The research on Ntot pollutant dispersion provoked by wind-driven currents

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Abstract. The paper uses the research means of numerical simulation for the current environmental pollution problem of the ocean dumps from offshore industries, which is concerned by the coastal countries. The article analyses and predicts the hydrodynamic feature of study area on the basis of Mike3 numerical model. It places emphasis the effect of wind-driven currents to the Ntot pollutant diffusion, the factors include the size of the wind-force, vertical stratification and different waste water movement at different depth and different mixed conditions. These changes will affect the vertical limitation, waste water diffusion and seasonal differences.

1. Introduction
The sewage point B3 locates in Guangxi Tieshan Bay. The position of study area is shown in Fig 1. Tieshan Bay is a table-land and submerged-valley bay in the funnel shape with north-south orientation. It is the depression structure drowned by the lifted sea level in the post frozen age, so it has 40km long (from the bay's top to the shoal) and 3~4 km narrow tidal channel[1].

Since the sewage outfall in the sea will form a mixing zone, according to the requirement of environmental protection regulations, the mixing zone can not affect the function of adjacent functional zones[1], and the water quality around sewage outfall required to sustain the No. Class III grade quality according to “marine water quality” (GB3097-1997). So this study need to predict the concentration of outlet contamination and analyze the affection to the accepting water.
2. Mathematical Model

2.1. Research methods
It is applied by the Estuarine and Coastal Ocean Model (Mike). This model can simulate tide, waves, tidal current, water quality and ecology in coastal and estuary areas. Hydrodynamic module is built on the basis of N-S equations, used finite difference (semi-implicit) numerical solution of the \( \sigma \) coordinate equations for the discrete solution. Continuity equation for three-dimensional flow motion, momentum equation, mass conservation equations and convection-diffusion equations refer in the literature [2]. Mike water quality model [3] is based on hydrodynamic simulation; make use of the principle of conservation of mass, considering the transportation and the distribution of the material due to convection, turbulent diffusion [4-5] and so on, to calculate the concentration of the diffusion of pollutants.

2.2. The selection of parameter in simulation
The seasonal difference of waste water diffusion reflects the difference of the monsoon direction. According to the average years of statistical information of North Sea area, the winter monsoon wind mainly considers the impact of N wind. Under the condition of 6 speed 10.8m/s near Tieshan’port, it is simulated by the effect on water quality after the sewage discharge into sea.

2.3. Simulating analysis of the tidal current
1. wind-driven current's influence on velocity
   (1) Surface-layer current velocity
   With the strong wind, the surface of the sea-water will form wind-driven current under the effect of the press. The wind-driven current has interaction with the tidal current; flow field shows different change characteristics according to the different wind and current direction. The wind and the current direction are reverse when the flood tide current of the sea facing the wind from the north. Compared with the case without wind, tide current of the windward and countercurrent is decreased. Among them, the velocity of 1# section decreases 8%-43% at most, 2# section decreases 13%-30%. The decreasing trend is larger and larger from mouth of the river to the outside. The direction of wind and
current are the same when the tide is falling. Therefore, the velocity is added to 5%-13% when the tide and the wind direction are same.

2) Mid-layer current velocity
According to the continuity and incompressibility of the seawater, the mid-layer velocity with its opposite way to change the surface-layer velocity, forms a closed loop.

The flood velocity of 1# adds 5%-31%, the 2# adds 8%-23%. The ebb velocity of 1# reduces 2%-10%, the 2# reduces 4%-7%.

3) Bottom-layer current velocity
There’s no difference and influence on bottom-layer velocity after the wind-driven current of N wind influence.

2. The effects on wind-driven current to direction

(1) Surface-layer current direction
The north wind is the offshore wind. During flood and ebb tide current direction are secund to the east by the stress of N wind. The current direction of 1# section changes 16°-46°. The greatest change in direction is near the 1-5#, 2# section changes 19°-25°. The change of 1# section are 14°-39° in ebb tide, the largest change is near 1-7#. The current direction of 2# section is secund to the east 17°-20°.

(2) Mid-layer current direction
The strong winds have little influence on the current direction of mid-layer in the sea. Flood and ebb tide current direction change 1°-2° after the process of N wind.

(3) Bottom-layer current direction
Bottom-layer current direction is unchangeable after the process of N wind.

