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# Efficacy of Sewage Treated Water on Fish Growth Performance and its Physicochemical characteristics

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**ABSTRACT: In the rapidly urbanizing world, freshwater shortage has been the major concern. On the other hand, there is growing realization to increase aquaculture productivity for food and nutritional security. Therefore, the concept of using wastewater for aquaculture is very much relevant to enhance the productivity. The water quality directly influences the fish's growth rate, health, survival and economics of the aquaculture sector. Despite being a rich source of nutrients, the presence of pathogenic microbes and heavy metals in the sewage water may distress the fishes affecting their health and worsening the conditions more. The present review is an attempt to collect all the available literature on fish survival and growth in sewage treated water, water quality parameters, presence of microbial count, heavy metals, their effect on different fish species and biological treatment of sewage treated water to optimize the conditions for fish growth.**

**Keywords:** Aquaculture, growth, heavy metals, microbial load, sewage treated water.

## INTRODUCTION

Sewage fed aquaculture is practiced under different forms. Addition of appropriate amount of sewage in fish culture ponds tends to increase the productivity. In many cases, sewage treated waste water is diluted before being used for fish culture whereas in other studies, sewage treated water is used as such. Studies have shown that the integration of sewage in fish culture ponds facilitated enhanced water productivity and made the aquatic life vibrant through incorporation of required nutrients. At present, sewage treated water is used for fish culture in eight states. A similar initiative is underway in Haryana to improve fish productivity in this area.

**Impact of sewage treated water on fish survival and growth.** The imperativeness of the use of sewage is assessed by many workers. Furedy and Ghosh (1984) reported that though Calcutta has many waste disposal problems, it is yet to lose its standing among South Asian cities for its efficient use of wastes, including the use of sewage in fisheries. Earlier studies indicated that uncontrolled sewage intake can damage fish crops severely, as BOD increases, the stress to fish crops develops, resulting in mass fish mortality (Chattopadhyay *et al*., 1988; Jana 1998). Ghosh *et al*. (1985) considered Indian major carps for culture in fish ponds fed with primary treated sewage. The usual ratio was followed for better output: Catla 1: Rohu 2.5: Mrigal 2.5: Common Carp 2: Silver carp 2. In carp culture, stocking density for the surface feeders was increased from 30 to 40 percent by reducing column feeder from 25 to 20 percent and bottom feeder from 45 to 40 percent, but no appreciable change in the yield rate was noticed, suggesting thereby that the sewage-fed ponds were equally good for surface feeders and bottom feeders. According to Das (1995),mrigal *(Cirrhinus mrigala):* common carp *(Cyprinus carpio)* rohu *(Labeo rohita):* Catla *(Catla catla):* andsilver carp *(Hypophthalmichthys molitrix)* are the five different carp species usually reared in sewage water. Additionally,bata *(Labeo bata),* grass carp *(Ctenopharyngodon idellus),*Tilapia *(Oreochromis mosambicus),* carp minnow *(Amblypharyngodon mola),* freshwater prawn *(Macrobrachium rosenbergii)*and diverse catfishes are also cultured in wastewater supported culture system.

Datta *et al*. (1996) evaluated the culture potential of *Labeo bata* under Wastewater Aquaculture. For a uniform seed density of 50,000 seeds per ha in ponds fed with treated domestic sewage effluent, an average yield of 1270.63 kg per ha was attained within a period of 6-10 months. As opposed to an initial weight of 0.096 to 0.193 g, the average size of the fish in each set of experiments varied from 23.3 to 37.9 g. Khalil and Hussein (1997) reported significantly higher Nile tilapia's(*Oreochromis niloticus)* growth rate when reared in treated waste water as compared natural habitat. Rai and Bista (2001) studied a Specific Growth Rate value of 0.17 to 0.3 percent/day for common carp. An evaluation of water productivity in a carp culture system using controlled irrigation was conducted by Dasgupta *et al*. (2008) compared to a fertilized method.

As a result of the experiment, the gross fish production with sewage incorporation was similar to those with fertilizer-based systems. Net water productivity, however, was 64 percent higher in sewage-based systems, as the sewage source was a nutrient source that was 64 percent more abundant. Dasgupta *et al*. (2008) observed better growth of fish in diluted sewage water than raw sewage water.

