INSTALLATION FOR RAISING OF HYDROBIONTS IN A RECIRCULATION SYSTEM, INTEGRATED WITH AQUAPONIC

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Abstract: *The integrated installation for the cultivation of hydrobionts and plants is in the field of ecological cultivation of freshwater and saltwater fish, crustaceans, mollusks, aquatic plants, herbs, vegetables and other plants.*
The treatment of the wastewater from the aquafarm, with the efficient use of the nutrients in the water from the plant species, where integration and closure of the production eco cycle are achieved.
The advantage of this biotechnology is the efficient wastewater treatment - treatment of the waters wasted by the hydrobionts and their purification from aquaponic raised crops. The installation is built/part of near recirculation systems for the cultivation of hydrobiotns - freshwater and saltwater, but can also be constructed as a floating type, located in different water basins, near the fish production cages. The installation provides safe and environmentally friendly aquaculture, which ensures the protection of aquatic ecosystems.

Keywords: *a model of aquaponics system, hydrobionts, vegetables, productivity*

Introduction

Aquaponic systems are recirculation system where the cultivation of hydrobionts (fish, crustaceans, etc) is integrated with the culture of different plants (vegetables, spices, and flowers) (Rakocy et al., 2006; Graber and Junge, 2009). The aquaponics is innovative technology for Bulgaria. Its introduction in our country from Trakia University, Stara Zagora started only recently (Sirakov et al., 2017).

The productivity of aquaponics systems is highly dependent on their design. The meaning of design for the productivity of aquaponic systems was demonstrated from Vermeulen and Kamstra, 2012 and Goddek et al., 2016. One of the most important questions for the design in an aquaponics system is the water loop - single water process loop, dual water process loop or even three water process loop are used in aquaponics recirculation system (Kloas et al., 2015;Goddek et al., 2016).

Goddek et al., 2016 gave the following definition of the decoupled aquaponic system (DAPS) – „Systems where fish, plants and, if applicable, remineralization are integrated as separate functional units comprising individual water cycles that can be controlled independently”. The advantages of DAPS were observed in different studies (Kloas et al., 2015; Goddek et al.,2016). Instead of the water loop, other design tools are also important for the productivity of aquaponics recirculation system and still remained not very well investigated.

The aim of current study was to design the industrial aquaponic recirculation system for cultivation of hydrobionts and vegetables by analyzing and removing the disadvantages of an existing prototype of aquaponics system improving this way its productivity.

Materials and Methods

The analysis of an existed model of the aquaponic recirculation system

The prototype of aquaponic recirculation system (Patent №WO2010/022800) was used. The weakness sides of an existed model of aquaponics were found and the possibilities to be overpassed were analyzed.

The design of aquaponic

The new model of aquaponics system was designed by improving existed model (Patent №WO2010/022800). The drawings of the newly constructed system were made by CorelDRAW®. The description of possible accomplishment of aquaponic's model was added.

Results and Discussion

The analysis of an existed model of the aquaponic recirculation system

The analysis of prototype of aquaponic recirculation system (Patent №WO2010/022800) showed the following weakness:

- The water loop in the system is closed through out the process of evaporation. This makes the speed of water loop low and highly dependent on temperature and humidity in the greenhouse;
- The artificial light and light regime were not planned in the aquaponic prototype system. The artificial light could increase the productivity of system and it makes possible year-round production. In the prototype the production of plants is based on natural light, which makes system dependent on daily meteorological condition and light cycle (day-night);
- The management of water in the relation of microelements addition is missing in the considered installation. This could lead to a deficient condition in cultivated plants;
- The system for control of pathogens is missing in the prototype. This increases the possibilities for appearance and distribution of diseases in hydrobionts as well as in cultivated plants;
- The system for management of gases in prototype system is also missing.