In conclusion, the variety of velocity is reflected as follow. As the flood current of N wind (offshore wind) is reduced, the ebb current is added.

3. The diffusion of the pollutant Ntot under the condition of wind-driven current
To illustrate the impact of sewage discharge on sea water quality, this article assumes one kind of discharge concentration of Ntot to predict and analyse (according to background information, the background concentration of Ntot is 0.18mg/L). The sewage emissions amount of 109158m³/d, emission concentration of Ntot of 8mg/L. Projections were calculated by these and superposition of background concentration.

Predicted results shown in Figure 4~Figure 5 and Table 1~Table 2. By the results of the simulation tidal flow, the flow around area of sewage outfall is basically alongshore current, so Ntot is basically showing zonal distribution. After sewage from the diffuser into the seawater the results showed that
the middle-layer has the largest influence distance and the smallest at the surface-layer. At 0.2mg /L concentration, the middle-layer enveloping is far than the surface about 1104m.

Table 1. sewage discharge of Ntot analysis on sea-water environment.

| Emission concentration space | ≥0.5 mg/L | ≥0.4 mg/L | ≥0.3 mg/L | ≥0.2 mg/L |
|-----------------------------|-----------|-----------|-----------|-----------|
| surface-layer               | —         | 0.0021    | 0.0067    | 0.043     |
| mid-layer                   | —         | 0.0029    | 0.058     | 0.33      |
| bottom-layer                | —         | —         | —         | 0.0015    |

Table 2. most influential distance(m) under different concentrations of sewage discharge of Ntot

| Concentration increment (mg/l) | ≥0.32 mg/L | ≥0.22 mg/L |
|--------------------------------|------------|------------|
| diffusion direction            | alongshore | offshore   | alongshore | offshore |
| surface-layer                  | —          | —          | 40         | 21       |
| mid-layer                      | —          | —          | 421        | 112      |
| bottom-layer                   | —          | —          | —          | —        |

| Concentration increment (mg/l) | ≥0.12 mg/L | ≥0.02 mg/L |
|--------------------------------|------------|------------|
| diffusion direction            | alongshore | offshore   | alongshore | offshore |
| surface-layer                  | 160        | 65         | 510        | 202      |
| mid-layer                      | 510        | 132        | 1614       | 235      |
| bottom-layer                   | —          | —          | 59         | 31       |
4. Analysis of Ntot of the sewage on sea environment

The result of research shows: the overall sewage in surface, medium and bottom layers reciprocates along the coastline in flood and ebb tides, when the range of motion along the vertical coastline is very small, so it is favorable for reducing the pollutants’ influence on the beach and the sensitive areas. Vertically, the concentration of discharged sewage in lift gets continuously lower, and the concentrations in medium and surface layers near the outfalls is relatively the lowest in vertical direction.
Generally, in vertical direction, the concentrations in characteristic layers near the outfalls are different; and as the sewage continues to mix with the nearby seawater, the vertical concentration gradient is larger (the concentration drops quickly). Ntot has little influence scope that violates the seawater-quality standards in every layer, so it won’t produce direct harm to Yinpan marine culture area, dugong nature reserve and mangrove nature reserve.

5. Summary
The results show that the hydrodynamic conditions and the pollutant dispersion laws of Guangxi Tieshan Port have the following features:

- Under the wind of N, the surface-layer velocity is strengthened. That is more beneficial for waste water mixture between the layers and layers. The result indicates dispersion of pollutants are impacted by the current of surface-layer and mid-layer;
- The rule of dispersion of pollutants is similar to the no wind condition in vertical direction. Vertically, the concentration of discharged sewage in lift gets continuously lower, and the concentrations in medium and surface layers near the outfalls is relatively the lowest in vertical direction. Under the wind condition, the concentration contours is closer to the shore than the condition without wind;
- Under the influence of the monsoon, Ntot has little influence scope that violates the seawater-quality standards in every layer. From the point of view of the port planning, the greatest influential scope of the pollutant dispersion will not have direct harm on Yinpan marine culture area, dugong nature reserve and mangrove nature reserve;

Therefore, the water quality model with wind-driven current can be more accurately determined the environmental objective, which is whether affected by the marine sewage engineering or not. Research methods can be used as a reliable method of environmental research. Research results will help the implementation of the marine environment protection, and also can regard as reference to the environmental protection department.

References
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