Nwabueze (2013) investigated the growth of six weeks old fingerlings of the mudfish, *Clarias anguillaris* in treated and untreated domestic sewage at 0, 25, 50, 75 and 100 percent conjcentration. In the treated domestic sewage, fish grew significantly faster (both in weight and length) than in the untreated domestic sewage. All concentrations of treated domestic sewage did not significantly differ from controls in terms of fish length. As a result, fish treated with 100 percent domestic sewage only increased in length more slowly than fish treated with other concentrations. Nwabueze (2013) reported an increased growth sequence (total length) in 100 <25 <75 <50 percent concentration and increasing sequence of growth (weight) in 25 <100 <75 <50 percent concentrations of sewage. The potential of sewage fed aquaculture system model was assessed by Kumar *et al*. (2014) in Karnal, India. A study of the economic feasibility of the model showed that selling fish in the local market and using treated effluent to feed the farmers would produce an annual profit of INR 8-10 lakhs. It is also possible to save fifty kilograms of urea and fifty kilograms of di-ammonium phosphate during the cultivation of one acre of crops using treated wastewater irrigation. In addition to removing physic-chemical pollutants, the system is also effective in removing bacteriological pollutants.

Quality of Red hybrid tilapia was compared by between Kenyir Lake and Semantan River, Malaysia, comparing the effect of contaminated water. According to their findings, the fish at the Semantan River site reached a weight of 250 grams, survived and grew faster (>250 grams) than the fish at the Kenyir lake.Because of water contamination in Kenyir Lake, fish in Semantan River were better quality, free from diseases, more resistant and more able to survive than fish in Kenyir River. Throughout Bheris, exotic carps are stocked as well, but Indian carps are preferred because of their herbivorous feeding behavior and rapid growth rate. There are several species of carps in Bheris, including the Rohu (*Labeo rohita*), the Mrigal (*Cirrhinus mrigala*), the Bata (*Labeo bata*) and Catla (*Catla catla*) although the mrigal outnumber all others (Chatterjee *et al*., 2014). Generally fingerlings are stocked to reduce mortality rate. The Tilapia culture (*Oreochromis nilotica* and *O. mossambicus*) is gaining popularity and consist about 5-10 percent of the stock. Jana *et al*. (2016) cultured *Labeo rohita* fingerlings in 25, 50, 75 and 100% concentration of sewage water in 500 L FRP tanks in laboratory conditions for a period of 90 days. The specific growth rate (SGR) of fish was significantly higher in 75 percent concentrated sewage water than the other treatments. It ranged from 0.35 to 0.47 percent/ day. The results obtained conclusively suggested that sewage water after dilution enhanced the growth of fishes without adding any additional food and fertilizers. Fish growth parameters like total body weight and total length showed an increasing trend along with the sewage concentration as 100 < 25 <50 <75 percent which strongly stated that fish growth is dependent on the amount of sewage. The growth was highest at 75 percent concentration of sewage than other treatments.

During the complete life cycle of tilapia (*Oreochromis niloticus*), Osman and El-Khateeb (2016) studied the effects of water contamination on the survival and yield of the fish.Raw water is used in the first pond culture (I) and treated water is used in the second pond culture (II). In the treatment process, 0.4 ppm of chlorine was added to the treated water and aeration was applied for three to four days. The results of the study stated that pond II had a growth rate of 2.09 grams per fish per day, whereas the other site had a growth rate of 1.27. Additionally, for I and II ponds, mortality rates were 25.4 and 7.24 percent, respectively. Zaibel *et al*. (2019) conducted studies on Guppy (*Poecilia reticulata*) fingerlings reared in 0, 50 and 100 percent tertiary treated waste water for 4 months. Treatment groups did not differ in fish survival rates, ranging between 77 and 80 percent.Reecha (2021) conducted a study to evaluate the growth parameters of *Pangasius hypopthalamus* reared in sewage treated water with and without feed. The study concluded that irrespective of the treatments, the maximum weight was recorded at $90^{th}$ day (27.16 g) which showed significant difference with fish weight at other observation period. Moreover, there was a significant increase in the weight and length of the fishes cultured in sewage treated water.

