Bangladesh Journal of Veterinary and Animal Sciences, Vol. 7, No. 2, July-December 2019

ISSN 2227-6416

**Bangladesh Journal of Veterinary and Animal Sciences**

Journal home page: www.bjvas.cvasu.ac.bd

*Research Article*

# Development of ideal filtration system for rooftop fish farming at urban households

***Mamun, M. M. M.[1], Jhumi, K. R. A.[2], Rubel, M.[3] and Nahid, S. A. A.[4]****

[1] Department of Fish Biology and Biotechnology
[2, 3, 4] Department of Fisheries Resource Management
Chattogram Veterinary and Animal Sciences University, Chattogram-4225, Bangladesh

## ARTICLE INFO

*Article history :*
Received : 06/07/2019
Accepted : 19/09/2019

*Keywords :*
Rooftop, Aquaculture, Filtration, Plant.

**Corresponding Author :*
Cell: +8801712505698
E-mail: nahid83bau@gmail.com

## ABSTRACT

The experimental study was based on the establishment of suitable filtration system on the basis of comparative study of the effectiveness between the different filtration systems consisting coarse filter, coarse filter with plant and only plant in re-circulatory condition at rooftop. During the six months study period the experimental study of the filtration systems were done on the reduction rate of $NH_3$, $PO_4^+$ and $NH_4^+$ of water used for prawn (*Macrobrachium rosenbergii*) culture in twelve (12) plastic barrel (250L water holding capacity). Water samples were collected from each filtration system after the recirculation process. Dissolved oxygen, temperature and pH were monitored daily; ammonia, ammonium and phosphate concentration determined once in a week. The average amount of $NH_3$, $PO_4^+$ and $NH_4^+$ of filtrated water was found (mean±SD) 0.15±0.01(mg/L), 0.16±0.02(mg/L) and 0.06±.03(mg/L) respectively in plant system; 0.17±0.02(mg/L), 0.42±0.01(mg/L) and 0.08±.01(mg/L) in coarse filter system and 0.13±0.02(mg/L), 0.31±0.01(mg/L) and 0.06±0.02(mg/L) in coarse filter with plant system. The level of $NH_3$ in water of coarse filter with plant was significantly reduced into (0.20±0.02 (mg/L)) than only plant system (0.04±0.01 (mg/L)) and coarse filter system (0.01±0.02 (mg/L)) ($p<0.05$). Plant system shows significant reduction ($p<0.05$) of $NH_4^+$ and $PO_4^+$ (0.39±0.02 (mg/L) and 0.09±0.03(mg/L)) than coarse filter (0.03±0.01(mg/L) and 0.19±0.01 (mg/L)). Coarse filter with plant also reduced more $PO_4^+$ (0.25± 0.01(mg/L)) than coarse filter system (0.19±0.01 (mg/L)).The average water temperature, pH and DO of the filtrated water were 27.6°C, 7.4 and 4.03mg/L respectively. At the initial stage of the study period prawn was stocked 55pL/tank where average length was 0.2mm. At the end of the study period final length estimated 5.5cm and the weight 2.85g on average. The results of this study showed the possibility of establishment of a suitable filtration system for rooftop fish culture.

**To cite this paper :** *Mamun, M. M. M., Jhumi, K. R. A., Rubel, M. and Nahid, S. A. A. 2019. Development of ideal filtration system for rooftop fish farming at urban households. Bangladesh Journal of Veterinary and Animal Sciences, 7 (2): 16-21*

