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Numerical Simulation of Groyne in Puger Beach Jember District

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Abstract. The Puger Fish Landing Base is located on the southern coast of Java Island, so this port is directly facing the Indian Ocean. At the entrance and exit of the ship to the harbor a groin exists. The groin is located on the Puger River and faces the sea. The groyne is influenced by current and tidal patterns. The groyne was built in 2014, and then was cut. Based on this phenomenon, numerical simulations were carried out to determine differences in sea water level and flow velocity, for the two conditions with and without groyne. Bathymetry data obtained from BIG (Indonesian Geospatial Information Agency) was used for simulations. Tidal observations from previous studies were used to validate the model. Two scenario models with and without groynes were simulated. Spatial variations of flow velocity in the highest tides, minimum tides, and representative time steps for both cases were presented. It can be seen that with groyne, flow velocity was greater and more unstable than models without groyne. Based on the flow velocity pattern at the four observation points and water level, it is concluded that the model with groyne showed a higher flow velocity than the model without groyne.

INTRODUCTION

The Puger Fish Landing Base is located on the southern coast of Java Island, so that this port faces directly the Indian Ocean. At the entrance and exit of the ship to the harbor there is a groyne. The groyne location is located at the mouth of the Puger river and facing the sea, then the groyne is still influenced by the pattern of currents and tides.Groyne was built in 2014 with a building height of 1.5 meters and a length of 40 meters. The groyne were modified to be 50 meters long and 5 meters high. The modification of the groyne building by the addition of the building length made it difficult for fishermen to enter the fish landing port area at Puger Beach. The fishermen protested to the Provincial Maritime Service questioning the performance of groyne on Puger Beach. The groyne was finally cutted after the demonstration. Based on these problems, tidal numerical simulations were carried out to determine differences in sea level conditions and flow velocity, on two conditions, namely when the groyne exist and when it does not. The modeling tool in this study uses Delft3D software.

Several studies of flow velocity in Puger Beach have been carried out. A study concluded that the existing breakwater structure still allows large waves at the entrance of the channel and causes a large current speed [1]. Another study showed that breakwater design and layout were effective in reducing waves [2]. Related research on groyne showed high morphological activity in the groyne field associated with flood discharge [3]. Significant sedimentation occurred in the observed area, whereas sedimentation in the deeper areas of the groyne field was less visible. The pattern and rate of sedimentation in the groyne field, to some extent, were found to be affected by various types of groyne and associated flow patterns. Another study showed that groyne arranged from large to small at an angle of 45◦ reduced the scour depth to 55%, and setting from small to large at an angle of 135◦ reduced

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the scour depth to 72% [4]. A study related to groyne shape concluded that T-head groyne is better than a straight groyne head at a river bend [5].

Objective of this study is to determine difference in sea level conditions and flow velocity, on two conditions, namely when the groyne exist and when it does not. This study was different from another study because the unique condition of study location in Bedadung River and groyne which are located close to the estuary. This condition causes the groyne to be affected by tidal condition.

RESEARCH MATERIALS AND METHODS

Research material

Tidal data utilized in this study was obtained from the results of measurements and sampling in the field by a consultant company on April 26 to May 10, 2012 at Puger Beach. Bathymetry data used in the is study: National bathymetry maps taken from BIG (Geospatial Information Agency).The data accuracy is 6 arc-second. It was an assimilation of breed data in shallow water and coastal areas. Groyne dimension data was obtained from UPT P2SKP Puger

Research method

This research uses descriptive research method which examines a condition in nature with a systematic interpretation. The implementation of this research was divided into three stages, namely the initial stage which included the preparation and data collection stage, the data processing validation, and the final stage which included simulation of two cases, model with and without groyne, and drawing conclusions

