Fish Poly Culture in Domestic Wastewater Ponds: A Step Towards Protein Rrecovery and Pollution Reduction

Sharique A. Ali
Postgraduate Department of Biotechnology & Zoology, Saifia
College of Science, Bhopal 462001 India
ORCID: htttps://orcid.org/0000-0003-4143-6380

ABSTRACT

Reclamation or recycling wastewater is an alternative to the gradual degradation of natural water resources. Reused or domestic sewage is highly loaded with nutrients, suspended solids, organic and inorganic matter, and microorganisms that provide natural food for several species of edible fishes. The effluent contains excessive nutrients which may increase the growth of aquatic plants and stimulate the production of natural food for fish. Oxidation ponds or stabilization ponds in the tropics are recognized as effective and economical units for the treatment of domestic sewage as well as biodegradable industrial wastes if managed properly. The driving force in a waste oxidation pond is solar energy utilized by active continuous photosynthesis. The action of sunlight on algae in the pond enables them to grow and rapidly consume the nutrients contained in the sewage. The algae and bacteria play an inter-dependent symbiotic role in these ponds, while the algae use the nutrients and carbon dioxide by bacterial decomposition, the bacteria make use of the oxygen liberated by the algae during photosynthesis, consequently increasing the rich natural biomass for the fishes. Updated compiled information in this review article suggests that domestic waste-water aquaculture is one of the best alternative ways to remove eutrophication as well as increase the culture of poly carps. This domestic sewage-purification cum reclamation bioprocess can be one of the cheapest methods, where natural sunlight, tropical conditions and biological parameters if managed judiciously, can be recycled and reclaimed for economically viable fish culture.

KEY WORDS: AQUACULTURE, DOMESTIC SEWAGE, EUTROPHICATION, RECLAMATION.

INTRODUCTION

World–wide attention has been focused on recent events in many parts of the world and on the problem of shortages and mal – distribution of food resources. The increasing population explosion coupled with apparent climatic changes and the rapid skyrocketing of oil prices has contributed to the worsening of the food situation to the conclusion that the problem will almost certainly become more critical in the future. To meet the critical shortage of world food supplies, intensive research is underway in several countries to develop technology for the massive and economic production of protein from the natural resources which at present are adequate, though dwindling fast.

Parallel problems receiving attention are those of preserving the quality of the environment and the proper management of limited resources, while fisheries constitute a small part of the gross national product (GNP) in most nations in Asia, their role in national development is of considerable significance in terms of job employment, foreign exchange earnings, food supply and more importantly socio-economic stability of the rural area where the majority of Asian populations live.

Reviews of the current status of the fisheries industries show that Asia still remains a center of fishery and aquaculture activities contributing more than 50% of fish production. Fishing and aquaculture play a significant role in contributing fish protein to a large population many of whom suffer from chronic malnutrition providing direct employment to fishermen and indirect employment in fisher stability–related industries; assisting in the socioeconomic stability of the rural area and in recent years in assisting developing countries earn foreign exchange through increasing export of high – priced commodities, (Ali et al 2021).

Unlike cereal protein, fish contains essential amino acids such as lysine and thus serves as an efficient supplement

Article Information:*Corresponding Author: drshariqali@yahoo.com
Received 05/04/2022 Accepted after revision 15/06/2022
Published: September 2022 Pp- 386-389

Available at: https://bbrc.in/ DOI: http://dx.doi.org/10.21786/bbrc/15.3.3

to the low-protein, high-carbohydrate diet of developing nations in Asia. Fish contribute a relatively large share of the animal protein intake and account for 33% of the meager animal protein consumed by the average Asian people. Moreover, the low official fish consumption rate presented by the United Nations Food and Agriculture Organisation (14.7 kg per capita, 1999-2006), does not reflect a reality where significant catches are unreported and therefore under-estimated in official statistics. Fish and other types of seafood are an important source of protein worldwide. Globally, they comprise about 6 percent of dietary protein, but for billions of people, fish account for up to 20 percent of the average per-capita intake of animal protein (FAO, 2014).

Water, which is one of the most vital resources for all kinds of life is also the resource which is most adversely affected both qualitatively and quantitatively by all kinds of human activities on land, air and water. It is known that the aquatic ecosystems are most delicately balanced and get easily disrupted by various human activities. The micro and macro communities in nature are orderly and play an important role in keeping the water healthy and acceptable for various uses. However, pollution of any kind, affects these communities, hindering their effective utilization. In various types of human activities, sewage disposal continues to be the most ominous one, especially in developing countries, (Vollenweider, 1968; Mara, 1976' Shuval, 1977; Biswas and Arar, 1988; Ali 1988 Ali, 1991, Ali 2000, Ali et al., 2020, 2021, Shobana et al., 2021).