## 1. INTRODUCTION

In re-circulating aquaculture different types of filters are used such as, aquatic plant filters, sand filters, rotating biological contactors (RBC), trickling filters, submerged filters (with or without aeration) etc. One of the critical processes in a re-circulating aquaculture system, and is a key objective in its design, is the removal of ammonia from water. The aim of this study was to invent a low cost and effective filtration system by using locally available materials such as brick, sand, herbs and charcoal etc. for re-circulating aquaculture in rooftop condition on the basis of ammonia removal from freshwater prawn (*Macrobrachium rosenbergii*) tank. Three different filtration systems were used including coarse filter where the filtering materials was sand, brick and charcoal; plant filter where locally available herbs used and the combination of coarse filter and plant. In recent years, rooftop farming has become a popular countermovement, with specific goals to minimize the environmental impact of conventional agriculture, increase food security, and increase social cohesion in cities (Buehler *et al.* 2016). Like urban agriculture in general, interest in urban rooftop farming has also been increasing. The precedence of the farming is that it does not compete with other land uses or uses of a building's interior, and it does not require fertile farmland (Specht *et al.* 2014). In Bangladesh the land for agricultural farming is rapidly squeezing day by day due to urbanization, industrialization and to provide room for increased number of peoples' habitat. Because of decreasing agricultural land and increasing people, it is the peak time to identify such a method, which can employ multi benefits like habitat, income generation and nutritional requirement for the nation. Perhaps rooftop fish farm will be the solution. After the completion of the experimental study we concluded the coarse filter with plant system was the effective filtration system especially for rooftop fish culture. Along with water conservation, this system allows large fish yields to be obtained in a relatively small area and provide year-round production (Gorder *et al.* 1994). Rooftop fish culture is not familiar in Bangladesh yet. This is due to lack of knowledge including technical information. One of the goals of this project is to make popularization of roof top fish culture among the urban people. Rooftop helps to proper utilization of unused places and it also offers ideal site for growing crops. The findings of this study identified where future research is needed in order to make rooftop fish farming a widespread sustainable solution.

## 2. MATERIALS AND METHODS

The experiment was conducted from March 2018 to August 2018 in rooftop at one of the CVASU teacher's resident. Filtration systems (coarse filter, coarse filter with plants and only plants) were used to study on their efficiency level in case of ammonia, ammonium and phosphate reduction from prawn tank. The present study was conducted in twelve(12) barrel drum (250L) as prawn culturing tank where each filtration system (half cut barrel with filtering materials) connected with four prawn tank. The system design was constructed on the basis of the load capacity of the rooftop. Growing beds for plants were made by locally available and cost effective resources such as sand, brick, coal and coir. Coconut coir was used especially for absorbing moisture for efficient plant growth. However many plant species can be grown in media based systems where we preferred locally available herbs like coriander, mint, jute leaf, red amaranth and stem of creeper and planted in a half cut plastic drum for plant filtration system. The filtering materials of coarse filter were sand, brick and charcoal. The stocking density of (*Macrobrachium rosenbergii*) was 55 post larvae per tank and formulated feed was provided twice in a day at a rate of 3% of bodyweight. Re-circulation of prawn tank water was done twice in a day for effective filtration by using submersible motor (0.5HP). Four samples were collected in each of the week of the month of research time frame. In every sample, physical water quality parameters such as Dissolve oxygen (DO), pH and temperature were measured by using DO meter, portable pH meter and Celsius thermometer and the analysis of chemical parameters such as phosphate, ammonia, and ammonium of prawn tank water and filtrated water were carried out in laboratory by using spectrophotometer (Model T 80).

Procedures of chemical analysis of prawn tank and filtrated water through spectrophotometer (Model T 80) are given below:

**Determination of phosphate:**

| | | |
|---|---|---|
| Program no. | : | 306 |
| WTW model no. | : | $PO_4$-1 TP |
| Category | : | RT (reagent test) |
| Measurement range | : | 0.007- 0.800 mg/l $PO_4$-P |
| | | 0.02 – 2.45 mg/l $PO_4$ |

At first 10.00 ml of sample was taken into empty cell. After that the contents of a VARIO Phos3 F10 powder pack was added to the sample. The empty cell was closed with a screw cap and shaken for 10 to 15 seconds and then allowed to react for 2 minutes. Then the cell inserted to the photometer cell shaft and the measured value appeared in the display.

**Determination of ammonia**

Program no. : 324
WTW model no. : $NH_4$-1 TP
Category : RT (reagent test)
Cell : 28mm
Measuring range : Corresponding to 0.01-0.64 mg/l $NH_4$ or 0.01-0.50 mg/l $NH_4$-N

At first 10.0 ml of sample water taken into the empty cell and added the VARIO AMMONIA Salicylate F-10 powder and closed the cell with the screw cap and allowed to chemical reaction for 3 minutes. After that the contents of a VARIO AMMONIA Cyanurate F-10 powder added in the cell and shaken the cell vigorously to dissolve solids and allowed to react for 15 minutes. At last the cell inserted in the photometer cell shaft and the measured value appeared in the display.

