Extended abstract


In recent years, several initiatives aimed at the conservation and preservation of a balanced environment increased significantly with laws applying penal and administrative sanctions derived from conduct prejudicial to the environment.

Arraial do Cabo, RJ, Brazil, is the city chosen to be the study area of an economy focused on port activities, fishing and tourism, with paradisiacal beaches with incommensurable beauty scenic.

According to Brazilian law, port facilities must have plans for oil spill incidents in waters under national jurisdiction, which is a document containing specific information and describes response procedures regarding an incident.

The Institute of Marine Studies Admiral Paulo Moreira (IEAPM), also located in Arraial do Cabo, has become a military organization potentially polluting with their ships and vessels applied in research.

In order to establish strategies for prevention and coordination of response actions in the management of environmental impacts in IEAPM, as well as, the upgrade of the institute Individual Emergency Plan (PEI), this study seeks, through computer modelling tools, verify the possibilities of drift from oil spill in the harbour of Arraial do Cabo.

The work has as main objective to evaluate the results of a plume of contaminants formed by oil spill scenarios through an environmental modelling system to assist Executive Commander in response actions in Arraial do Cabo harbour.

Specific objectives of this study are the ones described as follows:

→ to validate the hydrodynamic model to the data provided by an Acoustic Doppler Current Profiler (ADCP) installed in the region;
→ describe the pattern of hydrodynamic local circulation;
→ to evaluate the results and establish prevention and management strategies of the impacts from an oil spill;
→ to show the potential contamination zone, considering the currents generated by tidal with typical local winds.

The need of application of hydrodynamics models for studies, projects and assistance to the management of water resources is unquestionable, given the complexity of the environment in natural bodies of water, especially in lakes, reservoirs, estuaries and adjacent coastal watersheds.

The numerical results of such a reproduction - or hindcasting - must be compared with measurements. If a close correlation demonstrates the validity of the theory, this hydrodynamic-numerical method may finally be used to forecast the dynamic process of the sea, thus finding its practical application (RAMMING, KOWALIK, 1980).

This study presents the implementation of a hydrodynamic model and transport of contaminants to analyse the risks from an oil spill in Arraial do Cabo harbor.
Initially, the digital terrain model was produced using data from the mesh discretization, bathymetry, equivalent roughness and the land and sea boundaries (chapter 5).

The hydrodynamic model was forced by wind and tide data as boundary condition and then the calibration was performed. The model was validated through current and temperature Acoustic Doppler Current Profiler (ADCP) data, moored in the period of July 08 to September 09 of 1999 (chapter 6).

The Lagrangian dispersion model consists of the boundary condition, the type of oil, spill volume, the leakage scenarios based on local winds and the definition of the initial area of the stain (based on Fay models). Oil weight loss is simulated by using the computer program ADIOS2 from NOAA (chapter 7).

In the preparation of models, we used the Data-base Environmental Hydrodynamics System (SisBaHiA®), which is a professional system of computer models that are in continuous development in the Institute Luiz Coimbra of Studies and Research of Engineering from the Federal University of Rio de Janeiro (COPPE / UFRJ).
In this work, we utilized the 9aS13G12 version (64-bit). Among the existing models of the system we use the hydrodynamic model, and transport model Lagrangean advective diffusive.

The SisBaHiA® has a hydrodynamic model of 3D FIST lineage (Filtered in Space and Time 3D), optimized for natural water bodies.

3D FIST lineage represents system modelling bodies of water free surface composed of a series of hydrodynamic models in which the modelling of turbulence is based on filtering techniques similar to those employed in simulation of large vortices (LES - Large Eddy Simulation).

3D FIST version solves the complete Navier-Stokes with the approach for shallow water.

In the Lagrangean model, the transport of contaminant mass is simulated through particle motion launched, that are carried by current generated by hydrodynamic model, dedicated to observe the path of the particle, as opposed to observation of the movement as a whole.

The Lagrangean model is ideal to simulate the transport of scalars that may be floating, mixed or occupying only one layer in the water column, making it more suitable for simulating the transport of oil or contaminant plume which are small in relation to the domain of the hydrodynamic model or that have strong gradients (ROSMAN, 2015).

In this work, we have obtained some conclusions that follow down.

Tests conducted with intention to validate the computational model showed good relation between the results obtained with the model and the data from the ADCP (figures 32, 33 and 34).

Significant correlation between tide and currents, both Zonal component (U) and the Meridional component (V), was very clear (figures 26 and 27).

The hydrodynamic circulation pattern in the study area has significant influence of mesoscale wind which is the generator of the external current being modulated by the tide, i.e. the currents of intense mesoscale governing direction of movement. In situations where external dynamics is weak, the dominant currents are generated by the tide (figure 37 to 47).

The current regime in ADCP anchoring site, near the Boqueirão Sul, shows the existence of two main directions, NE and SW, with a predominance to
SW flow. The NE currents are less frequent, but more intense, usually associated with the pass of cold fronts (figure 35).

The occurrence of upwelling phenomenon in the studied period induced by intense winds quadrant NE (figure 15), with temperatures ranging between 13 and 18 °C, was observed.

It has been identified that the action of NE quadrant winds cause a lowering of the Mean Sea Level (MSL) and the action of the SW quadrant winds cause the water stacking along the coast and, consequently, the lifting of MSL (figures 36, 40 and 44).

The spill simulations demonstrated by the probabilistic model showed that there is a big possibility of oil slick drifting and affecting the whole Anjos Bay; with a less possibility (maximum 20%) to pass in Ponta d’Água, Forno Bay and Porcos Island. Another portion of oil is drifting to NE (maximum 15%); with a reduced chance (5%), the slick would head to Boqueirão Sul reaching the Cabo Frio Island (figures 52 to 55).

Probabilistic model fits well to the wind patterns in the wintertime provided by weather station in IEAPM, in percentage terms. SW quadrant winds have a frequency of approximately 20% in weather station (figure 18). This similar value demonstrated in the model, shows that, due to the current in Angels Bay being less intense, the circulation is predominantly generated by the wind. It has a fundamental importance in the oil spill (Figure 55).

The main consequences of the spill in the Arraial do Cabo harbour (EAC), with respect to socio-economic activities, may result in disruption of port activities, local fishing activities, tourist rides for sightseeing and diving activities. The temporary cancellation of such activities involves serious losses to the local economy.

Regarding environmental impacts, an accident would cause undesirable effects on four compartments, namely: beaches, rocky shores, water column and benthic environment.

**Keywords**

Hydrodynamics Modeling; Response Actions; SisBaHiA; Arraial do Cabo.