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Optimizing Chaotic Mixing in Open Ponds with Lateral Mixers for Enhanced Spirulina Cultivation

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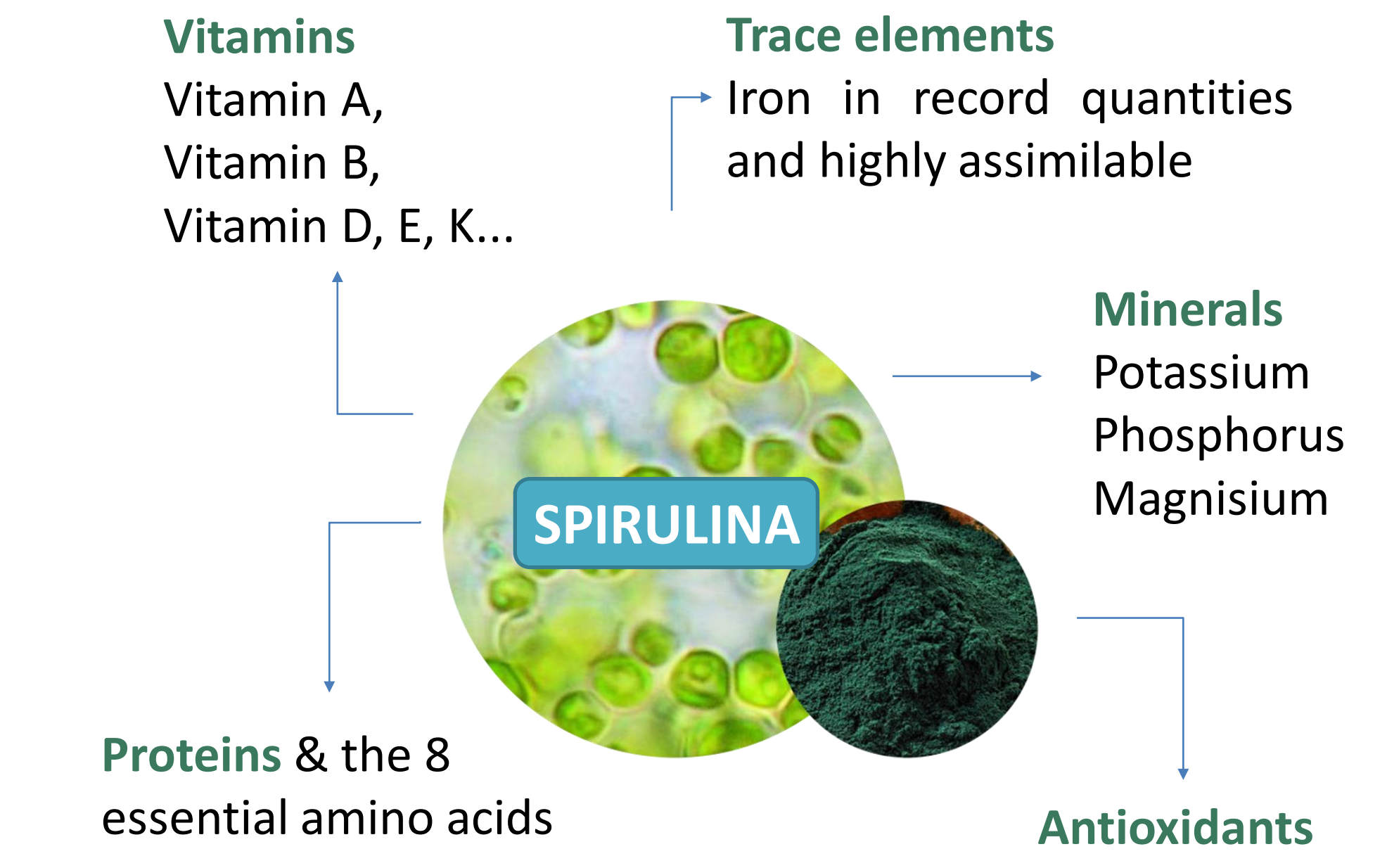
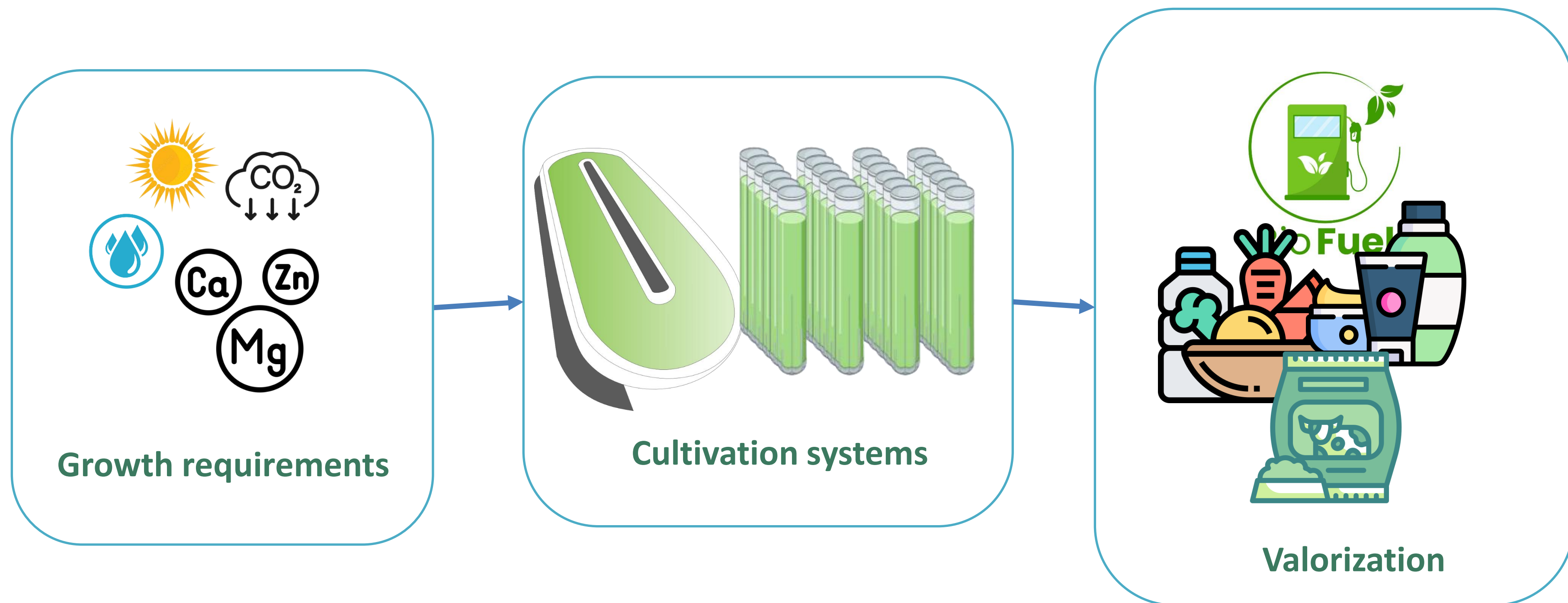
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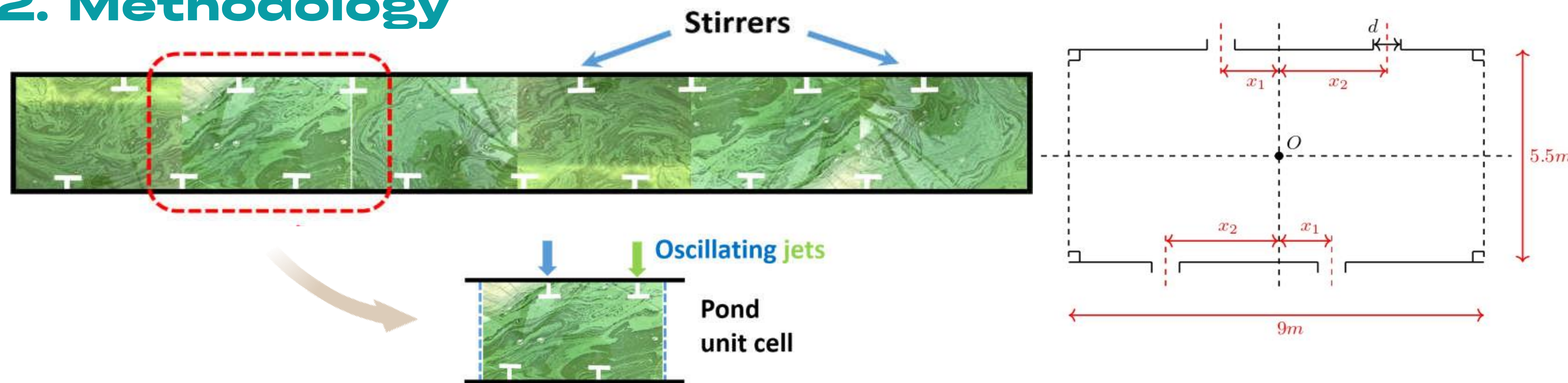
1. Spirulina cultivation



