

Numerical Simulation of Contamination Distribution in Bushehr Bay

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Abstract

Bushehr Bay plays an important role in environmental contamination of the Persian Gulf region because of different factors such as industrial contaminations or pollution from ship traffic, oil pollution, waste and toxic discharge or domestic wastewater. Therefore, it is needed to recognize and study the way of distribution of these contaminations. To do this, the COHERENS model has been used for modeling and studying contamination of Bushehr Bay. For the input of the model, data recorded in marine weather stations of Bushehr in a forty-year statistical period and four main tidal components of Bushehr port. After regulating the model for Bushehr Bay and inputting the required data, the model was performed and then the way of contamination distribution was predicted in different layers after reaching to a steady state and was validated by field observations. The study results show that contamination distribution mostly occurs under the influence of tidal flows in Bushehr Bay and they well agree with the result from the field observations. The model result can be used for the contamination distribution way and path of the pollutant flow in Bushehr Bay and also can be used to find out a good strategy to fight more distributions.

Keywords: contamination distribution, Bushehr Bay, COHERENS, Numerical Simulation

1. Introduction

Influx of some pollutants like industrial, ships, petroleum resources, wastes, poisons, and home swages plus the environmental problems cause some negative impacts on water quality and marine resources and oil is the most important pollutant of the seas. The source of about 90 percent of oil pollution is the maritime activities whether ship traffic, discharging water balance of ships, drilling and oil exploration. Bushehr coastal water has a special importance because of transportation and oil transition, so there are many different ways of pollutant pervasion.

1.1 General Description of COHERENS Model

The current work aims to present new and more complete results of hydrodynamic investigations of Bushehr Bay using an advanced hydrodynamic model: resuspension. COHERENS is a 3D finite-difference multi-purpose numerical model for coastal and shelf seas, which is coupled to biological, resuspension and contaminant transport models and can resolve mesoscale to seasonal scale processes. In this work, we are focusing mainly on physical aspects of the lagoon dynamics as an important background for the future investigation of nutrients dynamics, biogeochemical processes and contaminants transport in Bushehr Bay. In order to do so, here, the model that can forecast the pollutants pervade and move is required.

2. Data and Material

2.1. Study Area

The study area is Bushehr Bay that according to hydrographic map used in this paper has the extents of about $25 \times 16 \text{ km}^2$ from longitude of east 50 degrees and 42 minutes to east 50 degrees and 52 minutes and the Latitude of northern 28 degrees and 52 minutes to northern 29 degrees and 5 minutes (Figure 1). It's surrounded from north and east to Sheef Island and lowlands of Bushehr port and in the eastern south is connected to Lashgari and Soltani estuaries and from west and western south is connected to sea (Figure 1).

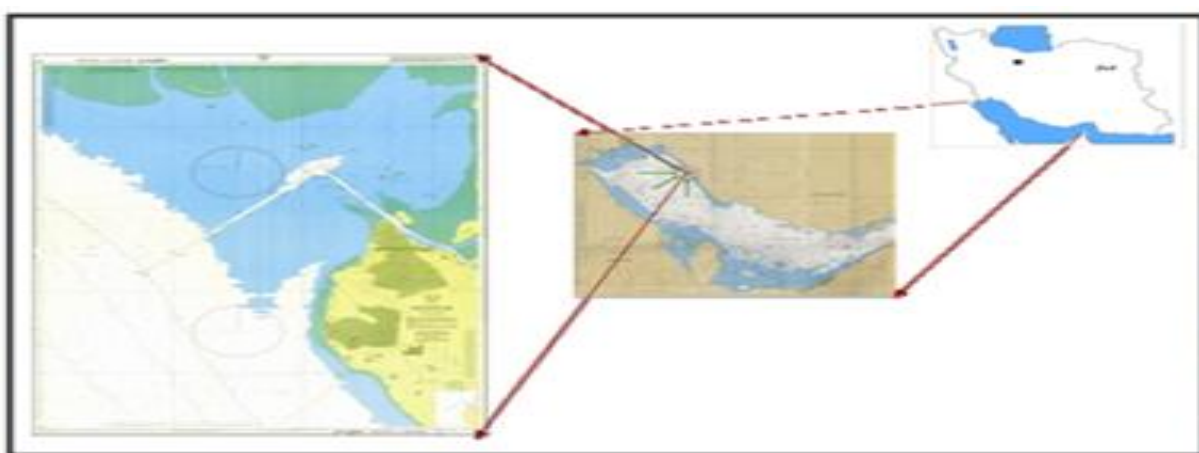


Fig1: The position of Bushehr Bay, Sheef Island and the access channels of the port

