A Numerical Study on the Surface Discharge of Ocean Outfall in the Keelung City of Taiwan

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ABSTRACT

In this study, numerical simulations of the ocean outfall were made for the discharge of the wastewater treatment facility on Hoping Island in the Keelung city of Taiwan. Approaches of such a surface discharged buoyant jet are divided into two parts. An integral model is established with the Gaussian assumptions on vertical and horizontal quantities of the excess velocity and the concentration for near field. In which entrainment coefficients are adopted to simulate the mixing mechanism for turbulent closure through the entrainment functions. Next, a far field model is developed by using the moment method, and the Crank-Nicolson scheme is chosen to solve the pollutant transport equation. Finally, results show the dilution and distribution of BOD and SS concentrations.

KEY WORDS: surface discharge; buoyant jet; entrainment coefficient; moment method; Crank-Nicolson scheme.

INTRODUCTION

To promote the sewage sewer popularity of Taiwan, the government promoted the construction of the sewage sewer positively in an all-round way since 2000. So that rainwater sewer is shunted with sewage one, the sewage no longer enters the rivers, and then the rivers can reach the effect to purify. While after collecting process, the sewage still needs to be dealt with after all. A comparatively economic way is to construct an ocean outfall system, and yields to increase the ocean outfall territory of sea area. Then the subject for to construct an ocean outfall system, and yields to increase the ocean outfall territory of sea area. Then the subject for the ocean outfall must focus on how to let it under the good management to prevent the ocean suffering the threat situation of pollution. In order to reach good control of the ocean outfall, it is important to understand the theoretical study of which then making ocean outfall can become economy effective tool of sewage disposal. The discharged ways of ocean outfall can usually be divided into two kinds, one is submerged discharge in the sea and the other is surface discharge along the coast. Generally for the surface discharges, the build cost is relatively low and the construction is much easier. However, since the waste water departs into ocean directly from the coast for the surface discharged type, the pollution of the coast is comparatively apt to take place. So the purpose of this project will study the course of ocean outfall with surface discharged through appropriately numerical simulating, and offer the results as reference to government policy and industry investment. The establishment of integral model for buoyant jet is mainly based on the conception of similar assumption of flow variables on the cross section. And then the governing equations are formed by integrating combined equations of the continuous, momentum and transport pollutant. A lot of researchers devoted much contribution during the developing process. Among those, Morton, Taylor and Turner (1956) proposed an entrainment concept by using an empirical function to close the turbulent mixing of jet, and then became pioneers on the subject of jet integral model. Until the 70s, Fox and Hirst (1971) resulted in an analytical function to describe the jet entrainment from the mathematical derivation. Hence, a two-dimensional jet flow integral pattern has formed in static waters completely. Afterwards, considering the effects of the flowing ambient, Fan (1967) and Abraham (1970) proposed additional entrainment terms induced by ambient flow respectively. That makes the integral mathematical model more to hasten perfectly, and let Hirst (1972) successfully developed three dimensional integral patterns in 1972. After then, many researchers applied this method to investigate the characteristics or parameters of jet flow, concerning such as the suitability of the entrainment function and coefficient, the distinction of flow pattern regime etc. As a whole, the fore-mentioned developed integral models can just be employed properly in the submerged buoyant jet. Although as early as in 1973 Stolzenbah and Harlemanz also developed an integral model suitable for the hot waste water surface emissions, but there are many limitations in usage. Lately, the model of Adams et al. (1975) was clearly the most advanced in its formulation with some attention to bottom interaction and shoreline attachment effects. Up to the year 2007, Jirka proposed an integral model for surface discharged buoyant jet, and which is believed to be with efficient and reliable predictive techniques in such aspect. Therefore in this study we will refer Jirka’s model to simulate the surface discharged buoyant jet in the region of near field.

At the end of the near field, the flow enters the region that convection and diffusion dominate in the flow field. It is no doubt that we can