

RESEARCH ON WATER REUSE TECHNOLOGY FROM HATCHERIES FOR FOR SUSTAINABLE DEVELOPMENT AND ENVIRONMENTAL POLLUTION CONTROL

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1. State of the art and practical requirements

To supply seeds for aquaculture, about five thousands existing hatcheries produce annually 20 billion shrimp varieties and some billions other species (crab, fish, mollusks, eel, crustacean) for grow - out production systems. Most hatcheries use saline water for production and therefore are situated near the seashore.

In applying conventional production schema “tank cultivation- open flow system” a huge quantity of wastewater originating from water exchange is discharged into the coastal environment. Wastewaters from hatcheries containing uneaten feed, faces, excreta, pathogens, antibiotics could damage land, receiving water bodies and habitats. Deterioration in water quality, habitat destruction, loss of biodiversity, soil salination, disease transmission, antibiotic resistant microorganisms, in some case, cause of algae bloom. [1, 4, 6, 7, 9] may also occur.

For environmental protection in general and for the sustainable development of aquaculture production specifically, the treatment of wastewater or reuse of wastewater is therefore important. In addition, wastewater reuse brings economic benefits for hatcheries far from saline water resources and shops trading in fresh marine products due to reduction in the costs of transporting saline water to these hatcheries.

Wastewater reuse is common in several countries [13, 14], but the production schema has not been widely applied in Vietnam.

2. Pollution characteristics and wastewater treatment technologies

Wastewater from hatcheries or in general from aquaculture production is not heavily polluted, but the existing contaminants are very toxic to aquatic species even with low concentrations. The mostly important concern is ammonia originating from uneaten feed, faces, and excreta. In the strictest sense, wastewater

treatment refers therefore to the biological conversion of ammonia into nitrate (nitrification process) which is lesser toxic than that of ammonia. [2, 3, 5]

Compared with other wastewaters, waste stream from hatcheries is characterised by low concentration of ammonia, high salt content, usually containing the inhibitors used in breeding, (for example antibiotics). For the purpose of reuse, it requires a deep purification level corresponding to the water quality for aquatic cultivation. The above mentioned inhibitor factors impact badly on the growth of autotrophic bacteria, which inherently represent slow growth rate. [8,10]

Other difficulties arising in applying biological treatment for this wastewater include the seasonal production, small scale hatcheries, and numerous varieties of animals existing at the same time within a hatchery.

All the factors result in high cost for both installation, operation and performance stability of treatment systems.

The existing treatment technologies such as trickling filter, fixed bed, bio-filtration, rotating biological contactor (RBC), and fluidized bed have limited application in these situations.

The appropriate treatment technologies according to specific production conditions in hatcheries require the following criteria:

- High performance.
- Simple operation and low cost.
- Adaptation to seasonal and small scale production.
- Convenient expansion into practice.

One of the rare technologies that could partly satisfy the requirements in such conditions is the Moving Biofilm Bed Reactor (MBBR). This technology uses media for microorganism attaching and the media are moving in water during operation. The performance of MBBR is not as high as that of the fluidized bed reactor, but it is much higher than other technologies. To compensate for lower performance, MBBR has a simple operational mode (compared with the fluidized technology, as it requires high automation for process control and does not need a separate sedimentation unit

This report presents some initial results of our bench scale research on the nitrification process using MBBR technology, which could be applied for wastewater treatment or for water reuse in hatcheries.

The MBBR technology has been developed and applied in several countries for treating aquaculture wastewater and it shows some advantages in comparison to the other technologies [13, 15, 16]. The MBBR technology developed in our laboratory used local materials with low cost, and high treatment performance, However it is not yet verified in a practical production system.

3. Research results

Recently, the laboratory for environmental chemistry, Institute of chemistry (VAST) has developed the nitrification process in saline water using MBBR technique for wastewater reuse in hatcheries. The simple scheme for wastewater recycle is presented in Figure 1.

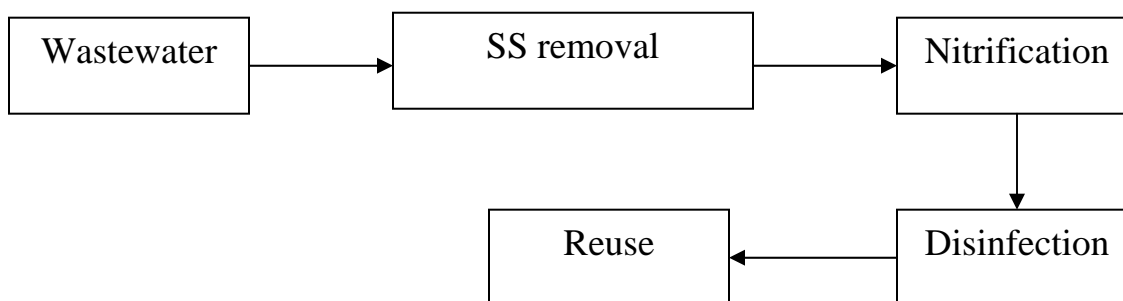


Fig. 1 Scheme for wastewater reuse in hatcheries

The biological treatment (nitrification) is the most important treatment unit in the treatment system, which is closely related to the specific characteristics of aquaculture wastewater; other treatment units have the similar behaviour as for other wastewaters.

The nitrification process oxidizes ammonium into nitrate, which is less toxic to aquatic animals and accepted at much higher concentration for stocking cultivation environment in comparison to ammonium.

