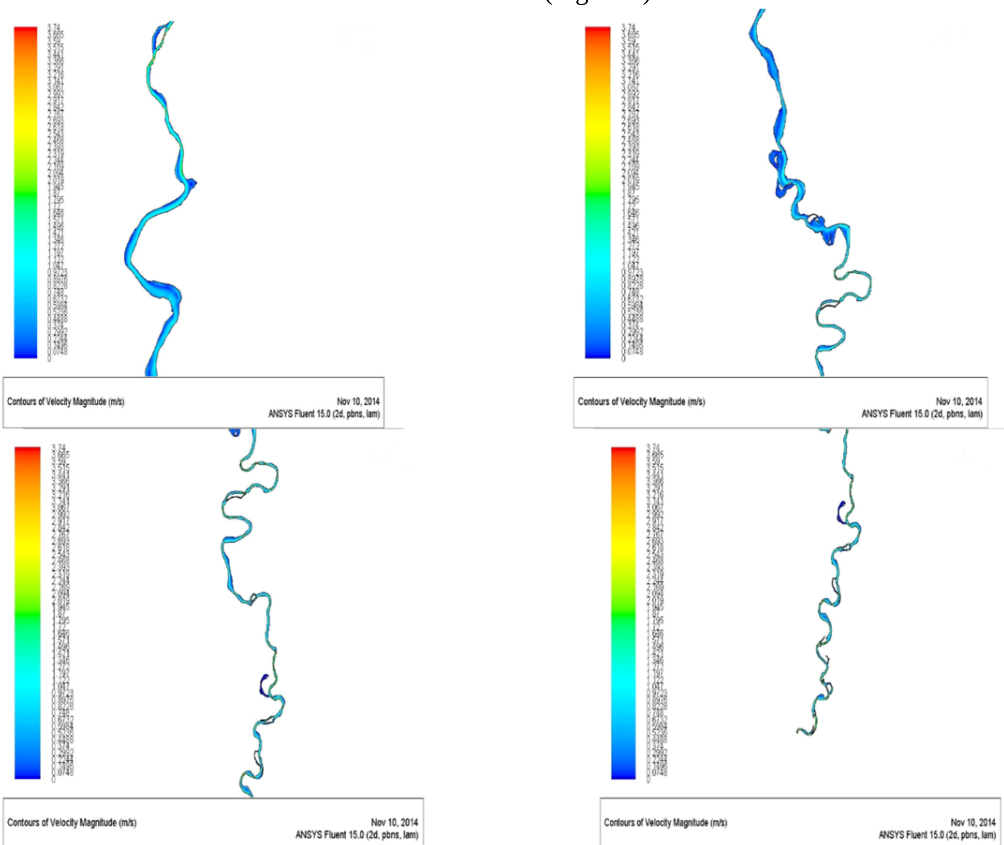

Fig. 4. Linear velocity variation for Siret river in 1954 on different sections

- For Siret river route for the year 1980 (Figure 5);
- For Siret river route for the year 2010 (Figure 6);

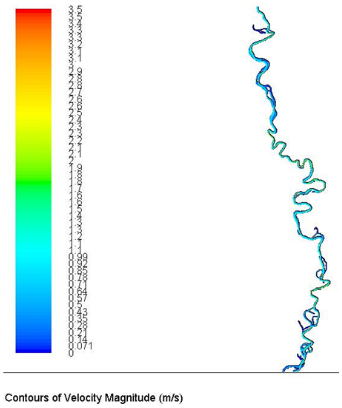

Fig. 5. Linear velocity variation for Siret river contour in 1980.

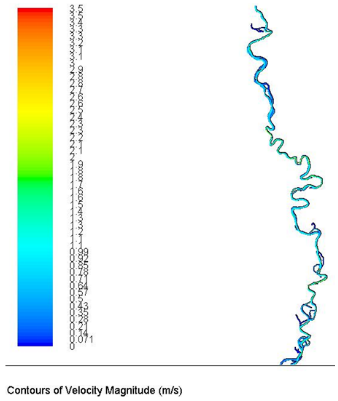

Fig. 6. Linear velocity variation for Siret river contour in 2010.

After analyzing the linear velocity distribution on Siret river, for the three analysed periods, the results are as following:

- the highest flow rate was obtained in 1954, 3.74m/s respectively;
- the lowest flow rate was obtained in 2010, 2.2m/s respectively;
- the analysis has been carried out in Drăgeşti area, where the hydrological monitoring station is located, and the simulations have been carried out for 2010, obtaining a variation of studied parameter, on the whole section of the river (0.73-0.86 m/s). These values are not significantly different from the reference value (0.8 m/s).