2.2 Theory and Background

This paper presents the theory and application of the model to Bushehr Bay, and illustrates the use of the model to study the behavior of pollutants within the system and the potential wider application of such models as an environmental management system.

In this study the pervasion of pollutants in Bushehr Bay with COHERENS the three dimension hydro dynamical modeling has been studied. In this model the tidal and friction forces and density changes simultaneously applied.

This model uses “Arakawa C network” for discretion of equations in horizontal direction and “vertical Sigma array” (Equation 1) for vertical direction that uses finite difference to solve equations (Kummar and Kakrani, 2000).

$$\tau = \frac{L_3 + y}{\delta + y} \quad (1)$$

Where L_3 is the vertical component vector in every point and $L_3=0$ is the average surface level of sea. δ is deflection from static leveling and y is the real depth of the water.

3. Research Methodology

3.1 Model Input

The Bushehr Bay hydrodynamic model was forced by considering: tidal and wave induced water surface changes and heat and salinity fluxes at open sea boundary, impact of river discharges and precipitation, surface shear stress and bottom friction, and surface heat fluxes depending on solar radiation, air temperature, relative humidity and cloud cover. Atmospheric parameters used in this model including wind speed, air temperature, relative humidity, cloud cover and rainfall as to marine weather station of Bushehr in a statistical period of 40 years from 1969 to 1999. The temperature and salinity of model open boundary has chosen according to temperature and salinity data simulations of COHERENS model in Persian Gulf that is matching with monthly hydrographic observations of “Alessi et al” in 1999. Also the amplitude and phase of four main components of tides (K1, O1, S2, and M2) as to Bushehr port in open boundaries of model has been intended. At last Navier-Stokes equations has been used for currents’ modeling (Jassim and Shatti, 2000). For verification of Bushehr Bay designed model used from available patterns of JAHADE-TAHGHIGHAT-AB-VA-ENERGY Company. This company had done some studies about the path of boats while the high tide and low tide occurs in the summer of 1379 for a better understanding of tidal currents. Finally by ensuring of good matching between models with reality, we forecasted pollutants pervasion’s patterns considering three pollution sources in different points of Bushehr Bay the time period of 7 days and 14 days after starting pollution.

4. Results and Analysis

From the results, currents move when high-tide occurs in outer channel position from south and western south to north and eastern north until some of that enters to the Soltani estuary and some other goes to northern coast of Bushehr Bay. From the results of tracking boats when low-tide occurs, the currents approach from Coast of Sheef Island to channels and pass from inner channel parallel to outer channel. Then some of the currents move to west of Bushehr gulf in outer channel and some other move to south parallel to Bushehr port. In figure 2 the maximum and minimum points of water surface level (A, B, C and D) minimum current measurement has its own value, because these points have threshold of current change from flux to ebb and inverse (slack water condition). In the time period between points of A and B and by increasing the depth of water surface level, the average pattern of flux current is in the surface level. After verification of model with reality, for understanding the state of pollutants pervasion pattern addition of the pollution source, two other source considered in the entrance

of Soltani estuary and end of outer channel and check the pattern of any pollution during 14 days. Figures 4 and 5 shows the position of other pollution sources in the surface and sugared levels when the infection starts until 14 days.

