MODELING AND OPTIMIZATION OF FLOW PATTERN IN TANKS FOR SEAWEED CULTURE

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Integrated multitrophic aquaculture (IMTA), more precisely the seaweed (macroalgae) cultivation integrated with RAS - recirculating aquaculture systems, is currently one of the most promising lines of action to increase sustainability of fish farms [1]. In our study we analyze the flow pattern in tanks for seaweed culture. Seaweeds are usually tumbled (mixed) by vigorous bottom aeration. Tumbling of seaweeds (and generally the mixing of the whole tank volume) improves the exposure of seaweeds to light and decreases the thickness of the boundary layer promoting the flow of nutrients from the water to the seaweed and the gas exchange between the culture medium and the algal culture. Moreover, either the bottom aeration or the impinging jet system, designed to tumble seaweeds, represents one of the major energy sinks in land-based seaweed culture systems and their cost is a large fraction of the total production cost. Therefore, seaweeds movement and entire tank hydrodynamics require further attention.

The cornerstone of modeling of the hydrodynamic conditions in seaweed tanks is the problem consisting in how to describe the tumbling pattern of seaweed within the tank in function of the operating conditions (air flow rate or the liquid velocity in the jet outlet in case of the impinging jet system) and tank geometry. Afterwards, having a mathematical model describing the relation between the hydrodynamics (flow pattern of algae) and the nutrients uptake and photosynthetic activity of seaweeds, e.g., in form of some constraints to be fulfilled, an optimization can be carried out.

Experiments at laboratory scale or at field are scarce [2], since they are laborious and time consuming. In this context, it becomes of utmost importance to couple a Computational Fluid Dynamics (CFD) code and well-designed experimental measurements along the research process. CFD based methodology for tanks design brings the promise of efficient optimization since it can provide the full flow field description expected in the tank model and to couple it with the algal growth model. Since it first successes in the 1970's, CFD is the art and science of analyzing and simulating systems in which a fluid flow is of central interest and in which mass transfer and (bio)chemical reaction may take place. As well as in other applications, its advantages in seaweed tank simulation over conventional experimental studies are substantial reductions in lead times and development cost. Finally, an ease of performing a large range of parametric studies for optimization is a crucial issue [3]. Obviously, the results obtained from CFD simulations have to be verified in subsequent laboratory or field studies.

The present work gives guidelines to apply the CFD to simulate the algae movement previously set-up in seaweed tanks. Two approaches, (i) full CFD, and (ii) laboratory model based approach, are used and their characteristics are illustrated here on a case study. We took advantage of our laboratory experiments, cf. [2], where the relationship between the rotating velocity of the seaweed and air-flow rate in the bottom of the tank were determined for two different tank geometries: vertical cylindrical (CV) and semi-cylindrical horizontal tank (SH).

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