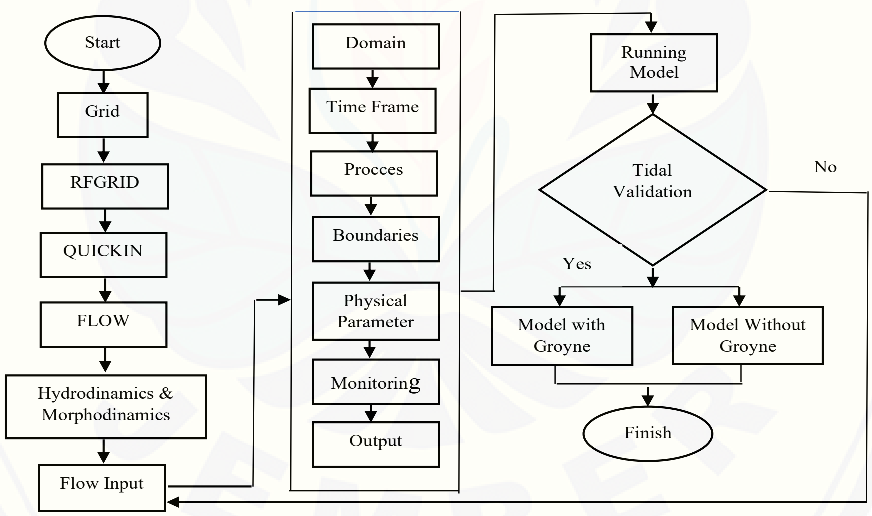

FIGURE 1. Framework of numerical modelling.

As seen in Figure 1, the implementation of this research was divided into several stages. The initial stage was preparation stage including the construction of simulation grid with 40-m resolution using Delft3D-Dashboard. Bathymetry data was interpolated into the grid using QUICKIN. Other input files were inserted in Delft3D-Flow including simulation parameters. Numerical simulations were conducted using Delft3D-Flow. After the simulation was validated using tidal data, the final stage which included the simulations of two cases was conducted.Model 1, designed to model conditions with groynes. Model 2, designed to model conditions without groynes

Numerical Model

Numerical models in coastal environments have been widely used by researchers throughout the world. The range of utilization is about marine renewable energy, coastal processes, contaminant transportation, and even for port planning or tsunami coastal infrastructure, and the potential power of other tidal currents as well. For this study, numerical modeling is proposed to show the effects of tides and flow patterns on Puger Beach. Some modeling tools that are well-known in coastal environments are MIKE, Delft3D [6], SMS, and others. Specifically in this study, Delft3D was chosen because it provides an open ware version for research activities and Delft3D has become one of the leading tools in multipurpose hydrodynamic modeling in the world

Model description

Delft3D is one of the leading tools in hydrodynamic modeling for coastal, river and estuary areas. This tool is able to simulate the phenomena of flow, sediment transport, waves, water quality, and others. Delft3D-FLOW used in this study is a module in the Delft3D package. This uses and solves the Navier Stokes equation for incompressible fluids, in shallow water and Boussinesq's assumptions.

This study aims to see the impact of the construction of groyne construction by analyzing flow velocity in the Puger Estuary. The analysis of changes in flow velocity on the condition of the model without groyne, and models using groyne are carried out. The hydrodynamic study is carried out with a 2D model using Delft3D version 4.01.01.The input data needed for the simulation is obtained from field measurements and the Provincial Maritime Service such as bathymetry, tides and groyne dimensions. To simulate tides. Delft3D-Dashboard and Delft3D-QUICKIN are also required to build simulation grid and to enter depth data. Simulation result are validated with tidal observation data. A grid of numerical models is designed as a uniform rectangular grid. The domain grid size is 40 x 40 m, and the number of cell grids in the domain is 8,832. Simulation domain is shown in **Fig 2.** In numerical simulation, groyne is represented as higher ground with elevation. Observation points are located around the groyne as shown in **Fig 3**.