**Determination of ammonium**

Program no. : 32
WTW model no. : RT (reagent test)
Cell : 28mm
Measuring range : Corresponding to 0.03-1.16mg/L $NH_4$ or 0.02-0.9 mg/L $NH_4N$

10ml of sample water added into the empty cell and then 1.2 ml of $NH_4$-1 added with a pipette and mixed properly. After that 2 level blue micro spoons of $NH_4$-2 was added in the cell and closed the cell with the screw cap and shaken the cell vigorously to dissolve solid. The reaction time was 5 minutes and then added 8 drops of $NH_4$-3 and again allowed to react for 5 minutes. After that the cell inserted in the photometer cell shaft and the measured value appeared in the display.

**Data Analysis**

Statistical data analysis was done in Microsoft Excel 2007 and IBM SPSS 23.0 to evaluate the performances of different filtration systems where One-way Analysis of Variance analysis was used and grouping of treatments was based on significant differences in mean values according to Duncan test (0.05) level of confidence.

## 3. RESULTS

The average amount of $NH_3$, $PO_4^+$ and $NH_4^+$ of filtrated water was found (mean ± SD) 0.15±0.01(mg/L), 0.16±0.02(mg/L) and 0.06±0.03(mg/L) respectively in plant system; 0.17±0.02(mg/L), 0.42±0.01(mg/L) and 0.08±0.01(mg/L) in coarse filter system and 0.13± 0.02(mg/L), 0.31±0.01(mg/L) and 0.06±0.02(mg/L) in coarse filter with plant system. The level of $NH_3$ in water of coarse filter with plant was significantly reduced into (0.20±0.02 (mg/L)) than only plant system (0.04±0.01 (mg/L)) and coarse filter system (0.01±0.02 (mg/L)) ($p<0.05$). Plant system shows significant reduction ($p<0.05$) of $NH_4^+$ and $PO_4^+$ (0.39±0.02 (mg/L) and 0.09± 0.03(mg/L)) than coarse filter (0.03± 0.01(mg/L) and 0.19±0.01 (mg/L)). Coarse filter with plant also reduced more $PO_4^+$ (0.25±0.01(mg/L)) than coarse filter system (0.19±0.01 (mg/L)).There were no significant differences found in physical water quality parameters between the filtration systems (Table 1). On a comparison coarse filter with plant showed the best result and we can conclude that coarse filter with plant filtration can be considered as the effective filtration system for rooftop tank culture.

**Table 1.** Mean and standard deviation of water quality parameters during the study period:

| Parameter | Influent water from prawn tank to coarse filter | Effluent water from coarse filter to tank | Influent water from prawn tank to plant filter | Effluent water from plant filter to tank | Influent water from prawn tank to coarse + plant filter | Effluent water from coarse + plant filter to tank |
|---|---|---|---|---|---|---|
| Temp. (°C) | 28±0.37$^c$ | 27.3±0.72$^b$ | 27.9±0.59$^c$ | 27.4±0.12$^c$ | 26.9±0.43$^a$ | 27.9±0.64$^c$ |
| pH | 7.9± 0.11$^a$ | 7.4±0.49$^c$ | 7.1±0.91$^b$ | 7.5±0.76$^b$ | 7.3±0.61$^c$ | 7.5±0.88$^a$ |
| DO(mg/L) | 3.6±0.05$^c$ | 4.1±0.01$^b$ | 3.5±0.35$^c$ | 3.9±0.56$^b$ | 3.5±0.21$^c$ | 4.1±0.43$^b$ |
| $NH_3$ (mg/L) | 0.18±0.01$^a$ | 0.17±0.02$^b$ | 0.19±0.01$^a$ | 0.15±0.01$^b$ | 0.33±0.01$^b$ | 0.13±0.02$^a$ |
| $NH_4^+$ (mg/L) | 0.11±0.00$^c$ | 0.08± .01$^b$ | 0.15±0.02$^b$ | 0.06± .03$^c$ | 0.12±0.03$^c$ | 0.06±0 .02$^c$ |
| $PO_4^+$ (mg/L) | 0.61±0.06$^c$ | 0.42±0.01$^a$ | 0.65±0.11$^c$ | 0.16±0.02$^c$ | 0.56±0.55$^c$ | 0.31±0.01$^b$ |

**Table 2.** Mean and standard deviation of $NH_3$, $NH_4^+$ and $PO_4^+$ reduction from filtration systems:

| | **Reduction level of $NH_3$ (mg/L)** | **Reduction level of $NH_4^+$ (mg/L)** | **Reduction level of $PO_4^+$ (mg/L)** |
|---|---|---|---|
| Coarse Filter | 0.01±0.02[b] | 0.03± .01[b] | 0.19±0.01[c] |
| Plant | 0.04±0.01[b] | 0.09± .03[a] | 0.39±0.02[a] |
| Coarse Filter + Plant | 0.20±0.02[a] | 0.06± .02[c] | 0.25±0.01[b] |