The nitrification rate is rather slow due to low growth of autotrophic microorganisms (*Nitrosomonas* and *Nitrobacter*), particularly in the presence of salt and at low ammonia concentrations before and after treatment (to satisfy the quality for cultivation). Low nitrification rate requires high investment costs for system installation and high operational cost. In that case, efforts are focused on the intensification of the biological nitrification rate. MBBR processes have high nitrification rates based on concentrating a high biomass on the carrier media (bio-film formed in media with a porosity of 98 % and specific surface of about 7000 m² /m³) and the movement of media in water (to strengthen the mass transport). The air supply for the ammonium oxidation is sufficient to cause the media motion because the density of media is approximately that of water. The size of media ranges in cm, so the system does not need the sedimentation unit and this enables easy operation. The biological nitrification is schematically pictured in Figure 2.

Research on the nitrification in our laboratory was conducted for synthetic wastewater containing 5 mg N/l and salt content ranges from 10 to 30 ppm under ambient temperature.

Nitrification process was performed by MBBR using polyurethane as moving media (cube shape of 1 x 1 x 1cm size) for microorganisms to attach to. Air provided by aerator for the oxidation process is also used to maintain movement of the media in solution to improve mass transfer, and to force the reaction.

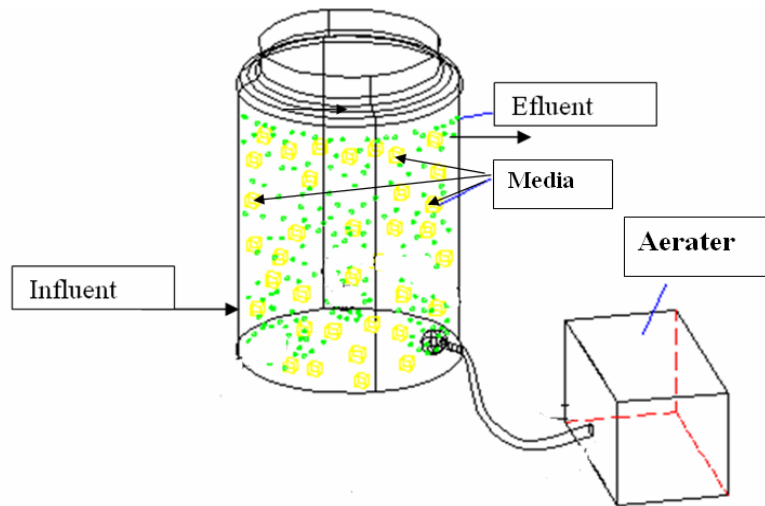


Fig. 2 The biological nitrification unit

Laboratory research waste focused on the influence of environmental factors (initial ammonia concentration, salt content, the presence of organic matters, alkalinity, temperature) and operational parameters (hydraulic retention time, effluent ammonium concentration, nitrite accumulation, volume ratio of moving media to water in reactor) on the rate of nitrification process. The results obtained were used to model the nitrification kinetics. In turn, the kinetic model was used to predict the behaviour of the existing process in actual conditions.

The investigation of nitrification process by MBBR on synthetic samples and sample taken from production showed the following results:

Synthetic samples are characterized by salinity from 10%, 15%, 20%, 25% and 30% and an ammonium concentration of $5\text{mgNH}_4^+\text{-N/l}$. It requires ammonium concentration in effluent less than $0.2\text{ mg NH}_4^+\text{-N/l}$ and nitrite accumulation must be low (nitrite is also toxic to aquaculture animals) corresponding to the aquaculture standards on the world [14]. Processing capacity (treated water

volume per media volume per day) depending on the salinity is presented in the Table 1.

Table 1: Impact of salinity on processing capacity in nitrification

Salinity (‰)	10	15	20	25	30
Processing capacity (litter of treated water /litter of media /day)	45	37	30	25	20

The volume ratio of media to water in the MBBR technique commonly ranged from 5% to 25%.

Assuming that a hatchery has breeding volume of 50m³; the water exchange rate will be 30% per day; corresponding a water reuse of 15m³ per day. Using the research results above to calculate the tank volume needed for recycling with media volume ratio of 20%, following results will be given:

Table 2: The extent of biological tank volume and corresponding media volume for recycle waste water of different salinity (see text)

Salinity (‰)	10	15	20	25	30
Media volume needed (m ³)	0.33	0.41	0.50	0.60	0.75
Nitrification tank needed (m ³)	1.75	2.02	2.50	3.00	3.75

Research results were proven by real samples taken from fish ponds at Rang Dong agricultural fields, Nghia Hung, Nam Dinh. This wastewater was characterised by: 23% salt and 1.2 mgN/l ammonium concentration. The treatment performance of MBBR achieved was 32 litre wastewater/litre of media/day. The quality of treated wastewater fully met the requirement for stock cultivation (ammonium concentration lesser than 0.2mgN/l; nitrite concentration smaller than 0.1mgN/l in effluent).

The cost for media is about 5 million VND/ m³ and the material for reactor is abundant as long as it can resist the salt corrosion. In comparison to imported treatment system the developed MBBR is certainly much cheaper.

4. Potential applications

From the bench scale experiment results it might be stated that the developed MBBR technology could be potentially used for wastewater treatment or for reuse in hatchery production. Treating wastewater from aquaculture production before discharge or reuse will be compulsory in the near future to achieve a sustainable production development and environmental protection

Because of the small and medium – scale production in most hatcheries, the nitrification treatment unit would be fabricated in a package form of different capacities for supplying to producers. Other treatment units (in fig.1) are easily incorporated into the system.

Unfortunately we have not yet the opportunity to implement a case study to assess treatment performances of MBBR and the economic benefit in a practical production system.

Before designing and fabricating the modules, it is essential to evaluate the effects of the proposing treatment scheme for a broad range of practical conditions.

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