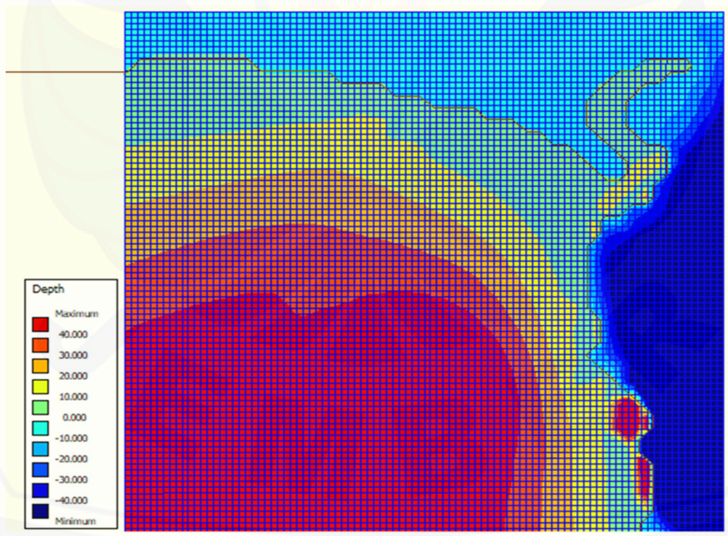

FIGURE 2. Simulation domain

FIGURE 3. Observation point

Result and Discussion

Tidal elevation validation

Location of tidal observation data is X = 772773.562; Y = 9072266.515. Comparison between water level from the simulation results and the observational field data is shown in **Fig. 4.** Discrepancy between model result and observation data are calculated using the average absolute error formula as defined in Eq (1). An error of 1% is obtained from the calculation. From an error of 1%, it can be said that the simulation data and the actual data are valid. Following are the validation results of the simulation results and the actual data:

$$\text{Error}=\frac{[\text{Model data-field data}]}{\text{Tidal range}} \tag{1}$$

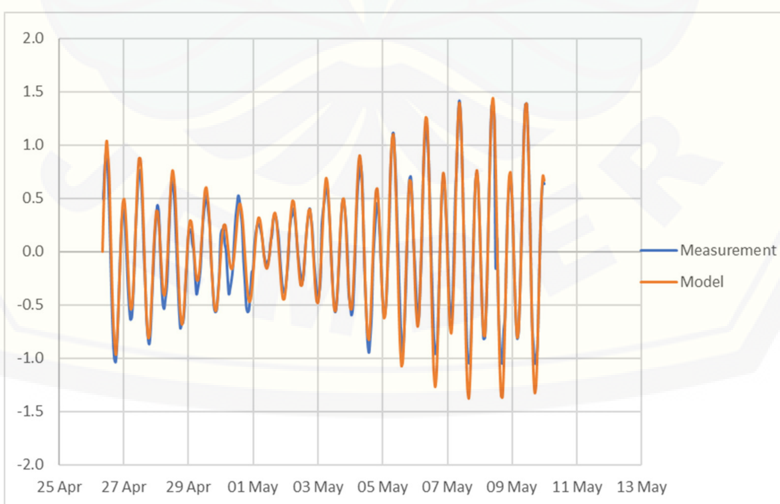

FIGURE 4. Comparison between water level from simulation results and field observation data

Water level

The model was simulated for 15 days on April 26 - May 10, 2012.The results obtained from the simulation model show that the highest water level for model with groyne reached 1.46 meters (**Fig. 5**), while the lowest tide of the model with the groyne elevation value reached -1.37 meters. The results obtained from the simulation model show that the highest water level for model without groyne (**Fig. 6**) reached 1.36 meters, while the lowest tide of the model with the groyne elevation value reached -1.2 meters.