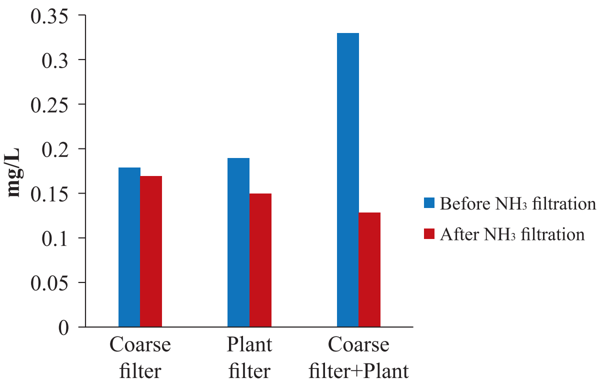


**Figure 1.** $NH_3$ of prawn tank water filtration by the filtration systems

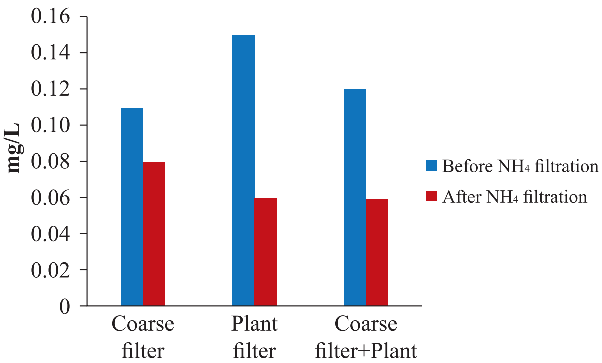


**Figure 2.** $NH_4^+$ of prawn tank water filtration by the filtration systems

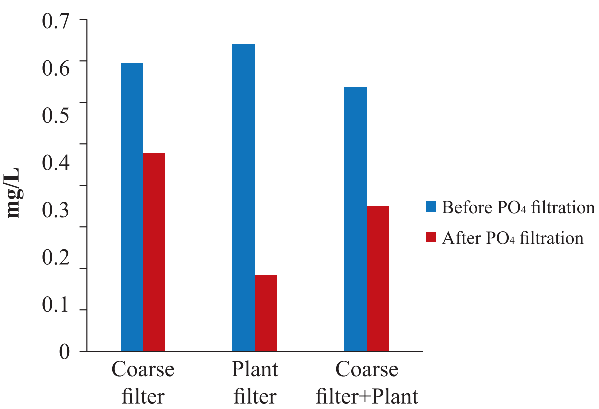


**Figure 3.** $PO_4^+$ of prawn tank water filtration by the filtration systems

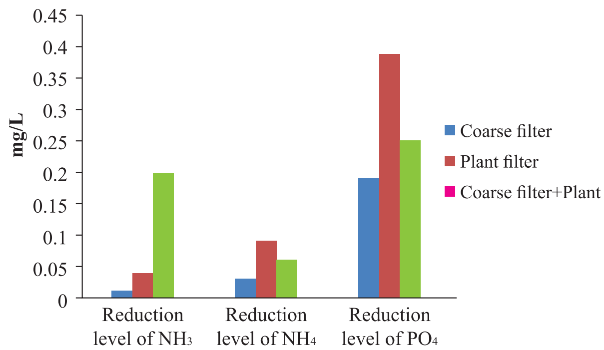


**Figure 4.** Comparison between the filtration systems

## 4. DISCUSSION

Rooftops of urban area consist of 40-50% of the total area and it is a great opportunity to replace all this impermeable surface area with vegetation and fish culture (Eleni, 2012). It is important to maintain within specific limits with sufficient dissolved oxygen, pH around neutral and low concentrations of nitrogenous compounds like ammonia (Masser *et al.*, 1999). The system can be run without pesticides and, because the fish environment is spacious and clean, without antibiotics (Roman, 2013). About 50% of the phosphorus in the fish feed can be lose in together with the animals' feces (Shafai *et al.*, 2007). One of the most important feature in a re-circulating aquaculture system and the key objective in its design is the removal of ammonia from water (Meade *et al.* 1985, Avnimelech, *et al.*, 1995, Avnimelech, 1999, Kim *et al.*, 2000, and Cristea *et al.* 2002). There are several filtration techniques available to remove ammonia nitrogen, but most commonly used is biological filtration (Losordo, T. *et al.*, 1992). According to Anak (2007), ammonia level in bio-filtrated water was 0.015 to 0.025mg/L which is lower than the present study. Savin *et al.*, (2012) showed that using bio-filter in tilapia re-circulating systems results in 0.068mg/L ammonia which is lower than any other filtration system used in present study and ammonium 8.54mg/L which is very high in comparison with the filtration systems used in present study. Szyper *et al.*, (2005) found that sand filter reduced ammonia concentration of about 1mg/ and trickling bio-filter systems reduced ammonia to 2 mg/l from the fish culture tank which is very high than the present study. Ammonia ($NH_3$) concentrations never exceeded 0.4 ppm in the aquaponic systems during the data collection and therefore never reached critical values for prawn (1 ppm). According to Pfeiffer T.J. *et al.*, (2009), the ammonia level of red drum juvenile culture tank was found 0.69mg/L by using sand filter which is higher than the coarse filter and plant filtration system used in present study and pH value ranged between 7-8 which is found similar. Kamstra. A. *et al.*, (1998) found that in eel culture the amount of ammonia and ammonium in effluent water from trickling filter was 0.18 mg/L o and 0.36 mg/L respectively and the average temperature in the systems varied from 22 to 24°C which is lower than the present study. According to Nhan D.T. *et al.*, (2009) a comparative study of comparison of reproductive performance and offspring quality of giant freshwater prawn (*Macrobrachium rosenbergii*) was done by using bio-filter where the value of ammonia and ammonium value in filtrated water were 0.01mg/L and 0.02 mg/L which supports the present study and the average temperature, pH and DO value were 28°C, 7.5 and 5.4mg/L where pH and temperature is similar to the present study and DO level is higher than the present study. Guang. *et al.