Submarine Outfall Design Methodology for Argentinean Coasts

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Abstract
The purpose of the following is to introduce why it is important and how we propose to improve the conditions of treatment and effluents discharge (urban / industrial / rain) on the Argentinean coasts. It is well known that those directly affect the quality of coastal waters and may have a considerable impact on human health (swimming area) or the environmental quality of coastal ecosystems (such as right whales in the bay of Puerto Madryn). The best ecological and economic way to reduce the harmful effects of wastewater discharged near the coast is a well designed combination of submarine outfalls with diffusers. It has been used and discussed all over the world for decades.Today Argentina is still falling behind other countries in South America such Brazil, Chile or Venezuela that sum together more than one hundred submarine outfalls.
The design of each submarine outfall is a unique case. It is characterized by the size of the city that operates it, the environment (waves, tides, currents, wind), the geometry and the nature of the seabed, the fragility of ecosystems that surround it and the budget. It is in fact important to design each submarine outfall to its application. Thus what we concretely propose here is to improve the knowledge on the capacity of different outfall diffusers and in different environments by measuring the mixing and the initial dilution that it causes. In order to control each variable parameter and to facilitate measurements the work will be part of a laboratory investigation. We will present a methodology based on reliable past studies and specially designed for the Laboratorio de Hidráulica of the Universidad Nacional de Cordoba with its 23m open water channel, its modern instruments (ADV, laser Nd:Yag for PID and LIF techniques) and the known numerical models such as Cormix and Delft3D.
To conclude the following presents a method to meliorate the knowledge on submarine outfalls diffusers capacities in different environments and thus improve the quality of Argentinean coastal waters.

Keywords
Submarine Outfall, Design, Argentina, Model Studies, Dilution, Diffuser

INTRODUCTION

Coastal contaminated water may cause very high health and economic injuries. For example, Esrey et al. (1991) found that the sickness from Diarrhea, Schistosomiasis, Trachoma but also child mortality might be largely reduced if a well-designed basic water sanitation and hygiene interventions were implemented at a community scale.
From a an economical point of view, the loss in the US or in China of water-borne diseases cost them billion dollars per year in medical bills and lost productivity (Bennet et al., 1987, Murphy, 1999 and World Bank, 1997).
In South America and many other places in the world, submarine outfalls have been now largely used and appear to be in most cases, the best costal discharge technology compatible with an eventual treatment in order to satisfy human health and environment conservation.
Based on updated surveys conducted by CEPIS Salas *et al.* 2000 (Pan American Center For Sanitary Engineering And Environmental Sciences), with 2 submarine outfalls, Argentina is still falling behind other countries in South America such Brazil, Chile or Venezuela that sum together more than one hundred submarine outfalls of 500 m or greater.

The design of such a structure has to be specific to the financing and to its location (How many habitants are living in the city that will operate it? Is there a lot of wind/wave is this area? What is the geometry and what is made of the sea bed?). Then, the design alternatives have to be compared and evaluated regarding public health, environmental impact (such as right whales in the bay of Puerto Madryn), the investment costs, and operational demands.
Each submarine outfall is defined by its length, diameter, depth, and its number of ports that are at the origin of the pollutant plume concentration. This concentration *C* (substance mass per unit volume) can be reduced by mixing, transport, decay and transformation processes (Jirka and Bleninger, 2004) which improve then the dilution *S* (Fisher et al., 1979).
In the following methodology, we introduce how we will attend to use the Laboratorio de Hidraulica (L.H.) at the Universitad Nacional de Córdoba (UNC) to investigate on the effects of the combination of different ambient conditions (waves, flow and waves+flow) on the dilution *S*. The combination of these different elements will be based on specific Argentineans real cases (Puerto Madryn, Mar del Plata,…)

INSTRUMENTS AVAILABLE AND DESIGN METHODOLOGY

We propose an experimental investigation of *S* and turbulence but before we explain the methodology that will be used a list of instruments available at the L.H is presented below.

List of the instruments at the L.H.

- A 23 x 0.5 x 0.6 m open channel that is equipped of a wave generator with dynamic absorption (figure 1). The open channel can be modified in order to use both flow and waves.

Figure 1: 23m Open Chanel in L.H. equipped of a wave generator with dynamic absorption

- A 16Hz Acoustic Doppler Velocimeter (ADV) from Sontek®
- A laser Nd:Yag from Danter® and models to use Particle Image Velocimetry (PIV) technique and the Laser Induced Fluorescence (LIF) one.
- Conductivity and pressure sensors.
- Existing Numerical models such as CORMIX, Delft 3d, MOHID.

Methodology

The effects (in Near Field) of waves and flow on *S* and the velocity field will be studied in Laboratory. This means that physical scale will be used and their geometry will be a variable parameter.

Scaling
The equipment available in the L.H. let us to use a geometric scale (in Plexiglas) about 15 of the Mar del Plata submarine outfall. At this scale, the related Froude number *Fr* and Reynolds number *Re* are also doable in laboratory.

Density difference
In the reality the density of waste water ρ_e is close to the fresh water one and is rejected into the sea water which has a higher density ρ_a. This leads to a positive buoyancy of the effluent. Since it is more difficult to prepare a large quantity of salt water than a small one, we will prefer using a salty effluent from the top of the open channel. The results will be then mirrored. However in wavy conditions the effluent has to be at the bottom of the channel. In these circumstances the whole open channel will be filled with salt water (by disolving the proper amount of solid NaCl to the fresh water).

Discharge
The discharge will be made with a head tank above the channel. To ensure a constant flow the head tank will always have to be filled and equipped of an overflow to keep the same water column.

Dilution
The LIF technique has been recently used to quantify the mixing of aqueous streams (Koochesfahani and Dimotakis 1985 y 1986; Ferrier *et al*. 1993; Karasso and Mungal 1997, Chen and Jirka 1999; Crimaldi and Koseff 2001; Crimaldi *et al*. 2002 and Webster et al. 2002 in open channel). More recently Tian and Roberts 2003 designed a new 3D LIF technique using mirrors. The spatial variation of dilution *S* will be measured as described in Tian et al. 2004. Which is a three-dimensional laser induced fluorescence system. The laser sheet will be sprayed into the open channel from its transparent bottom.

Velocity Field and Turbulence
The PIV technique has been developed and refined by various investigator (Adrian 1991; Rafael *et al.* 1998, Stanislas *et a*l. 2003. We will use it as Kwon *et al*. 2005 describes it. As the LIF method the laser sheet will be sprayed from the bottom on the channel.

Experimental program
The experiments will be run from the easiest configuration to realize to the most complex one. First we will look at *S* and the turbulence generated from a simple jet. Then we will change the geometry of the effluent and add more ports. Then it will be repeated but in wavy conditions following by the flow only and finally both waves and flow.

Finally the results will be compared to the reliable literature and to the numerical models that are available.

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