Numerical Simulation of Discharging the Wastewater of Chalous City into the Caspian Sea Using Outfall

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Expanded Abstract

Introduction

Coastal towns have specific positions for the possible utilization of sea and tourism attractions. Finding useful methods for sewage disposal at lower costs with higher efficiency and also expanding the capacity of the coastal towns is very important. Releasing residential sewage of Chalous city into the Caspian Sea makes marine environment a source of raw wastewater and these contaminants affected the water body.

The contaminants can pollute fishes, sediments and coastal waters and then transmit to human bodies through the consumption of contaminated marine organisms or by swimming. Many of researchers and experts believe that secondary treatment of wastewater needs a lot of costs and energy and sludge disposal and production should also be continuously monitored. But with proper planning of drainage system for the sea, we can discharge large amounts of sewage into sea with no need to treatment maintenance. Oceans, seas and great lakes have high self-purification capacity to absorb sewer of coastal towns.

There are many types of wastewater discharges into the sea. These are including discharges directly onto the beach, discharges with a short outfall with likely contamination of recreational waters and discharge with an effective outfall designed so that the sewage is efficiently diluted and dispersed and does not pollute recreational areas.

Dilution of the wastewater into the sea have three phases including near-field, far-field and long-term flushing. Generally, the near and far field dilution mechanism strictly disagree that they act separately as an independent treatment service. The outfall system typically consists of tunnel or pipeline, diffuser and ports on the diffuser; in this system the basis is the dilution of wastewater without any problem for the marine environment. Prediction of near field mixing requires understanding of the dynamics of jets, plumes and buoyant jets; a jet is a flow driven by the source momentum flux only, a plume is driven by the source buoyancy flux only and a buoyant jet is driven by both momentum and buoyancy fluxes. Discharges from an outfall diffuser have both momentum and buoyancy and are, therefore, buoyant jets, but the buoyancy flux is usually dominant and ocean outfall discharges can often be approximated as plumes. In this study, the use of outfall as sewage disposing system in the city of Chalous, where is located near the southern coast of the Caspian Sea, has been assessed in term of environmental effects.

Materials and Methods

Mathematical models are now widely used to predict the fate and transport of ocean discharges. This is not possible to simulate these types of discharges with one overall omnibus model, because of the very wide range of lengths and time scales for various mixing processes. Therefore, linked sub-models of the various phases are usually used.

In general, the assumptions used in the modeling of dispersion and dilution of waste water are the incompressibility of flow. The pressure is hydrostatic and molecular scattering is ignored. The theory of mixing zone and near-field models are different by far-field models andthe length scale, entrainment and CFD models. For far-field, the hydrodynamic models were developed in the past few decades to predict increasingly the fate and transport of marine discharges.

There are three basic equations for the discharge of sewage into the sea through an outfall: mass flux, momentum flux and buoyancy flux. One of the common near-field models is CORMIX for analyzing the discharge of various typesinto marine waters. CORMIX is a comprehensive application system for the analysis,

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prediction, and design of outfall mixing zones resulted from discharge of aqueous pollutants into diverse water bodies. It contains mathematical models of point source discharge mixing within an intelligent computer-aided-design (CAD) interface. Its focus is environmental impact assessment and regulatory management. CORMIX has been developed under several cooperative funding agreements between US, EPA, US Bureau of Reclamation, Cornell University, Oregon Graduate Institute (OGI), University of Karlsruhe, Portland State University, and MixZon Inc. during the period of 1985-2007. The major emphasis of the CORMIX system is on the geometry and dilution characteristics of the initial mixing zone including compliance with regulatory constraints as well as predicting the behavior of the discharge plume at larger distances. However, this system has also capabilities to predict the wastewater over long distances in the far-field. CORMIX contains three core hydrodynamic simulation models: simulation models for single port discharges (CORMIX1), simulation models for submerged multiport diffusers (CORMIX2) and simulation models for buoyant surface discharges (CORMIX3). In this paper, the CORMIX2 has been used for predicting and modeling of the discharges from an outfall diffuser; the following items must be respected in the design of a multi-port diffuser: port and nozzle diameters (not too large to cause the sea water to enter diffuser and not too small that waste increase pumping costs), nozzles angle to the seabed in a way to flow horizontally into the water body because of optimal dilution and the outlet port shape of nozzles. This must notto cause friction in the direction of wastewater disposal.

Factors of water contamination are nutrients, bacteria and pathogens, toxic chemicals, organic, heavy metals and suspended solids. Pathogens are the most important factor to design the outfall.It can be controlled by initial mixing, diffusion and destruction by sunlight.