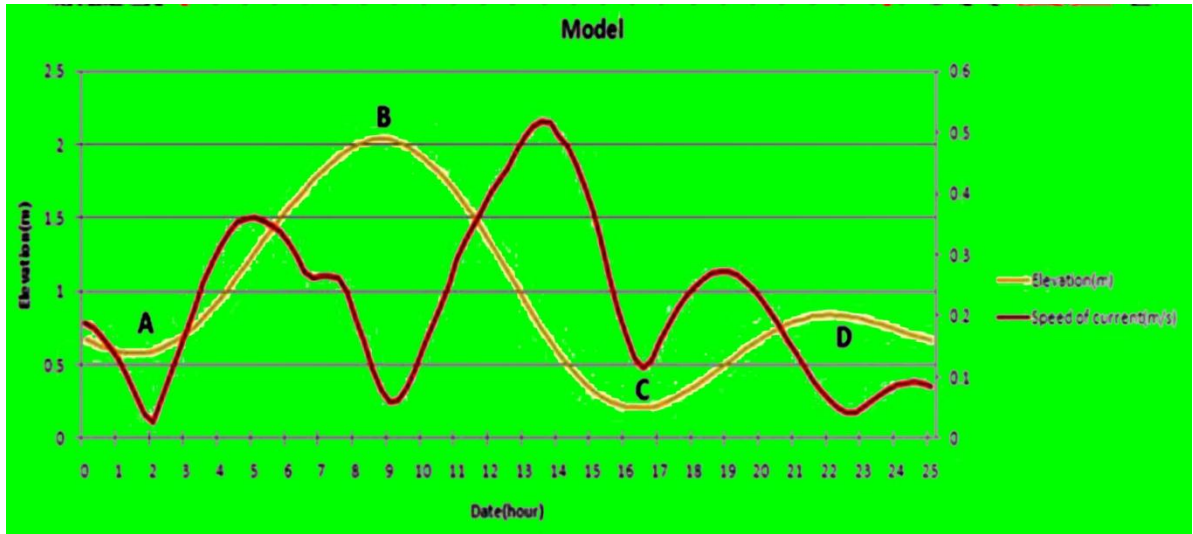


Fig2: Oscillation of water surface level and the current size from the model in a tidal period