**Nutrient load in sewage treated water.** By reclaiming nutrients from wastewater, wastewater-based integrated aquafarming a cost efficient technology creates employment and mobilizes resources for nutrient reuse.Those who are interested in organic fertilizers can use sewage effluent, which contains a high amount of nutritive substances. Dehadrai and Ghosh (1979) reported that sewage effluent was capable of containing high quantities of nutritive substances. Within 3-5 days of application, phosphorus, nitrogen, and trace elements are liberated from wastewater, and phytoplanktons begin blooming, followed by zooplanktons (Ghosh *et al.*, 1988). According to Mann (1972), smaller waste particles became food for zooplanktons and benthos while large waste particles were eaten by fish directly. Planktons consume soluble organic materials and their rate of reproduction is directly related to the nutrients they receive. Allen and Heper (1979) found that plankton use soluble organics as food.

Based on the feeding of Nile tilapia (*Oreochromis niloticus*), Neto and Ostrensky (2015) estimated the nutrient load in aquatic wastes. The observation concluded that in the aquatic environment, 18% of the feed given to the animals was not consumed. For the organic matter in the diet, the average digestibility was 71.97 percent, for protein, it was 84.06 percent, and for phosphorus, it was 54.40 percent. With respect to what was actually ingested by the tilapia, the estimated nutrient deposition efficiency was 26.39 percent for organic matter, 43.25 percent for protein and 34.07 percent for phosphorus. One liter of treated sewage can generate an average of 0.05 g nutrients in the form of N and P and conserve 99 percent of water (Mandal *et al*. 2015).According to research, fish reared in sewage-fed water bodies produce an average of 0.30 g biomass per liter of effluent consumed.

**Physico-chemical characteristics of sewage treated water.** Sewage effluent contains nutrients as well as contaminants and it is important to ensure that effluent from sewage systems is properly incorporated into fish rearing systems in order to ensure adequate water quality suitable for fish culture, while keeping contamination risks within safe limits (Rajan *et al*., 1995; Bhowmik *et al*., 1997). Studies were conducted by many workers on water quality parameters of sewage treated water. Growth of fish was strongly dependent on the amount of sewage received following stocking (Ghosh *et al*., 1980). A direct relationship was found between fish production and sewage intake levels, since percent weight gain and gross production levels were directly related (Jana, 1998). Water quality parameters were significantly affected by lower sewage effluent incorporation with 1:1 dilution than in the control, according to Dasgupta *et al*. (2008). Carp growth was aided by maintaining water quality parameters such as BOD, temperature, pH, dissolved oxygen, and alkalinity at an optimum level. In sewage-incorporated systems, total ammonia–nitrogen (TAN) and phosphorus ($P_2O_5$) levels were higher than in controls (Chakrabarty, 2002; Saha and Mandal, 2003).Higher levels of sewage nutrient incorporation did not correlate positively with gross primary productivity values and hence was concluded that Allocanthonus systems depend on bacterial food chains to contribute high fish yield, which cannot be addressed by the GPP alone.

Two fish farms in Nigeria were examined by Davies and Ansa (2010) to estimate physicochemical parameters. The pH, Dissolved Oxygen, Biological Oxygen Demand and ammonia values for stagnant concrete tanks were 6.48, 4.34, 6.66, and 0.09 while those for tidal earthen ponds, the recorded values were 6.18, 6.33, 6.35 and 0.48 that receive water from the New Calabar River contaminated by human activity. Using these results, the authors concluded that variation of water quality due to human activity and natural effects have a negative impact on the lives of fish in the farms. There is evident that tilapia can survive in fish farms at concentrations of 0.3 mg/L dissolved oxygen for several hours, although it is preferred to have concentration of DO from 7 to 8 mg/L as experimented by Kumar and Pur (2012). In Egypt, there are tens of tons of fish that have died on the shore of the Nile in Delta area because of the high levels of ammonia (from factories) (Mohamed *et al*., 2013).An analysis of domestic sewage water by Nwabueze (2013) found untreated sewage had higher turbidity, alkalinity, biochemical oxygen demand and nitrate content compared to treated sewage which was significantly clearer than untreated water. Bhadravathi town (Karnataka) receives sewage continuously from residential areas around it, causing a biochemical and physicochemical change in the water body. Kiran (2014) estimated physicochemical and biological characteristics of the water body. It showed an alkaline pH with the values ranging from 7.50 to 7.95. The higher range of pH indicates higher productivity of water. Total dissolved solids and phosphate level varied between 345.20- 418.70 mg/l and 0.22 to 0.95 mg/l, respectively. Phosphate level increased during summer season with 0.80 mg/l and decreased in winter season to 0.28 mg/l.

