A NOVEL APPROACH TO COMBINED ANIMAL AND PLANT BIOMASS PRODUCTION FOR HUMAN NUTRITION IN CLOSED LOOP SYSTEMS

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Based on the construction principle of the already operative Closed Equilibrated Biological Aquatic System (C.E.B.A.S.) t the concept of an aquaculture system for combined production of animal and plant biomass was developed. This system initially was developed as an experimental device for biological space research with aquatic organisms including its own bioregenerative life support system in a totally closed state. As well the space as the ground-based versions consist of a tank for intensive fish culture which is equipped with a feeding lock representing also a trap for biomass removal followed by a water recycling system. This is an optimized version of the original C.E.B.A.S. filters adapted to higher water pollutions. The main subcomponents of this are the C.E.B.A.S.-C-filter and the C.E.B.A.S. BIOCURE filter which operate in fully biological mode and are able to convert the high ammonia ion concentrations excreted by the fish gills into nitrite ions. The second biomass production site is a higher plant cultivator with an internal fiber optics light distributor which may connected, e. g., with a HIMAWARI collector for direct utilization of solar energy.

The selected water plant is the tropical rootless duckweed *Wolffia Arhiza* which possesses an extremely high capacity in nitrate elimination and is terrestrially cultured as a vegetable for human nutrition in Southeast Asia. It is produced in an improved suspension culture which allows the removal of excess biomass by tangential centrifugation. The plant cultivator is able to supply the whole system with oxygen for respiration and eliminates vice versa the carbon dioxide exhaled by the fish via photosynthesis. An emergency gas exchanger is implemented into the closed loop which garantees survival of animals and plants for several hours with compressed air in case of light energy loss. This device, however, can also be used to deliver excess oxygen into tbe environment during normd operartion and may be implemented into the air regeneration system of a closed environment of higher order. The plant biomass obtained by centrifugation is fed into a biomass processor which delivers condensed fresh and dried biomass as pellets of different size. The recovered water is fed back into the aquaculture loop. The fresh plants can be used for human nutrition immediately or can be store after sterelizationr in an adequate packing. The dried *Wolffia* pellets are colleted and brought into the fish tank by an automated feeder. In parallel the water from the plant cultivator is driven back to the animal tank by a pump. The water quality is permanently monitored by the improved C.E.B.S. data acquisition/corrtrol/system. The special feature of the system described is, however, the used fish species. It is the herbivorous teleost *Ctenopharyngodon idellus* (Chiness Grass Carp) which can be raised solely with plant biomass. By utilization of the so-called *light back reflex* these animals can orientate also under reduced gravity so that the totally closed and self-sustaining system can be implemented as a module into a bioregenerative life support system of a lunar or planetary base. In this case, moreover, it can be useful for the bioregeneration of plant biomass inedible for humans which can be used easily as additional food for the fishes thus resulting in an intensivation of animal protein production The resupply of removed fish biomass has to be guaranteed by a separate hatchery connected to the water recyeling system in which fry must produced by partially automated artificial fertilization of removed oocytes. The total system volume may vary between 5 and more than 100 cubic meters depending on the demanded biomass production. For terrestrial applications an *open version* can be operated without these complications. It is essentially suitable for utilization in subtropical and tropical areas providing sufficient ammounts of solar energy. Tite currently disposed volume is about 25 cubit meters in the standard type which may be increased step by step. A second project in currently under development together with an industrial German company which developed a microalgal bioreactor which replaces the higher plant cultivator allowing the production of biomass of a variety of microalgal speacies like *Chlamydomonas, Chlorella, Scenedesmus, Spirulina*, etc. In this case algal pigment and secondary plant compounds are of much higher commercial interest than biomass for animal or human nutrition because they may be utilized, e, g in cosmetics as natural products without further expensive animal experiment test procedures in Eurpean countries.

The paper presents the detailled concept of this novel aquacultute system, elucidates some economic aspects and demonstrates the stage of development of the terrestrial laboratory prototypes.

Moreover, the important of the development of bioregenerative aquaculture systems for water recycling is explained with the intention to demonstrate the tremendous productive and regenerative potential of organisms in comparison to Physical and chemical solutions.