*, (2005) used two layers floating bed filter system and found 1.0mg/L of ammonia in filtrated water which is higher than all filtration systems used in this experiment. In the present study the phosphate reduction was significant by the plant filtration. Palmer (2010) found that in shrimp culture the phosphate level of filtrated water from polychaete- assisted sand filters was 0.14mg/L which relates the present study of phosphate reduction by plant system. The average value temperature, pH and DO was found 28.36°C, 8.09 and 7.14 mg/L from effluent of RAS with biofloc system used in *M. rosenbergii* culture (Ballester *et al.*, 2017) which relates the present study. Species selection for rooftop culture should be done on the basis of quick growth, good market price, seed-stock availability, tolerate high stocking density, robust, they also need to be approachable and not stressed by human interaction (Roman, 2013). In the present study period *Macrobrachium rosenbergii* was selected with a stocking density of 55pL/tank where initial length was 0.2mm. At the end of the study period final length was estimated 5.5cm and the weight was 2.85g on average. The mortality rate of the prawn was lower in combined coarse filter and plant filtration system compare to other filtration systems that observed in the present study than generally reported in other studies (Cruz & Ridha, 2001, Shafai *et al.*, 2007). From above the discussions we can conclude that low cost filtration system can be used in rooftop fish and crustacean farming. Unused rooftop can be converted into a production unit for fish culture by taking proper approaches.

## 5. CONCLUSIONS

Rooftop fish farming has a great potential in Bangladesh. In developed countries this farming system provides commercial benefits to the people. In urban areas rooftop are mostly remain unutilized. We can utilize our rooftop by fish farming. Rooftop fish culturing need less management strategy than pond culture, there is no need to liming, fertilization, minimal risk of pathogenic attack and disease. A small portion of rooftop can provides us recreational and commercial benefits if we know the proper utilization of it. There is more research needed in order to improve the operation of rooftop farms, by systemically integrating them into buildings and connecting the material and energy flows with the building they are located on. This will foster further innovation in terms of combined energy and food production, use of waste heat in buildings, combined water treatment, and fish production. In addition, future research is needed to deepen on technical and economic aspects of rooftop fish farming. These findings highlight the great potential and show in which direction future developments might lead.

## 6. REFERENCES


Anak. P. 2007. Feasibility Study of A Recirculation Aquaculture System. Malaysian Fisheries Development Authority, Kuala Lumpur Malaysia, Final Project 2007.

Avnimelech, Y., Mozares, N., Shaher, D., and Kochba, M.1995.Rates of organic carbon andnitrogen degradation in intensive fish ponds. Aquaculture, 134:211-216.