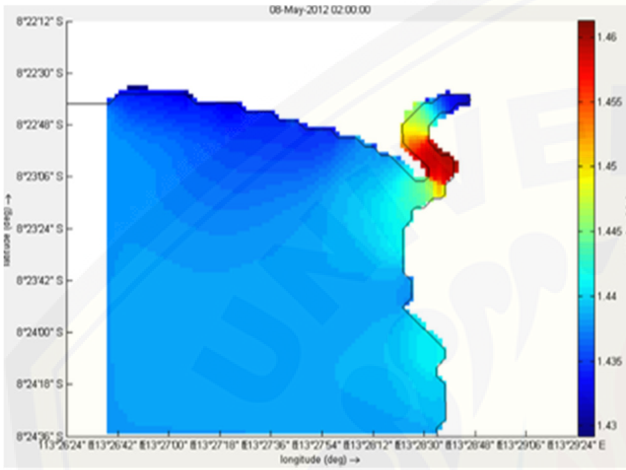

FIGURE 5. Water level of the model with groyne at the highest tide

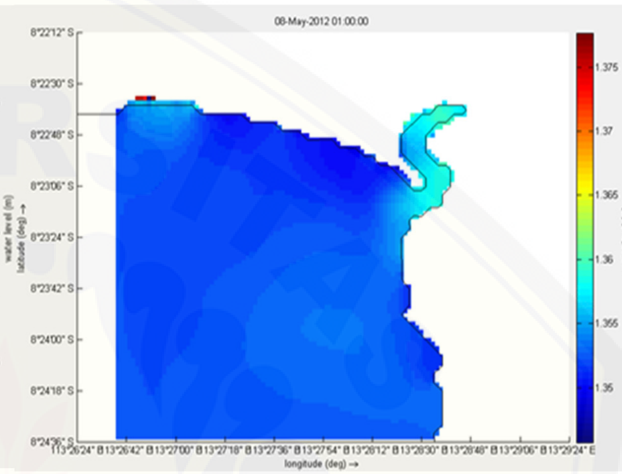

FIGURE 6. Water level of the model without groyne at the highest tide

Flow velocity

Based on the simulation results of the flow velocity for 15 days, the maximum value of the flow velocity and water level is taken at the five observation points shown in **Fig. 3**. The maximum values of flow and maximum values of water level for each case is shown in the table. **Table 1** shows results for model with groyne while **Table 2** shows results for model without groyne. The results show that maximum velocity of the model with groyne is 0.204 m/s which is higher than that of the model without groyne (0.102 m/s).

TABLE 1 Flow velocity and water level for model with groyne

Observation Point	Flow velocity Maximum (m/s)	Water level Maximum(m)
(81,62)	0.114	1.435
(81,64)	0.018	1.441
(82,62)	0.204	1.437
(82,63)	0.134	1.440

TABLE 2 Flow velocity and water level for model without groyne

Observation Point	Flow velocity Maximum (m/s)	Water level Maximum(m)
(81,62)	0.125	1.440
(81,64)	0.096	1.440
(82,62)	0.102	1.440
(82,63)	0.086	1.440

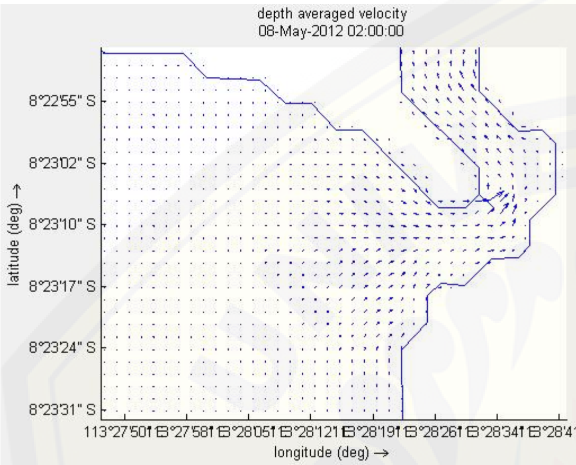

FIGURE 7. Depth average velocity condition of the model with groyne at the highest tide

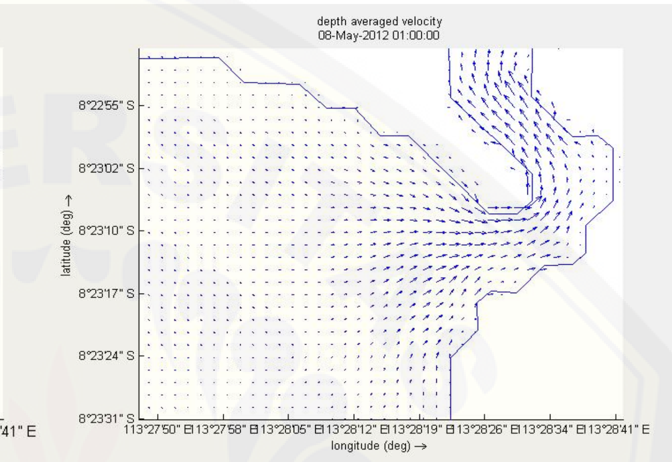

FIGURE 8. Depth average velocity condition of the model without groyne at the highest tide

Flow velocity

Based on Delft3D simulation results, the highest tide of the model occurred on 08-05-2012 at 01.02-01.04. The following is an illustration of the flow velocity of the model using groyne and models without groyne in 1-minute intervals:

