ANALYSIS OF RESIDENCE TIME DISTRIBUTION (RTD) IN AQUACULTURAL TANKS, AND CORRESPONDENCE WITH THE FLOW PATTERN CHARACTERIZED USING PARTICLE TRAKING VELOCIMETRY (PTV) TECHNIQUES

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Introduction

The knowledge of the hydraulic characteristics of aquacultural tanks is essential to provide proper and homogeneous rearing conditions to fishes.
Particle Tracking Velocimetry Techniques (PTV) have been used by Oca *et al* (2004) to characterize the flow pattern in rectangular tanks. This techniques have great restrictions when large dimensions tanks are analysed and, specially, with the presence of fishes.
Residence Time Distribution (RTD) curves can also be used to characterize the hydraulic behaviour of the tank, for the detection of short-circuiting, dead zones, recirculation, and mixing intensity. This technique was used mainly in chemical reactors design (Levenspiel, 1966), but also in the study of aquaculture tanks (Cripps and Poxton, 1993; Watten *et al*, 2000).
The aim of this work is to obtain the RTD curves of a rectangular tank with three different water inlet configurations and compare the results with the flow pattern characterized by Oca *et al* (2004) using Particle Tracking Velocimetry (PTV).

Materials and methods

In a rectangular tank (100x35x5 cm^3) three inlet configurations were analysed: i) a single horizontal submerged entry, ii) two upright waterfalls and iii) two tangential inlets placed in the centre of the longer side wall, in order to perform two large eddies.
A fluorescein solution was instantaneously injected (pulse input) in the water inlet of the tank and samples of water leaving the tank were taken at constant time intervals. The tracer concentrations in the samples were measured with a spectrofluorimeter (model KC4 Microplate, Bio-tek Inc.).
The evolution of tracer concentrations in time was showed in a dimensionless form, in order to be able to compare different experiments. The equations used to obtain the dimensionless concentrations and time were:

$$E_{ro} = \frac{VC}{Q\sum C\Delta t} \qquad t_{ro} = \frac{Qt}{V}$$

Being V the tank volume, C the sample concentration, t the time and Q the flow rate.
The data obtained where used to construct the RTD curves and to obtain the time of first response ($t_{f\text{-}ro}$). In a mixing flow the non-dimensional time of first response should be close to 0 and in a plug flow should be around 1. A first response time much lower than 1 in a plug flow would indicate the presence of a short-circuit current.

Results and discussion

Configuration with a submerged entry showed an early peak ($t_{f\text{-}ro}$=0.12±0.03) followed by a multiple decaying peaks, this indicates a presence of a short-circuiting and some internal recirculation.
With two waterfalls, a longer first time response was observed ($t_{f\text{-}ro}$=0.45±0.03) followed by a progressive increase and an exponential decay. The curve showed a combination of plug flow and mixing flow which corresponds to the intense mixing zone followed by a near-plug flow pattern described by Oca *et al* (2004) and showed in Figure 1.
In configuration with two tangential inlets, an immediate first response was obtained, as corresponds with a mixing flow ($t_{f\text{-}ro}$=0.08±0.00), with maximal concentration values higher than those that should be expected in an ideal mixing tank.
In the three configurations, results obtained with RTD techniques were in good agreement with those described by Oca *et al* (2004) using PTV techniques. Nevertheless, RTD does not give a description of the velocity field and interpretation of results is not so easy.

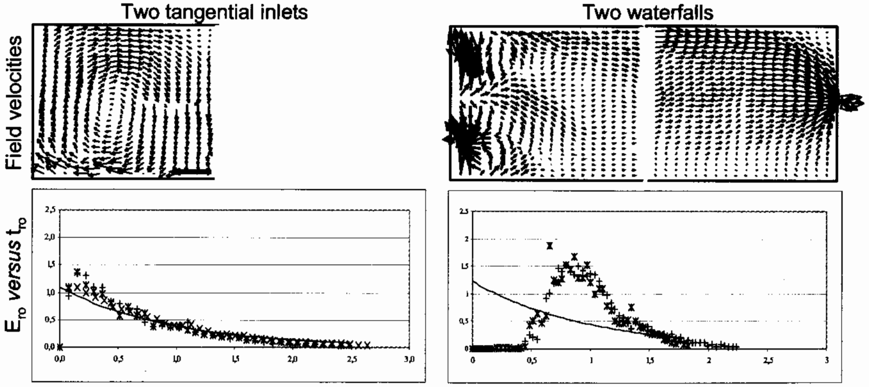

Fig. 1. E_{ro} *versus* t_{ro} and field velocities obtained from RTD and PTV respectively for two different tank configurations. Line in graphics=ideal mixing flow.

References

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