Avnimelech, Y., 1999.Carbon/nitrogen as a control element in aquaculture system, Aquaculture. 176, 227–235.

Ballester, C. L. E , Marzarotto1, A.S., Castro,D. S.C., Frozza. A., Pastore. A. & Abreu, C.P.2017. Productive performance of juvenile freshwater prawns Macrobrachium rosenbergii in biofloc system. Aquaculture Research.48, 4748–4755.

Cristea V., Grecu I., Ceapă C.2002. Recirculating aquaculture system engineering, Didactic and Pedagogic Publishing House, RA Bucharest.

Cruz, E.M. & Ridha M.T. 2001. "Growth and survival rates of Nile Tilapia *Oreochromis niloticus L. juvenils* reared in a recirculating system fed with floating and sinking pellets. Asian Fisheries Science 14, 9–16.

Eleni .K. 2012. Addressing Food, Water, Waste and Energy yields in Urban Regenerative Environments, MSSD Thesis Carnegie Mellon University.

El-Shafai S.A., El-Gohary F.A., Nasr F.A., van der Steen N.P. & Gijzen H.J. 2007. Nutrient recovery in an integrated system for wastewater treatment and tilapia production. Environmentalist 27, 287–302.

Guang,.C., Shu-yi. J, Yong. L., Shi-cheng. H., Zhong-xiang. C. 2005. Study on design and performance of two-layer floating bead biofilter for recirculating aquaculture system (Heilongjiang River Fisheries Research Institute, Chinese Academy of Fishery Science,Harbin 150070, China. Journal of Fisheries of China . 2005-04.

Jennifer, .H. 2012. Rooftop Fish Farm Ups the Ante for Urban Agriculture, TreeHugger, https://www.treehugger.com/green-food/rooftop-fish-farm-ups-ante-urban-agriculture.html

John, .H., Sue. E. and Edoardo. P. 2013. Aquaponics Research Project. The relevance of aquaponics to the New Zealand aid program, particularly in the Pacific Commissioned Report Prepared by Hambrey Consulting for New Zealand Aid Program Ministry of Foreign Affairs and Trade.

Kamstra, A., van der Heul, J., and Nijhof, M. 1998. Performance and optimisation of trickling filters on eel farms. Aquacultural Engineering ,17(3) , 175 – 192.

Kim, S., Kong, I., Lee, B., Kang, L., Lee, M. and Suh, K. 2000 .Removal of ammonium – N from a recirculation aquaculture system using an immobilizednitrifiers, Aquaculture Engineering, 21, 139-150.

Losordo, T., Masser, M., and Rakocy, J. 1992. Recirculating aquaculture tank production systems: An overview of critical considerations, Southern Regional Aquaculture Center Publication, 451.

Masser, M.P., Rakocy J.E., and Losordo T.M. 1999. Recirculating Aquaculture Tank Production Systems.Management of Recirculating Systems. SRAC Publication No. 452 (revision March 1999) Department of Agriculture, USA.

Meade, J.W.1985. Allowable ammonia for fish culture, Progress in Fish Culture, 47, 135-145.

Nhan, D.T., Wille, M., Hung, T.L., Sorgeloos, P. 2009. Comparison of reproductive performance and offspring quality of giant freshwaterprawn (*Macrobrachium rosenbergii*) broodstock from different regions. Aquaculture, 298(1-2), 36-42.

Palmer, P.J. 2010. Polychaete-assisted sandfilters. Aquaculture , 306(1-4), 369-377

Pfeiffer. T. J. and Wills. P.S. 2009. Low-Head Saltwater Recirculating Aquaculture Systems Utilized for Juvenile Red Drum. Production International Journal of Recirculating Aquaculture, Volume 10, 11pp.

Roman G. 2013. The Farming Technique That Could Revolutionize the Way We Eat – CityLab. https://www.citylab.com/design/2013/03/farming-technique-will-revolutionize-way-eat/4880.

Savin. C., Păsărin. B., Talpeş. M., Hoha G., Tenciu. M., Paltenea. E., Mocanu. E., Gruber. A. 2012. Filter System Performance in a Tilapia Recirculating System, Animal Science and Biotechnologies, 45 (02).

Szyper. P. J., Tamaru. C. , Ako. H. , Hopkins. M. J., and Howerton. R. 2005. Low-Cost Biofiltration Systems. Aquaculture Extension Bulletin Spring.