Technical performance of designed industrial aquaponics system

The installation for the integrated cultivation of hydrobionts and plants is consisting of an aquaculture unit A and an aquaponic unit for plant growing B. Both units are connected through bi-directional pipeline system between which a purification unit is installed. In particular, the installation consists of tanks for the cultivation of hydrobionts, a purification unit, a sump, a mixing vessel and deep water aquaponic tanks connected each to another through a piping system equipped with at least two three-way valves. They are mounted in compartment A and compartment B. The connections between the fish tanks and purification unit through the pipeline system and from the deep water aquaponic tanks to purification unit via a waste piping system are accomplished with at least two three-way valves which are open in both directions.

In the direction of the hydrobionts tanks to the aquaponic tanks, the connection is built through the purification unit, via a pump, through a three-way valve, through a sump, through a mixing vessel that all connected with the pipeline system. The mixing vessel is equipped with a pump and a mixer. The mixing vessel is connected to the pipeline system with at least two deepwater aquaponic tanks arranged parallel to each other. In the outlet, along with the flow of fluid in the aquaponic tanks, are provided with an overflow tube located 25 cm from the bottom of the tanks.

In the opposite direction, the aquaponic tanks are connected to the purification unit via an outflow piping system and via valves, a direct pipeline connection is provided to a sump or indirect to the purification unit, and in both cases, the system is closing. After a three-way valve via a crane, a direct pipeline connection is made to a drum filter, through a pump, which provides the treatment of the purified water.

The purification unit is composed of a consistently connected drum filter connected by a pipeline system with a biological filter coupled to a trickling filter connected to an aerator, followed by a UV filter at the end of the purification unit. The purification unit is located this way to provide two-way water treatment – in the direction of hydrobionts growing to aquaponic tanks and in the opposite direction.

Above the hydrobiont's tanks and the deep water tanks, LED lighting bodies are situated to create additional light, depending on the needs of the crops.

A trickling filter at its top side is provided with a fan that is connected to an air duct system ending with a CO_2 separator over the system of parallel deep water aquaponic tanks.

The advantage of the installation consists in the effective treatment of wastewater, in two directions - purification of waters contaminated by hydrobiont's production while preserving and enriching with substances favorable for the aquaponic cultivation of crops and water purification of aquaponic crops , while assuring the clear water for the cultivation of hydrobionts. The installation allows with the control of the three-way valves both water loops (in compartment A and B) to operate independently, making it possible repeated filtration of water, as well as several cycles of water through the deep water aquaponic tanks, maximum utilization of the macro and micro elements in it, taken up by plants, which reduces its quantity to permissible levels for the raised hydrobonts. The productivity of plant is increased with appropriate lighting modes. Favorable conditions are provided for the removal of pathogenic microorganisms which can adversely affect both the fish and plant growth and the hygienic conditions in the aquaponic system. There is also the exchange of gases from the cultivation of both crops and CO2 respectively from the hydrobionts to the plants, and the water to the hydrobionts is enriched with oxygen by additional intensive aeration.

Example for the accomplishment of aquaponic's model

One possible accomplishment of the installation is performed by two compartments housed in two separate premises A and B (Figure 1). The aquaculture unit A is housed in a premise A where hydrobionts tanks are mounted and connected in a system to each other. The tanks are made of fiberglass or HDPE material with a diameter of 6 m and a depth of 1.5 m. At the end of the hydrobionts tank's system 1, a connected pipeline finished with the pump 18. The duct is connected to the beginning of the purification unit 2 in which at least one drum filter 11 is connected in series by the piping system 6 with a biological filter 12 connected to a trickling filter 13 which is connected to an aerator 14 and then to the end of purifying unit 2, a UV filter 15 is provided. The drum filter 11 is equipped with two depth level probes – the first one turn on the washout of drum filter and a low-level meter probe, which in the low-level signal includes the pump 18 for proceeding water into the filter. The biological filter 12 is a closed tank in which the bio-rings are immersed in the water which is actively aerated by an aeration system. The biological filter 12 is connected to a second biological filter - a trickling filter 13 over which is located a fan 21 connected to an air duct system 24 which ends with a separator 17 which is located above the system parallel to the aquaponic tanks 5. After trickling filter 13, connected with aerator 14, followed by a UV filter 15 with which terminates the purification unit 2. Each of the elements of the