With increasing urbanization and rapid growth in population, the reuse of wastewater in agriculture and aquaculture plays an essential role in reducing waste products and saving water especially when there is fast depletion of freshwater resources. Oxidation ponds or stabilization ponds are recognized as effective and economical units for the treatment of domestic sewage as well as biodegradable industrial wastes. The driving force in a waste oxidation pond is solar energy utilized by active continuous photosynthesis. The action of sunlight on algae in the pond enables them to grow and rapidly consume the nutrients contained in the sewage.

The algae and bacteria play an inter-dependent symbiotic role in the oxidation ponds, while the algae use the nutrients and carbon dioxide by bacterial decomposition, the bacteria make use of the oxygen liberated by the algae during photosynthesis, consequently increasing the rich biomass. This mechanism of sewage purification is one of the cheapest methods, where natural sunlight, tropical conditions and biological oxidation are used. Due to these biological processes taking place in special ponds, the chances of recycling and recovery of nutrients from sewage are very high, (Chakrabarti et al, 2011; Lahiri et al. 2018; Bojarski et al., 2020, Ali et al., 2021).

Sewage may be defined as "a cloudy or dark fluid with a very foul smell, arising out of domestic wastes containing mineral and organic matter either in solution or heavy particles of solid matter floating or in suspension or in colloidal and pseudo-colloidal forms in the dispersal of state. Sewage may vary considerably in composition and strength from place to place owing to marked differences in dietary habits and consumption. The strength of sewage is determined by the amount of oxygen to oxidize the whole organic matter content present in it (Modak, 1938; Mara, 1976).

Domestic treated sewage in the tropics is a rich source of nutrients, hence has been used for intensive aquaculture as well as abating the eutrophication of waters, but is often neglected in India due to well-known reasons. Disposal of sewage is a worldwide problem and consequently has received great scientific attention. Raw domestic sewage contains a huge amount of organic and inorganic compounds along with nutrients (WHO, 1989; Kaur et al., 2018; Hoffmann et al., 2020), which can be recycled. Hence, the enormous nutrients in sewage water can be used to culture fishes (WHO 1989, Ghosh, 2018 Ali 2000). Fish farming using domestic sewage water has been practised for decades by many cultures. In sewage water, an enormous amount of nutrients serves as an ideal fertiliser for phytoplankton and zooplanktons to increase and flourish the productivity of the aquatic ecosystem, which eventually serve as valuable food for the fishes, (Mandal et al, 2015; Mandal et al, 2018; Bunting and Edward, 2018; Prakash & Verma 2020; Shobana et al., 2021).

Fish farming using domestic sewage water has been experienced for hundreds of years by many countries across the world, (WHO, 1989, Nandeesha et al., 2002; Jana et al., 2018). It is one of the best alternative ways to treat domestic waste for the fish culture. It also involves one of the cheapest and eco-friendly processes to remove excessive nutrients like phosphorous and nitrogen to maintain a balanced food cycle of the ecosystem, (An et al., 2003; Wang et al., 2013; Manea, & Ardelean, 2016; Yang et al., 2019, Ali 2000, Ali et al., 2020; Li et al., 2021).

In India, fish culture practices in freshwater ponds utilised with domestic sewage are of rather a recent origin. Several successful attempts were made by various investigators on the productivity of sewage ponds in several southern and eastern states of India. The use of sewage effluent or treated sewage for raising fish from ponds in India was advocated by Hora (1944), Pillai et al. (1945), Ganapati and Chacko (1951), Bhatia et al. (1970). Apart from the fish culture in sewage-fed ponds made some observations on the hydrological conditions of newly constructed sewage-polluted ponds in Madurai, Saha et al. (1970) have described the chemical nature of raw sewage and hydrological conditions in sewage–fed ponds.

In view of the present rate of generation of sewage and already loaded aquatic resources, it has been increasingly recognised that disposal of sewage into fresh waters possess a variety of hazards. In developed countries, the sewage is handled by well-developed organizations, treated at various levels and ultimately disposed to freshwater or recycled. The reuse of municipal and industrial sewage has become an attractive option to avoid the effects caused by sewage on the freshwater ecosystem. On the other hand, in developing countries, sewage disposal still remains a major problem,

despite the fact that low-cost technologies for disposal of domestic and industrial sewage are available. The concept of oxidation ponds in tropical countries has been found to be of utmost utility. By way of solar energy and its use, the sewage can be very well degraded and even has been found to be of reuse in aquaculture, agriculture and other uses.

In order to reuse the domestic wastewater or sewage for the fish culture, it requires that the sewage must be physically and biologically treated and this treatment of domestic wastewater for its purification gives rise to the concept of proper functioning of the oxidation or the stabilization ponds as suggested by several pioneer workers in the field, (Allen, 1970; Allen and Hepher, 1976 and Mara, 1976; Ali, 1988, 1991, 2000, and Ali et al., 2020, Prakash & Verma 2020; Shobana et al., 2021). The culture of fishes in highly nutrient waters has been made evident by the experiments of these above workers, which have demonstrated that fishes can grow considerably fast because of the easy and highly nutrient food web available to the fishes. It has become clearly known that fishes show significant changes in their growth rates.