It was evident that the parameters related to water quality changed significantly with seasons and were indicative of productivity. (Chatterjee *et al*., 2014). There was a higher level of phosphorus among the nutrients and the values of all other nutrients was directly proportional to the increase in temperature. There was a negative correlation between total fish production and total plankton production, Dissolved Organic Matter, Biological Oxygen Demand and nitrate-nitrogen. Jana *et al*. (2016) conducted experiment on *L. rohita* and exposed the fingerlings in 25, 50, 75 and 100% concentration of sewage water. The temperature and pH of water ranged from $27.53^0$C to $30.47^0$C and 7.41 to 7.81, respectively which were considered ideal for carp culture. The Dissolved Oxygen level varied from 5.01 to 5.74 mg/l in all the treatments which supported good fish production. Total alkalinity, hardness, $NO_3$-N, $NH_3$-N, $PO_4$-P, Total Solids and Total Dissolved Solids of various treatments were significantly higher than the control which justifies the presence of organic matters in sewage water directly affecting these parameters.

**Microbial population in sewage treated water.** Most of the studies reported higher microbial count in untreated sewage water than in treated sewage water. Using chemicals or biological methods, Shelton and Murphy (1989): Joseph and Simeon (2015) showed that fish farms increase the likelihood of diseases or deaths as a consequence of water pollution. This leads to a shortage of animal protein in the market and economic losses (Olufemi, 1985). Khalil and Hussein (1997) reported significantly higher bacterial loads in gills of Nile tilapia *Oreochromis niloticus* reared in treated waste water followed by intestine, skin and edible muscles. Biological components in edible muscles of fish raised in secondary treated effluent were very low ($9.3 \times 102\ g^{-1}$) and met WHO recommendations (less than 105 $g^{-1}$). Upon examination, none of the fish samples tested were contaminated with *Shigella*, *Staphylococcus* or *Salmonella*. Cholera, Tuberculosis, shigellosis and dysentery are caused by the consumption of fish infected by *Vibrio cholera, Mycobacterium tuberculosis, Shigella dysenteriae and Escherichia coli,* respectively (Austin and Austin 2007).

In another study, microbial analysis showed the presence of *Escherichia fecalis, Streptococcus fecalis* and *Enterococcus fecalis* in untreated sewage along with ciliated protozoans in treated as well as untreated sewage (Nwabueze, 2013). The study showed that healthy fish growth is best achieved using treated domestic sewage, which is less likely to transfer pathogens to the fish. The reported removals for fecal coliformfecal, streptococci and total coliform were found to be 99.98, 99.96 and 99.95 percent, respectively in sewage-fed aquaculture system of Karnal (Kumar *et al*. 2014). Osman and El-Khateeb (2016) compared the total viable bacterial count for water and fish tissue in treated and untreated pond and reported alower bacterium count of *Streptococcus fecalis*, *Salmonella* species, *Pesudomonas auerognosa, E. coli*in treated ponds. Zaibel *et al*. (2019) used tertiary treated waste water to rear *P. reticulata.* Water analyses revealed that 33 out of 67 tested organic micropollutants (OMPs) were detected at least once in tertiary treated waste water samples, at concentrations comparable to those found in domestic waste water. Infections with Tetrahymena species resulted in similar growth and mortality in all treatment groups (between 64 and 68%). Immunological parameters such as lysozyme and anti-protease were similar in the fish that were reared with 50 percent tertiary waste water, whereas complement activity was highest in the fish that were reared with 50 percent tertiary waste water.