purification unit 2 can operate independently of each other, the order and volume of the elements of the purification unit 2 being controlled by an operator.The outlet of the purification unit 2 is connected to the first position of a three-way valve 8, whose position is dependent on the passage of the treated and purified stream. The stream could pass up to the fish tank 1 (the second valve position) or to the collecting vessel 3 (the third position of the valve) , and from there to mixing vessel 4 and further elements of the system. By controlling a water tap16 and a direct pipe connection after a three-way valve 8 to a drum filter 11, the fluid could be purified by processed several times by rotating in the small closed circuit.

Piping system 6, after purification unit 2, via a three-way valve 8 reaches a sump 3 which is mounted at a level higher than that of a mixing vessel 4 with which it is connected to a pipe system. Mixing vessel 4 is equipped with a pump 19 and a mixer 20. Mixing vessel 4 is connected by a piping system 6 with at least two parallel deep water aquaponic tanks. In the flow-out stream of the fluid at the end of aquaponic 5 are provided with an overflow tube 22 located 25 cm from the bottom of the tanks, and through the outlet pipe system 23 through the valves 10 and 9 a pipeline connection is provided directly to the sump 3 or indirectly to the purification unit 2, and in both cases the system closes.

Above the tanks for raising of hydrobionts 1 and the aquaponic tanks 5, the LEDs 7 are assured to provide additional light according to the needs of the crops; A drip filter 13 at its upper part is provided with a fan 21, which is connected to an air duct system 24 which ends with a CO_2 separator 17 over the system of deep water aquaponic tanks 5.

The installation works in the following way: the water in one direction, purified from the purification unit 2, through a three-way valve 8, a sump 3, a mixing vessel 4 where it is enriched with micro- and macro elements if necessary by the operation of a pump 19 and a mixer 20 entre in the deep water aquaponic tanks 5, where it nourishes plants cultivated hydroponically. Once this water has been left from the aquaponic tanks 5 through the overflow 22 to the outlet conduit 23 where water’s flow is controlled by the valves 10 and 9. It enters the purification unit 2 for cleaning and then through the second position of the three-way valve 8 with a closed valve 16 enters the tanks for the cultivation of hydrobionts. The enriched water entering to the aquaponic tanks 5 and could circulate several cycles through them by the help of the three-way valves 10 and 9 for maximum absorption of nutrients from the plants.

The operation of the purification unit 2 (Figure 2) starts with a drum filter 11. Depending on the type of the filter, it can be used for cleaning by hydraulic, pneumatic or mechanical vibration. The sieve cleaning is performed continuously, periodically or upon request. The size of the filters recommended for the needs of aquaculture is in the range from 60 to 100 and from 80 to 110 μm. The water cleaned from mechanical particles water then enters to the first biological filter 12, where the purified water is aerated by the aeration system. Afterward, the purified water enters in a trickling drip filter 13 in which CO_2 is exhausted by aeration, which is removed from the fan 21 through the air duct 24 to a separator of CO_2 17 located above the system of parallel aquaponic tanks. When the purified water moves in the opposite direction from the aquaponic tanks 5 to the tanks for the cultivation of hydrobionts 1, then the water is enriched with oxygen in the aerator 14.

The LEDs 7 according to the modes preset by the operator, create an optimal and continuous light mode according to the need of the additional light of the crops to be cultivated.

The water, passing through the UV filter 15, decreases the number of pathogenic microorganisms present in the system and reduces the potential for the occurrence and spread of diseases in both - the hydrobionts and the plants.

Each circle received from the tanks for the cultivation of hydrobionts 1 and the purification unit 2 or the aquaponic tanks 5 and the purification unit 2 via the three-way valve system 8, 9 and 10 can function independently in an unlimited number of cycles.