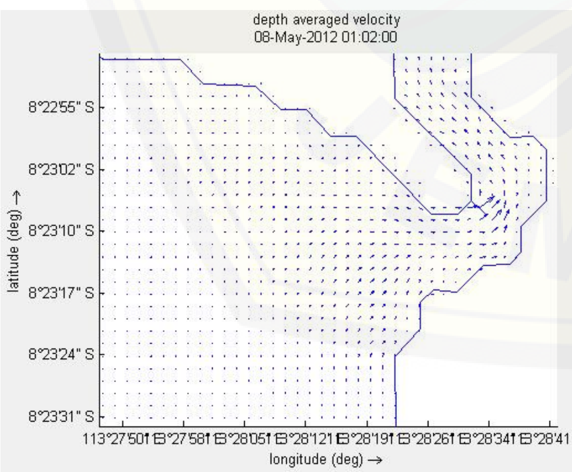

FIGURE 9. Depth average velocity condition of the model with groyne at 01:02

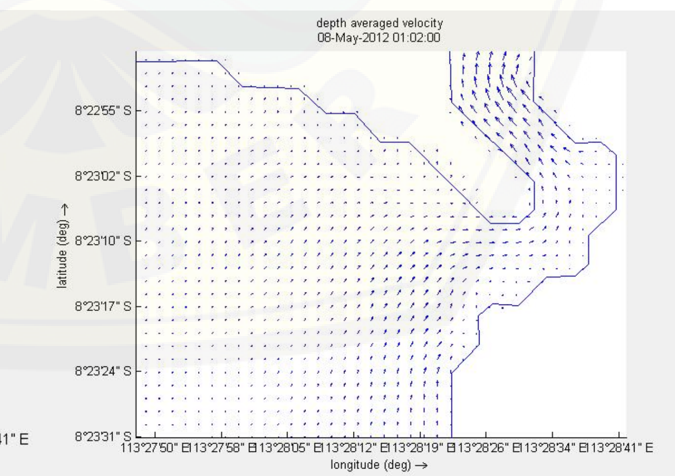

FIGURE 10. Depth average velocity condition of the model without groyne at 01:02

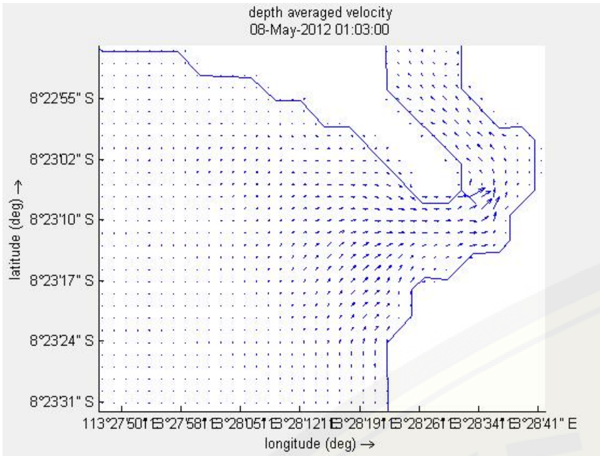

FIGURE 11. Depth average velocity condition of the model with groyne at 01:03

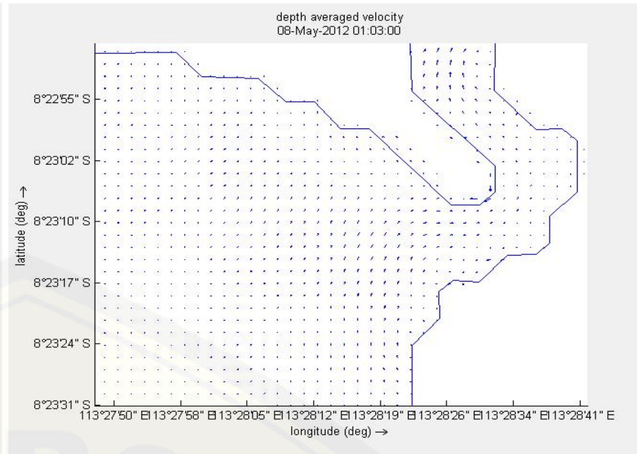

FIGURE 12.Depth average velocity condition of the model without groyne at 01:03

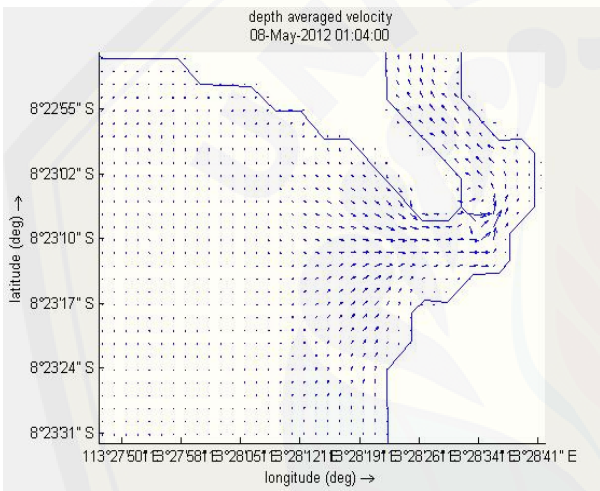

FIGURE 13. Depth average velocity condition of the model with groyne at 01:04

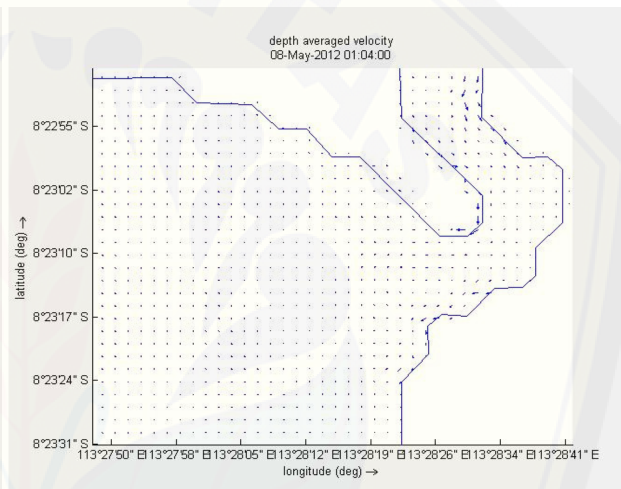

FIGURE 14.Depth average velocity condition of the model without groyne at 01:04

Fig. 9-14 show spatial variation of flow velocities at representative time steps. The size of flow velocity is represented by the length of the arrow. At 01.02, the difference between the two models was clearly visible. **Fig. 9** shows higher flow velocities around the groyne than the flow velocities at the same location without groyne that was shown in **Fig.10**. At 01.03, the flow velocity of the model with groyne in **Fig. 11** has increased compared to the previous 1 minute and in **Fig.12** the flow pattern of models without groyne has decreased in speed. This condition was shown by arrows that are getting smaller than the figure 1 minute before. **Fig. 13** shows the flow velocities for the model with groyne at 01:04. The figure shows flow velocities that higher than 1 minute before. This is different from **Fig. 14** that show smaller amplitude of flow velocities that that of the model with groyne at the same time.

From the discussion above, the difference of flow velocities between the model with and without groyne are shown. It is shown that the flow velocities for the model without groyne are generally smaller and more stable than that of the model with groyne.

CONCLUSION