**Effect of microbial population on fish health.** Buras *et al.* (1987) reported that in treated domestic wastewater, the blood or muscles of healthy clean fish was devoid of any bacteria. However, bacteria can be present in other organs but in small concentration. Bacteria were found in the muscles of fish exposed to treated wastewater throughout their growth period. A total of $10^4$-$10^6$ /g of bacteria were recovered from various organs, and $10^8$-$10^9$ /g were recovered from the digestive tract. Najiah *et al*. (2012) reported lethal consequences from Tilapia fish when infected with *Aeromonas* spp., *Pseudomonas* spp., *Enterococcus* spp., *Streptococcus* spp., *Staphylococcus* spp., *Vibrio* spp., *Enterobacteriaceae* and *Micrococcus* spp. Marcel *et al* (2013) noticed that the water in Semantan River and Kenyir Lake contains a large amount of potentially pathogenic bacteria as a result of human activity. A random sample of 30 tilapias was collected to detect these bacteria from brains, tissues, kidneys and eyes and concluded that the fish was not suitable for human consumption.

Ali *et al*. (2015) studied in Egypt the influence of wastewater on Oreochromis niloticus health at two sites (80 fish/site) on the River Nile (El-Sail Drain). Bacterial counts were conducted at the site before draining and at the site after draining and according to their findings, the average total bacterial count at $37^oC$ (cfu/ml) was as follows: total coliform (MPN/100 ml): fecal coliform (MPN/100 ml): fecal Streptococci (MPN/100 ml):*Salmonella* spp. (cfu ml$^{-1}$) and *E coli* (cfu ml$^{-1}$) were recorded $3.1 \times 10^4$, $21.9 \times 10^4$; $3.5 \times 10^2$, $1.6 \times 10^3$; $0.5 \times 10^2$, $2.75 \times 10^2$; $1.1 \times 10^2$, $1.1 \times 10^2$; $0.2 \times 10$, $0.4 \times 10$; and $1.6 \times 10$, $3.5 \times 10$, for two sites, respectively. Especially at site II, which is a reservoir for untreated wastewater in River Nile, scientists report that the fish are of poor quality and pose a serious health risk. Joseph and Simeon (2015) attempted to study the yield of tilapia fish (*Oreochromis niloticus*) on both raw and treated water body located in Nigeria. The average counts for total bacterial, total coliform, *E. coli*, fecal streptococci, *Staphylococcus aureus* and *Salmonella* spp. were detected in different sites, where in lagoon water samples were recorded as $9.6 \times 10^7$, $9.1 \times 10^6$, $4.8 \times 10^6$, $2.5 \times 10^6$, $1.4 \times 10^6$, and $2.9 \times 10^6$ cfu/100 ml but in water pond water samples were $5.6 \times 10^5$, $0.4 \times 10^5$, $0.3 \times 10^4$, $0.3 \times 10^4$, $0.3 \times 10^4$ and $0.5 \times 10^4$ cfu/100 ml, respectively. In addition, all the samples of water and fish tissue was tested for *Pesudomonas aerugnosa.*

**Heavy metals in sewage treated water.** The wastewater treatment process produces sludge whose chemical composition depends on the wastewater influent and its process of treatment (Tytła *et al.,* 2019). As contaminants in wastewater accumulate in the sludge, it increases organic load tremendously, resulting in a reduction in dissolved oxygen levels and nutrient enrichment in lakes and rivers (Okoh *et al.,* 2007). Among Nile tilapia reared in treated waste water, concentrations of heavy metals follows the respective trend: liver, intestines, gills, and muscles (Khalil and Hussein, 1997). Comparing the accumulation levels of hazardous elements in fish and fishery products with international legal standards, they were within acceptable limits. Three sewage treatment facilities and their receiving waterbodies were assessed for heavy metal distribution (Pb, Cd, Zn, Fe and Cu) by Agoro *et al.* (2020) in the Eastern Cape Province, South Africa. Generally, Cu, Cd, Fe and Pb concentrations in the sludge ranged from DL (below detection limit) to 1.17 mg Kg $^{-1}$, <DL to 0.14 mg Kg $^{-1}$, 27.588 to 69.789 mg Kg$^{-1}$, and <DL to 0.099 mg Kg $^{-1}$ for Cu, Cd, Fe and Pb, while Zn was below detection throughout. Similarly, the levels of Cu, Cd, and Fe in the influents, effluents, upstream and downstream across the three plants ranged from <DL–6.588 mg L$^{-1}$, <DL–0.636 mg L$^{-1}$, <DL–0.878 mg L$^{-1}$ and <DL–0.711 mg L$^{-1}$, respectively; Zn and Pb were less than DL in all the matrices and study locations. Cd was the only contaminant that was higher in effluents and surface waters, while all other contaminants were below hazardous levels in all sludge and aqueous samples.

