

# Technical Report: Skoog Coastal Life-Seed (SCLS)

## 1. System Definition and Purpose

Skoog Coastal Life-Seed (SCLS) is a biotechnological system architecture for the production of protein-rich biomass in crisis-affected environments. The system transforms seawater into a nutrient substrate in 72 hours through a closed, controlled process. The solution is based on a cascade of safety barriers: biological selection pressure, visual process monitoring, and mandatory thermal final treatment. The purpose is to offer a decentralized method for food supply where conventional logistics and infrastructure have collapsed.

## 2. Microbiological Architecture

The system is driven by an optimized co-culture of halophilic organisms:

- **Vibrio natriegens (ATCC 14048):** BSL-1-classified marine bacterium chosen for its extreme growth rate and efficient biomass production. The biomass exhibits an amino acid profile typical of microbial protein, suitable for human survival.
- **Dunaliella salina:** Halophilic microalga that through photosynthesis contributes with oxygenation, lipids, and production of beta-carotene. The system requires exposure to direct sunlight for optimal metabolism, but can survive shorter periods of cloudy weather with a reduced growth rate.
- **Tetragenococcus halophilus:** Halophilic lactic acid bacterium responsible for preservative fermentation and lowering of pH through the production of organic acids.

## 3. Chemical Composition and Indicators

- **Nutrient base:** Sodium nitrate ( $\text{NaNO}_3$ ) and Sodium acetate ( $\text{C}_2\text{H}_3\text{NaO}_2$ )
- **Process monitoring: Anthocyanin complex.** A natural pH indicator that is integrated directly into the system's tablets. It provides a visual receipt of the achieved pH level by coloring the entire water volume yellow/orange (at  $\text{pH} < 4.5$ ), which eliminates the need for external measuring equipment.
- **Sensory barrier: Quassin extract.** A built-in taste barrier that functions as a warning signal (bitterness) in the absence of dominance by the target population.

## 4. Operating Schedule: Pulse-Feeding and Geometric Coding

Three physically coded tablets control the process sequentially to minimize user error. Each tablet contains a specific composition of organisms and chemical components to drive the process forward:

- **DAY 1: START-SEED (Round):** This tablet initiates the system by supplying freeze-dried inoculant of *Vibrio natriegens* and *Dunaliella salina*. Simultaneously, a high concentration of sea salt (NaCl) is released which raises the salinity to >7 %. This salinity functions as a biotechnological filter; it is optimal for the target population but strongly inhibits survival for non-halophilic marine bacteria, which establishes an immediate and strong selection pressure.
- **DAY 2: GROWTH-SEED (Square):** This tablet supplies the majority of the nutrient substrate in the form of Sodium nitrate ( $\text{NaNO}_3$ ) and Sodium acetate ( $\text{C}_2\text{H}_3\text{NaO}_2$ ). By supplying the nutrients first on day two (Pulse-feeding), it is ensured that only the desired organisms, which now dominate the liquid, can utilize the energy for an explosive increase in biomass and protein.
- **DAY 3: FINISH-SEED (Triangular):** This tablet supplies inoculum of *Tetragenococcus halophilus* as well as the built-in Anthocyanin indicator. The tablet starts the final fermentation process where the lactic acid bacteria consume remaining carbohydrates and lower the pH value below 4.5. Simultaneously, a flocculant (modified chitosan) is released which draws the individual cells together into larger units (flocculation) so that they sink to the bottom and can be harvested.

## 5. Temperature Regulation and Ground Insulation

For the system to function in sunny climates, an exact balance is required between sunlight (for the algae) and cold (for the bacteria).

- **Partial burial (Mandatory):** The container must be buried in the ground so that 70-80 % of the volume is below ground level. Only the uppermost section and lid of the container shall be left free above ground. The ground functions as a heat sink that keeps the liquid within the biological window of 20-35 °C, while the top allows necessary sunlight for photosynthesis.
- **Temperature monitoring:** If the entire container is left in direct sunlight, the temperature will exceed 40 °C, which kills the bacterial culture. If the container is buried completely, the algae die from lack of light. The user controls the temperature manually by feeling the liquid that flows out during agitation against the inner wrist; the liquid should feel warm but not burning.
- **Mechanical agitation (Fixed routine):** Vigorous manual agitation shall be performed as a fixed routine at sunrise, midday, and sunset regardless of weather conditions. In strong sunlight, more frequent agitation is recommended (e.g., every two hours). This routine ensures that cooler liquid from the buried part circulates to the surface, which prevents local overheating and optimizes nutrient distribution.

## 6. Mass Balance and Yield

| Parameter     | Value   |
|---------------|---|
| Biomass yield | ~40g dry biomass per unit                                     |
| Protein yield | 20-22g pure protein per batch (approx. 50-55% of the biomass) |
| Quality       | Rich in amino acids and lipids suited for human survival      |

## 7. Hygienic Barriers and Final Treatment

To ensure food quality, three independent control steps are integrated:

1. **Visual Verification:** The Anthocyanin indicator confirms a safe pH level ( $< 4.5$ ) through a clear color shift to yellow/orange. This functions as a biological receipt that the environment is sufficiently acidic to inhibit pathogenic *Vibrio* species and ensure that the biomass is safe to handle further.
2. **Harvest and Separation:** After completed flocculation (Day 3), the clear salt water is carefully decanted. The remaining biomass shall be pressed through a dense cloth or piece of fabric to remove remaining free salt water. A simple taste test is recommended; the mass should be salty but edible. This step ensures that the protein biomass is separated from the excess salt and achieves a safe salinity for consumption.
3. **Thermal Final Treatment (Mandatory):** The pressed biomass is formed into units with a maximum thickness of 5 mm before heating to 75 °C. The thin geometry ensures full heat penetration and reduction of remaining pathogens.

## 8. Conclusion

SCLS constitutes an operational system architecture ready for immediate implementation and field validation. By combining passive ground insulation with a fixed agitation schedule, a stable protein production is ensured even in extreme climates, completely independent of existing infrastructure. This architecture is technically established and optimized to serve as a basis for direct interventions and local scalability in crisis-affected environments.