Two numerical simulation cases were carried out for 15 days at Puger Beach, Jember. The simulation is well validated with tidal data. Based on the simulation, the results show that water level at the observation point in models with groyne is higher (1,437 m) than water level at the observation point in models without groyne (1.440) m). In the case of flow velocity, it is shown that maximum velocity at the observation point on the model with groyne (0.204 m/s) is higher than maximum velocity at the observation point of models without groyne (0.102 m /s). From the spatial variations of flow velocities at representative time steps, it is also confirmed that flow velocities for the model without groyne are generally smaller and more stable than that of the model with groyne.

REFERENCES

1. Widiyanto H. 2004. Perencanaan Pemecah Gelombang Pada Pintu Masuk Kolam Labuh Pangkalan Pendaratan Ikan (PPI) Puger Jember. Skripsi. Surabaya: Jurusan Teknik Kelautan Fakultas Teknologi Kelautan Institut Teknologi Sepuluh November Surabaya.
2. Yuliamangesti, A.A. 2017. Evaluasi Kinerja Bangunan Pemecah Gelombang (Breakwater) Di Pantai Puger Jember. Jember: Universitas Jember
3. Henning, M dan B. Hentschel. 2013. Sedimentation and flow patterns induced by regular and modified Groyne on the River Elbe, Germany. Ecohydrology 6: 598–610
4. Choufu, L, S. Abbasi, H. Pourshahbaz, P. Taghvaei and S. Tfwala. 2019. Investigation of Flow, Erosion, and Sedimentation Pattern around Varied Groyne under Different Hydraulic and Geometric Conditions: A Numerical Study. Water 2019 11: 235
5. Dutta, D dan H. M. Kalita. 2013. Performances of Straight Head and T-head Groyne as River Training Structures. International Conference on Mechanical and Aeronautical Engineering. 491
6. Deltares 2014 Delft3D-Flow, Simulation of multi-dimensional hydrodynamic flows and transport phenomena, including sediments (Netherlands: Deltares) p 186,679