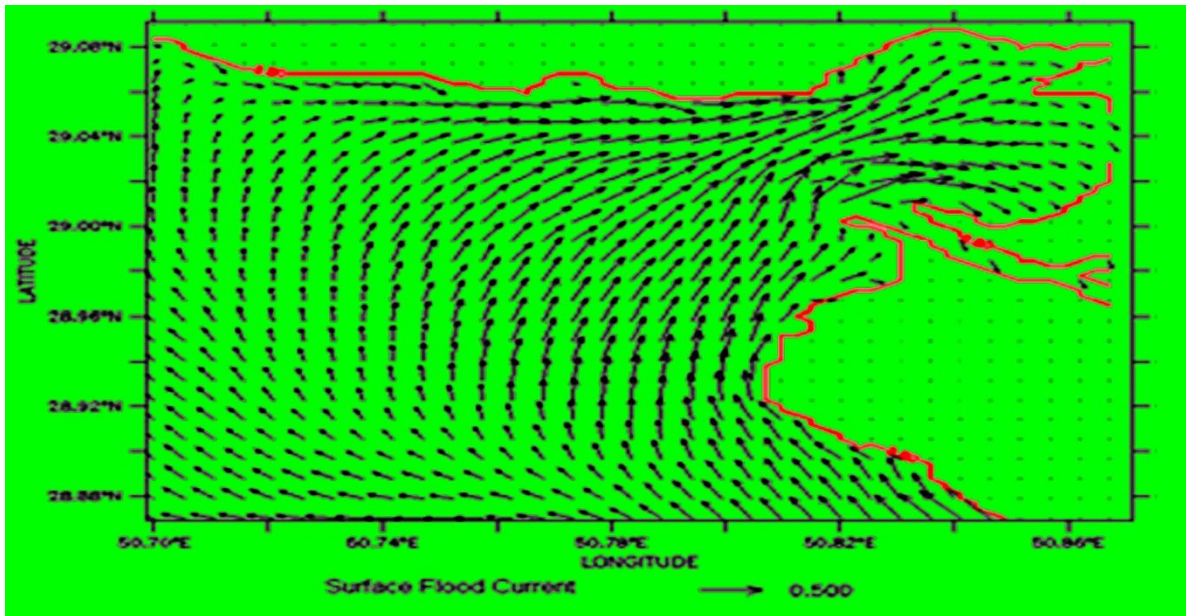


Fig 3: Average pattern of surface flux in Bushehr Bay

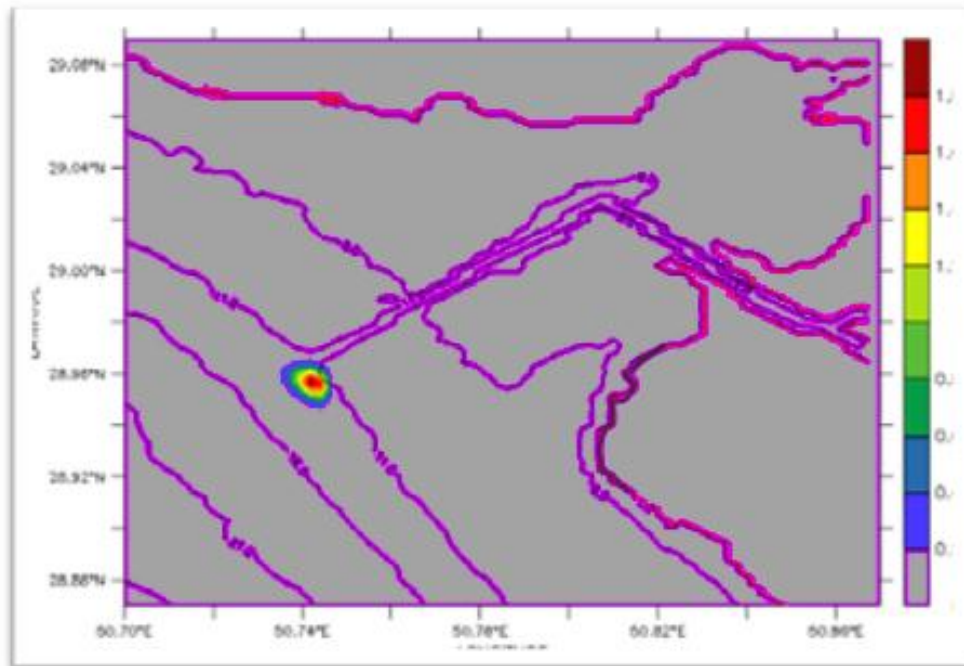


Fig4:Starting moment of polluting in the end of outer channel on the surface level

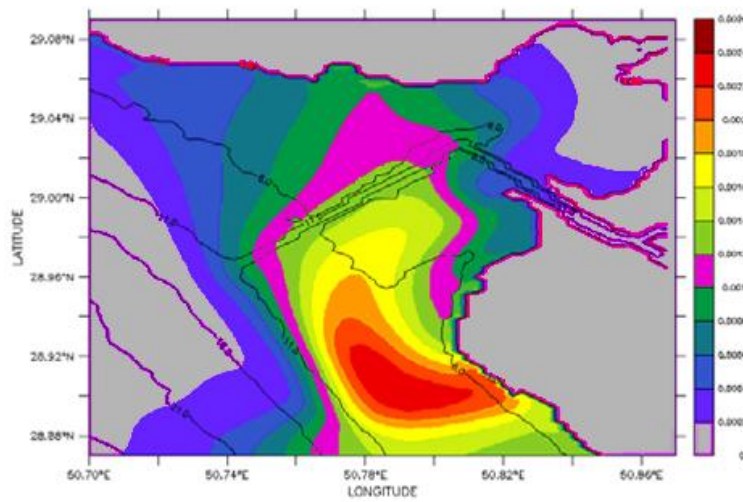


Fig5:The day after starting polluting in the end of outer channel on the subgrade level

5. Conclusions

Surveying the results of modeling show us that the pattern of Bushehr Bay currents often affected by tides and tracking of boats approves this.

The model used in this study forecast the ways the pollutants pervade with very good accuracy. We can forecast and track the pollution pervade in the marine environment of Bushehr Bay by using the results of model and then providing a good solution to avoid wasting time and money. By the way this study can be a base for the future studies.

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