CONCLUSION

Domestic sewage has become a very attractive proposition for the recovery of valuable protein and its products it has been found to be quite rich in nutrients. Fish and other aquaculture products have grown in domestic sewage and offer excellent high-yield opportunities. Fishes grew in domestic sewage in developing and developed countries have been found to be quite suitable for human consumption. It is concluded that aquaculture is the best alternative way to remove eutrophication from water by taking the excessive amount of nutrients such as nitrogen and phosphorus by fishes that were produced after the oxidation of ponds and ultimately maintaining the water quality. This is the best alternative way and also plays an important role in removing the eutrophication from sewage for aquaculture. The biological treatment of domestic sewage oxidation ponds is one of the economical methods to produce fish and also can reduce the aquatic pollution. However, more work has to be carried out in this aspect to remove myths and misbelieves about sewage pond aquaculture.

ACKNOWLEDGEMENTS

The author acknowledges the US Department of Agriculture, Office of the International Cooperation and Development, (OICD-FERRO) American Embassy New Delhi, India for Grant No (PL-480) In AES-208, FG In 623. Thanks, are also due to the Secretary Saifia Education Society Bhopal India for providing the necessary facilities.

Conflict of Interest: The author declares no conflict of interest.

REFERENCES

Allen, M.B. (1970). General features of algal growth in sewage oxidation ponds. California Publ. 13, p. 47, California.

Allen, G.H. and Hepher, B. (1976). Recycling of waters through aquaculture and constraints to wider application. Advances in aquaculture. FAO, Rome, Italy, 478-487.

Ali, S.A. (1988). Management of productivity and production of fish in sewage pond effluents in urban areas. USDA (PL-480) Research Programme. In AES-208, FG In 623. Final Technical Report, 1-128.

Ali, S.A. (1991). Enhancement of food production and abatement of eutrophication through waste water fish culture. The 6 world Fisheries Congress, Athens, Greece, April 14-19.

Ali SA. (2000). Monitoring and evaluation of domestic waste water for fish culture. Aquaculture Research Needs For the Year 2000 A D, Oxford University Press UK US Department of Agriculture & ICAR New Delhi Publication 87-99

Ali, S. A., Raju, M. H., & Parveen, N (2020). On The Analysis of Certain Biochemical Parameters of Carps Cultured in Domestic Sewage Oxidation Ponds. Bioscience Biotechnology Research Communications 13(4): 2311-2318. DOI:10.21786/bbrc/13.4/103.

Ali, S. A., Raju, M. H., & Parveen, N. (2021). Seasonal analysis of certain biochemical parameters of carps cultured in domestic sewage oxidation ponds. Journal of Applied Biology and Biotechnology, 9(5), 1-5.

An J.Y., S.J. Sim, J.S. Lee and B.W. Kim, (2003). Hydrocarbon production from secondarily treated piggery wastewater by green alga Botryococcus braunii. J. Appl. Phycol., 15, 185-191.

Bhatia, H.L., Saxena, M.K., Sastry, C.A., and Rao, A.V. (1970). Rearing of fish try of Indian major carps in sewage stabilization ponds. The Vikram, 13 (1&3).

Biswas, A.K. and Arar, A. (1988). Treatment and reuse of waste water. Butterworths & FAO, London, Rome.

Bojarski, B., Kot, B., Witeska, M., (2020). Antibacterials in aquatic environment and their toxicity to fish. Pharmaceuticals 13, 189. https://doi.org/10.3390/ph13080189

Bunting, S. W., & Edwards, P. (2018). Global prospects for safe wastewater reuse through aquaculture. In B. B. Jana, R. N. Mandal, & P. Jayasankar (Eds.), Wastewater management through aquaculture (pp. 95–118). Springer Nature Singapore Pte Ltd.

Chakrabarti, P. P., Ghosh, P. K., Mukhopadhyay, P. K., & Jayasankar, P. (2011). Urban sewage water recycling through aquaculture. Everything About water, 36–39.

FAO (2014) The state of world fisheries and aquaculture. Opportunities and challenges. Rome, Italy: FAO; 2014.

Ganapati, S.V. and Chacko, P.I. (1951). The Madurai Municipal Sewage fish farm. Indian Geog. J. 15(3) : 35-44.

Ghosh, S. (2018). Wastewater fed aquaculture in East Kolkata Wetlands: State of the art and measures to protect

biodiversity. In B. B. Jana, R. N. Mandal, & P. Jayasankar (Eds.), Wastewater management through aquaculture (pp. 119–137). Springer Nature Singapore Pte Ltd.