The dominant fluid stirring mechanism in open ponds is **paddlewheel**.

Spirulina is mainly cultivated in **open ponds (83%)** rather than photobioreactors [1].

2. Methodology

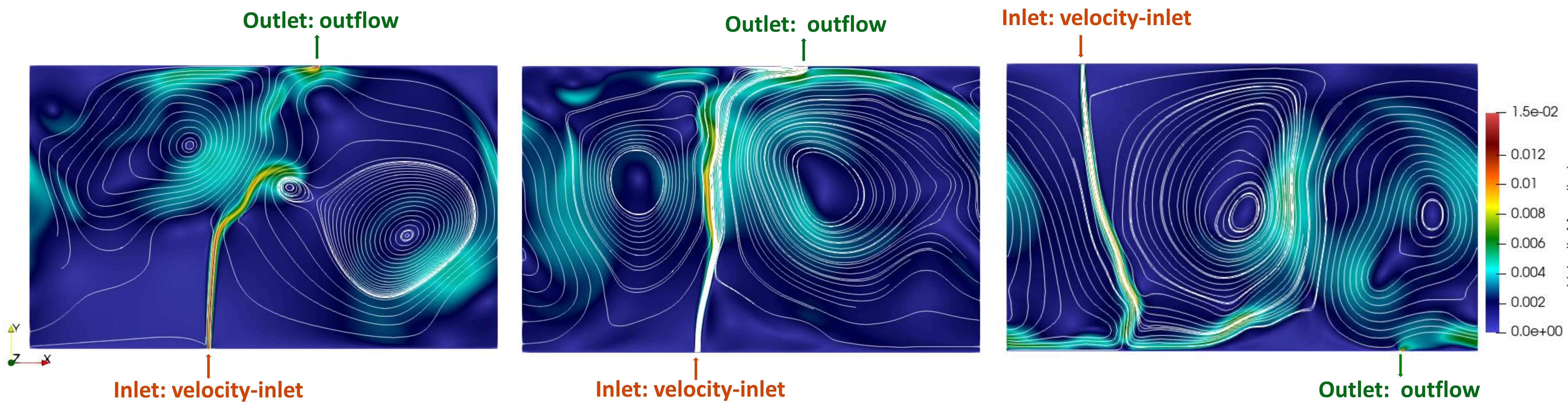


Simulation Set-up	
STATE	Transient
FLOW REGIME	Laminar
BOUNDARY CONDITIONS	Periodic 1 inlet 1 outlet
FLUID	Water based liquid
INLET VELOCITY	0.01 m/s
DYNAMIC VISCOSITY (μ)	3×10^{-3} Pa.s
REYNOLDS NUMBER	331

We seek to optimize the mixing process within **rectangular ponds**, which can be visualized as **2D plane media**.
Strategically positioned jets along the lateral sides of the pond will generate fluid circulation.

Objective
The current production rates in ponds are limited at approximately **1-2 g/L** of dry matter, indicating a relatively **low output**.
Our objective is to ascertain optimal mixing protocols by combining suitable solutions with varying jet positions, which will ensure better nutrients and CO_2 distribution.

3. Results

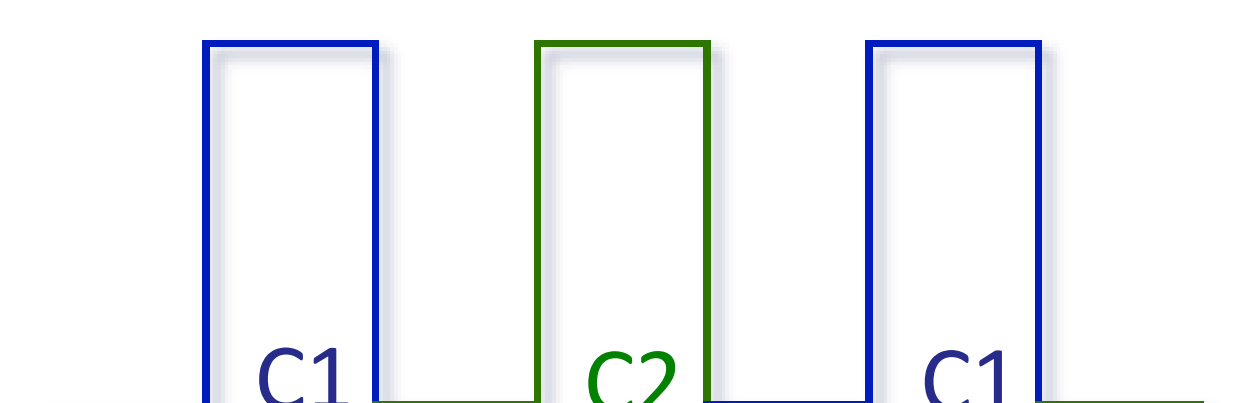


Configuration 1
Flow time = 6300 s

Configuration 1
Flow time = 9000 s

Configuration 2
Flow time = 7000 s

Proposing a **dual-system strategy** with a single inlet and outlet, our goal is to combine two distinct solutions.
The methodology entails alternating between these solutions over a **designated timeframe**.



4. Conclusions & perspectives

Configuration with **lateral mixers** in open ponds remain largely unexplored.
To optimize the mixing process within rectangular ponds, we define a new mixing protocols by combining different solutions to achieve a **homogeneous mixing**.
The physical mechanism of **chaotic mixing** will be employed. This involves introducing temporal modulations of velocities in the 2D plane flow, resulting in a gentle yet highly effective mixing action by stretching and folding the fluid filaments.
After mixing patterns optimization, we will validate our protocols by experimenting with **spirulina** cultivation.

References

[1] R. Araújo, F. Vázquez Calderón, J. Sánchez López, I.C. Azevedo, et al., (2021). Current Status of the Algae Production Industry in Europe: An Emerging Sector of the Blue Bioeconomy, *Front. Mar. Sci.* 7:626389