Identifying the hazard areas for the river course modification

In order to identify the areas palying a major part, undergoing the river course modification due to river's flowing features, over the changes of Siret river bed profile, the following methodology has been applied:

- Two consecutive routes of Siret river profile have been overlapped, for the years 1954 – 1980 and 1980 - 2010 (Figure 7);
- The images of the finite element analysis corresponding to referred year have been overlapped:
  - for the first interval the year 1950 has been referred to;
  - for the second interval the year 1980 has been referred to;
- The distribution of the fluid's (water) current velocity and modifications of Siret river route have been analysed.

Identifying high hazard areas for the river course modification for the year 1980

By consecutive overlapping of:

- Siret river route in the year 1954;
- Siret river route in the year 1980;
- simulation carried out for Siret river route for the year 1954.

The result may help us to understand the changing process of a river bed. We can thus identify the influence of the river's velocity over the erosion or settling process. In the same time we can emphasize the modifications underwent by the river (Fig. 8).

Identifying high hazard areas for the river course modification for the year 2010

The same methodology as for the previous case has been used, to compare Siret river profiles for the years 1980 and 2010. Also, the areas to produce modifications over the river flow have been identified. These are emphasized in Figure 9.

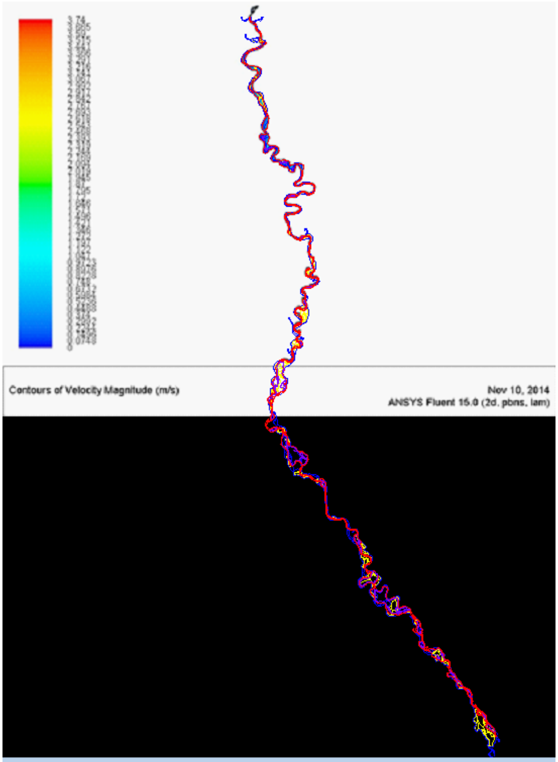

Fig. 7. Overlapping two courses of Siret river, from 1950-1980.

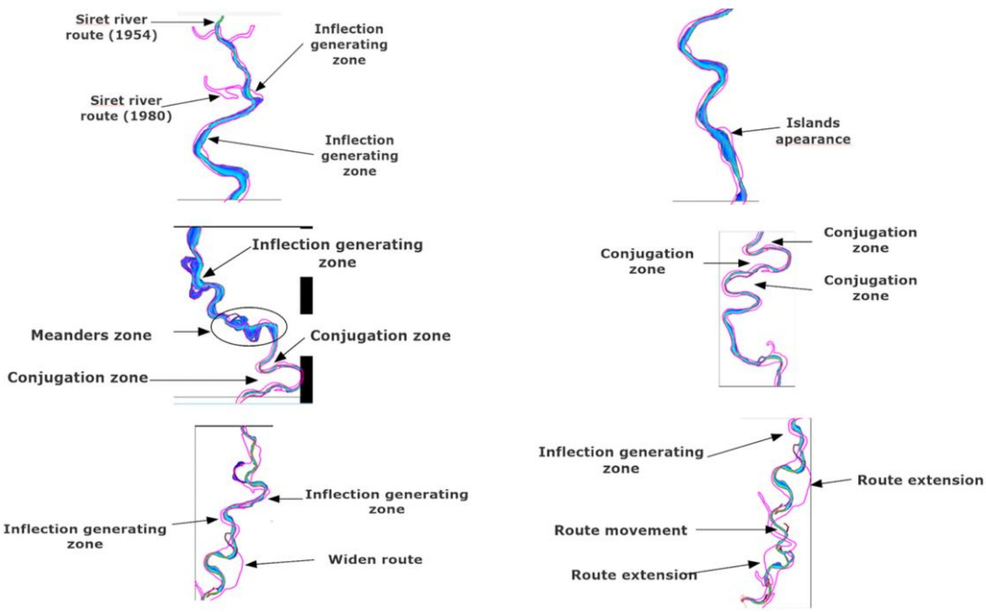

Fig. 8. Modifications occurred on Siret river course between 1954 and 1980.