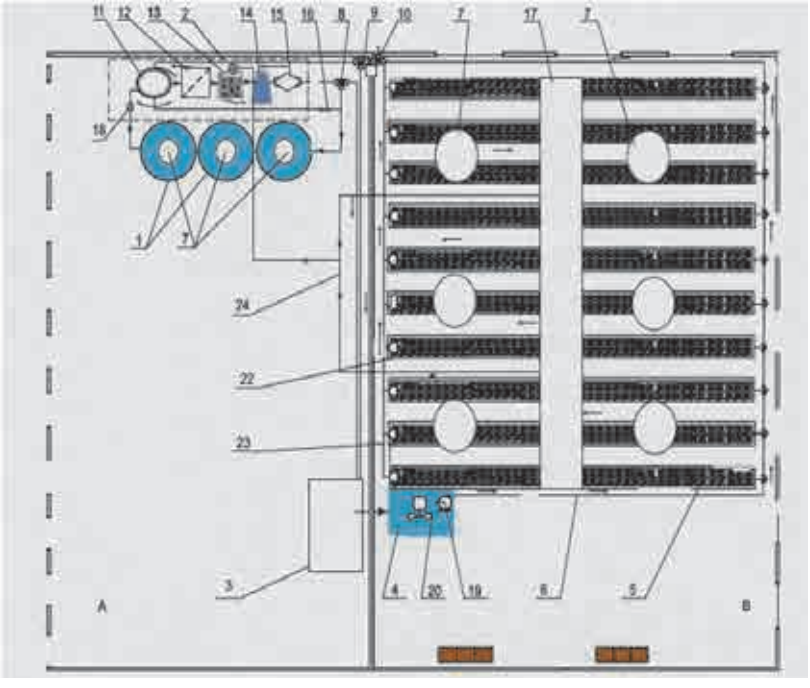

Fig.1. General view of a designed model of industrial aquaponics recirculation system:1)

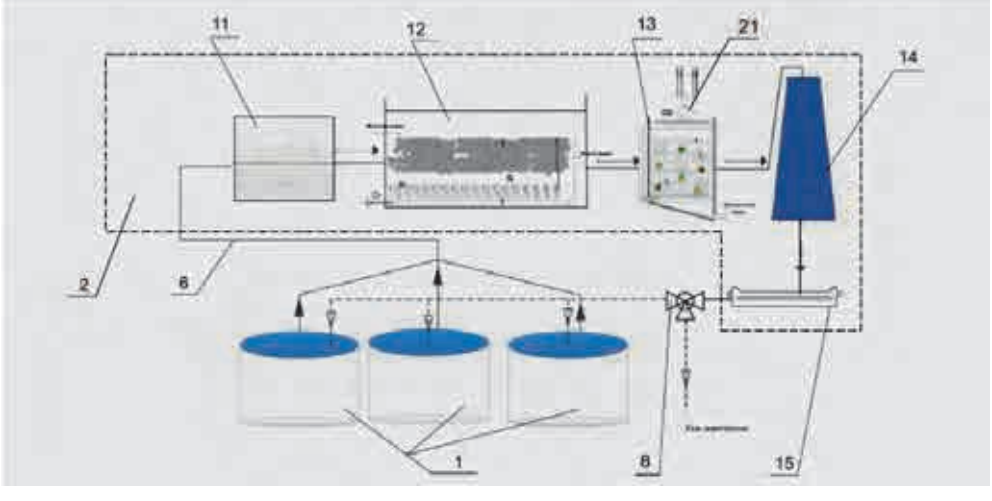

Fig. 2. The view from compartment A (for the cultivation of hydrobionts)

Conclusion

The present model of industrial aquaponics system gives opportunity productivity to be increased in the system by the following way:

- effective treatment of wastewater;
- assure favorable lighting modes;
- removal of pathogenic microorganisms;
- exchange of gases from the cultivation of both crops and CO_2 respectively from the hydrobionts to the plants, and the water to the hydrobionts is enriched with oxygen by additional intensive aeration.

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