California ocean plan is an instruction to a successful discharge of sewage into marine waters without complications for the environment. This plan limits the level of water quality such as bacterial, chemical and physical properties and also considers some limitations for sewage.

The most important indicator bacterium in sea water and natatorium is Enterococcus. According to the California Ocean Plan, USEPA has limited the levels of coliform bacteria Enterococcus for the 30-day geometric mean to 35 units per 100 ml.The maximum of coliform units in the discharged wastewater to the sea is also limited to 1000 units per 100 ml.

Discharges near environmentally sensitive areas such as coral reefs or shell fishing beds should be avoided. If the diffuser cause rapid dilution and dispersion of the effluent and the waste field transport to critical areas is minimized, only the preliminary wastewater treatment such as milliscreening may be needed. To choose a convenient location for an outfall, the various parameters are effective. These are water depth and the slope of the seabed, type and direction of currents, swim areas, regional water quality, concentration of population, and entry of river waters into the sea; thus, three routes along the coast of the Chalous City are proposed and the proper route and discharge depth are chosen during a process of trial and error.

The worst dilution conditions such as no currents and strongest density stratification must be considered for designing an outfall. Therefore, to obtain the worst dilution case, the model is run for different seasons. Thus, outfall designing takes place based on specifications of the summer season when the currents are minimal and the density difference is the highest value.

Results and Discussion

Diffuser geometrical design is plotted using CorSpy that is one of the CORMIX post processing tools. The diffuser has the length of 50 meters with eleven ports that each port has a T-shaped nozzle with 25 cm height and 50 cm from the seabed. Due to strong density stratification of sea in the summer, the discharged sewage doesn't reach to surface water and becomes stuck in the terminal layers. The distance between the source of discharge and where the plum meets bank is about 6500 meters and due to average speed of the currents, that is 0.058 meters per seconds, the time of reaching to the bank is about 31 hours. Thus, that is more than 24 hours and there is enough time to kill bacteria. According to the results of CORMIX the bacteria reach certain standards within regulatory mixing zone and there are no worries about natatorium area that is the thousands of meters away.

Because of poor density stratification of sea in winter, the discharged sewage reaches to surface water and, therefore, the 100 value of dilution must be checked at that water level; By CORMIX modeling the distance between discharging sewage and where it reaches to surface level is about 120 meters and the dilution value is 250.

According to the results of the modeling, the discharged wastewater meets the bank with a distance about 10 to 25 kilometers from the source with different ambient currents that is adjacent to residential and swimming areas. But as its arrival time is more than 24 hours, there is enough time to kill bacteria.

The model was also tested for the reversal ambient current that is usually occuring on cold days and the plume meets the bank with a distance about 10 to 20 kilometers from the discharging source with different ambient currents. The results of the modeling in terms of average monthly current in summer and winter show that the value of plum dilution when it reaches to water surface in winter and the time the plume meets the bank from the discharging source in summer, are two main parameters for designing of Chalous city outfall.

Conclusions

The goal of this project was to design an efficient outfall that have features such as proper drainage location, sufficient diffuser length, proper discharge depth, safety purposes, economic value, and trustworthiness of the biological, chemical and physical effects. The outfall was designed in the worst environmental case modeling with almost no currents and maximum density stratification in summer. To ensure the proper functioning of the outfall, other conditions were also modeled.

Desired location for installing outfall is chosen according to the parameters like beach slope for decreasing outfall pipe length, flows and wastewater fate in the far field so as not to reach swimming and tourist areas and pollution from streams and existing municipal waste.

The results of the model indicate that in the first movement, sewage discharge is diluted more than 100 times in a few minutes and within 10 meters of the discharge location, all pollutants comply with environmental conditions and adherences to the strictest standards. This amount of dilution is more than a lot of secondary treatments ability.

The major environmental advantages of the project are protection of groundwater from contamination by sewage, elimination of the direct discharge of wastewater into the Caspian Sea and thus improvment of the quality of sea water, removal of the harmful effects caused by sewage sludge dumping, and reduction of energy consumption and thus production of less heat and pollution.

The results of this study also demonstrated that the use of marine outfall in the city of Chalous with some considerations such as preliminary treatment prior to discharge is desired option. In addition, the results indicated that the outfall not only eliminates the environmental problems of wastewater disposing, but it is the most economical method for sewage disposal.

Keywords: Chalous, CORMIX, Marine environment, outfall, wastewater disposal.