Hoffmann, L., Rawski, M., Nogales-Merida, S., & Mazurkiewicz, J. (2020). Dietary inclusion of Tenebrio molitor meal in sea trout larvae rearing: effects on fish growth performance, survival, condition, and GIT and liver enzymatic activity. Annals of Animal Science, 20(2), 579-598.

Hora, S.L. (1944). Fish farmer's Calendar. Bengal Fisheries Department Circular 1-7.

Jana, B.B., Mandal, R.N. and Jayasankar, P. eds (2018). Wastewater Management Through Aquaculture. Springer Singapore. Pp 1-16.

Kaur, S., Khera, K. S., & Kondal, J. K. (2018). Heavy metal induced histopathological alterations in liver, muscle and kidney of freshwater cyprinid, Labeo rohita (Hamilton). Journal of Entomology and Zoology Studies, 6(2), 2137-2144.

Lahiri, S., Ghosh, D., & Sarkar-Paria, D. (2018). Biogeochemical cycling bacteria and nutrient dynamics in waste stabilization pond system. (pp. 29–52). Springer Nature Singapore Pte Ltd.

Li D, Yang JW, Li Y, Li S, Zhang SR, Wang WQ, Zhang J. (2021). Aerobic Granular Sludge Operation and Nutrient Removal Mechanism from Domestic Sewage in an Anaerobic/Aerobic Alternating Continuous Flow System. Huan Jing Ke Xue. May 8;42(5):2385-2395. Chinese.

Mandal, R. N., Chakrabarti, P. P., & Jayasankar, P. (2015). Sewage fed aquaculture: A viable proposition for fish production through nutrients recovery and water conservation, in effect of abating water pollution. In R. P. Singh, & A. Sarkar (Eds.), Waste management (pp. 93–113). USA: Nova scientific Publication.

Mandal, R. N., Chakrabarti, P. P., Paul, B. N., Chattopadhyay, D. N., Das, A., Hussan, A., et al. (2018). Recycling of sewage in aquaculture: Decadal technical advancement. In B. B. Jana, R. N. Mandal, & P. Jayasankar (Eds.), Wastewater management through aquaculture (pp. 95–118). Springer Nature Singapore Pte Ltd.

Manea, R. G., & Ardelean, I. I. (2016). Nitrogen and phosphorus removal from municipal wastewater using cinsortia of photosynthetic microorganisms. Scientific Bulletin. Series F. Biotechnologies, 20, 286-292.

Mara, D. (1976). Sewage Treatment in Hot Climates. London, John Wiley & Sons.

Modak, N.V. (1938). Sewage disposal, Bombay Municipal Corporation.

Nandeesha, M. C., Gangadhara, B., & Manissery, J. K (2002). Further studies on the use of mixed feeding schedules with plant-and animal-based diets for common carp Cyprinus carpio (Linnaeus). Aquaculture Research, 33(14), 1157-1162.

Pillai, S.C., Rajagopalan, R. and Subrahmanyam. V. (1945). Main progress report on investigations on sewage farming for the period 1st June 1942 to 31st March 1945. Indian Institute of Sciences, Bangalore.

Prakash, S., & Verma, A. K. (2020). Effect of Arsenic on Serum Biochemical parameters of a fresh water cat fish, Mystus vittatus. International Journal of Biological Innovations, 2(1), 11-19.

Saha, K.C. (1970). Fisheries of West Bengal. West Bengal Government Press, Alipore, West Bengal, 138 pp.

Shobana, C., Rangasamy, B., Hemalatha, D., & Ramesh, M. (2021). Bioaccumulation of silver and its effects on biochemical parameters and histological alterations in an Indian major carp Labeo rohita. Environmental Chemistry and Ecotoxicology, 3, 51-58.

Shuval, H.I. (1977). Public Health Implications of waste water reuse for municipal purposes. In Waste Water renovation and reuse. Ed. By D'ltri, Marcel Dekker Inc., New York and Basel, pp. 349-386.

Vollenweider, R.A. (1968). Scientific Fundamentals of the Eutrophication of Lakes and flowing water with special reference to nitrogen and phosphorus as factors in eutrophication. OCED, Paris.

Wang, C., Yu, X., Lv, H., & Yang, J. (2013). Nitrogen and phosphorus removal from municipal wastewater by the green alga Chlorella sp. Journal of Environmental Biology, 34(2 suppl),

WHO, (1989). Health Guidelines for Use Of Wastewater In Agriculture And Aquaculture. WHO technical report series No.778. World Health Organization, Geneva.

Yang SQ, Zhang XQ, Han RM, Du MX, Dai KW, Han X. (2019). The enhanced effect of supplemented lighting on nutrient removal by an aquatic vegetables (lettuce) purification system from rural domestic sewage. Int J Phytoremediation. 21(10):953-957.