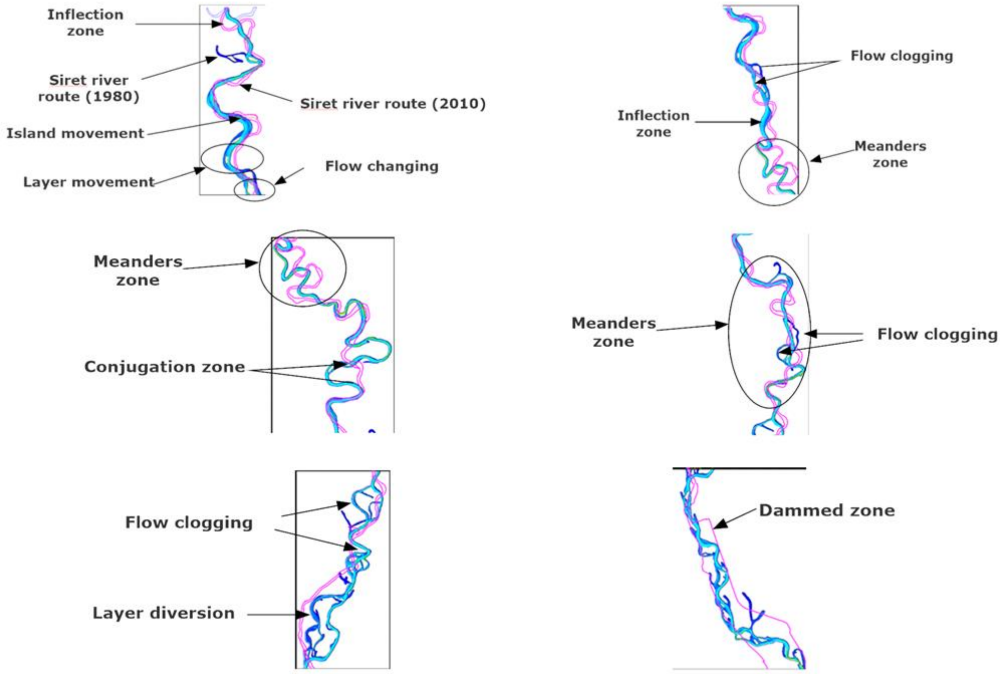

Fig. 9. Modifications occurred on Siret river flow between 1980 and 2010.

After the simulation we can say the following:

- the areas showing an increment of the current velocity can be viewed, and following the analysis of the overlapping representations we note in changes of the riverbed in that particular areas;
- between the Siret River Route in 1954 and the one1980, it is noted that there are no substantial changes for the first transom of the river. These changes appear in the last section of the route, on the last 30 km;
- major changes appear between the Siret River Route in 1980 and the one in 2010, as a result of the erosion process as well as of the human activity;
- the simulations have been performed on 2D riverbed patterns and therefore they do not accurately describe the process of a riverbed changing. This is best highlighted in the areas of change of the river's direction. Within this simulation, fluid flows along the shortest route and therefore the highest speed is identified on the inside wall of a curve. In reality, the effect is opposite, i.e. the highest flow velocity is on the outer wall of a curve and the river flows along the longest path. This is best identified by the overlap on the last two Siret River routes (1980 and 2010).

Conclusions

A river is a living “entity” which, due to its dinamics, it influences all landforms it passes through;

The incluence a river on the landforms depens on a series of factors, such as: soil characteristics of the region, weather conditions for studied region and other features of flowing water.

By using Ansys-Fluent software, we could achieve a Siret river flow simulation on the portion that crosses Bacau County, those on an approximate length of 92 km.

To highlight the influence of the river on the banks, three simulations corresponding to three different time periods have been performed, for three different routes of the Siret River respectively.

By overlapping two consecutive routes of the Siret River we could determine the impact it has Siret river velocity on its evolution.

The riverbank erosion simulation method is a widely used method aiming to identify the critical points of a river's route.

By simulating a river flow the variations of the flow velocities on different sections of the river can be identified, by means of the variation of representation colors.

Following the simulations, we noted is a decrease of the river flow rate from 3.7 m/s in the case of the1954 riverbed to 2.2 m/s for the 2010 riverbed.

This type of analysis is used in order to predict the evolution of a river and the velocity of its route changing.

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