**Bioaccumulation of heavy metals in fish tissues.** As per World Health Organization (WHO): the permissible levels of Chromium and Copper are 12– 13 and 30µg/g. The maximum permissible doses of lead and Mercury as per European Union are 0.4 and 0.5–1.0µg/g (FAO/WHO, 1976). In accordance with international standards, the range of lead in fish is 0.5–10µg/g (EU, 2001). The FAO/WHO (1976) has not established guidelines on acceptable zinc levels in fish muscle. The liver and kidney accumulate cadmium, with the kidney accumulates more than the liver, according to Gosselin *et al*. (1984). The concentration of nickel was 1.64 - 3.58ppm in fishes (Idodo-Umeh, 2002). Ashraf (2005), collected *Epinephelus microdon*, from the Arabian Gulf, Eastern province of Saudi Arabia to test for Co, Pb, Ni, Cu, Cd, Mn and Zn levels in kidney and heart tissues . Based on the analysis of metals in the kidney tissues, Zn was accumulated in the highest quantities than Cu, Pb, Ni, Co, Mn, and Cd, with a Zn level of 47.73 ppm and a Cd level of 0.41 ppm. There was a significant decrease in Cu, Mn, Co, and Ni levels in kidney tissues compared to previous reports. A similar pattern of metal accumulation was observed in the heart tissue; Zn > Cu > Pb > Co > Ni > Mn > Cd. Heart tissues showed high levels of nickel (1.69 ppm), lead (3.19 ppm), cadmium (0.34 ppm), cobalt (1.75 ppm) and copper (3.96 ppm), and while kidney tissues showed high zinc and manganese concentrations. It was found that the heart of C. *gariepinus* had a cadmium concentration of 0.25ppm and the kidney had a cadmium concentration of 0.69ppm (Farombi *et al*., 2007). Cobalt concentrations in *Oreochromis mossambicus* ranged from 0.039 to 1.44ppm (Eralagere and Bhadravathi 2008). Among the three species, chromium levels ranged between 0.40 and 5.61ppm from *Parachanna obscura*, 29.8 - 31.6ppm from *T. zillii* and 28.1 - 32.2ppm from *C. gariepinus* (Ishaq *et al*., 2011).

The Banan section of Chongqing in the Three Gorges of the Yangtze River was investigated by Zhang *et al*. (2007) for heavy metal contamination in 19 fish species. The results showed that with the exception of zinc in the upper strata, intestines had higher heavy metal concentrations than muscles. As, Cr, Cu, and Hg concentrations in muscle and intestine of fish inhabiting the upper strata were significantly different. Also, the concentrations of Cr and Cu in muscle and intestine of fish living in middle strata varied significantly. Interestingly, both intestine and muscle tissues of fish inhabiting bottom strata showed significant differences in mean concentrations of As, Cd, Hg, Pb and Zn. Additionally, among the fishes inhabiting different strata, As, Cd, Cr, Cu, Hg, and Pb concentrations were higher in muscle and intestine of fish from the bottom strata (BS) than those from the upper strata (US) and middle strata (MS); meanwhile, fish inhabiting upper strata had a higher Zn concentration in muscle and intestine. Results from the Banan section of the experiment showed that fish muscle had slight contamination from heavy metals, but not to the level of Chinese food standards. The study conducted by Reecha (2021) to evaluate the bioaccumulation of heavy metal in different tissue of *Pangasius hypopthalamus* when reared in sewage treated water revealed that the net accumulation of heavy metal was estimated as follows: Fe>Mn> Cu > Zn although all were well below the permissible limits. In addition, the bioaccumulation trend among the five fish organs were: Gills > Muscle > Brain > Heart > Stomach. The results of study conducted by Mensoor and Said (2018) showed that there was an excess of heavy metals in the samples of fish destined for human consumption in Iraq, exceeding the limits at which they can be consumed. In the tissues of the selected fish sample, high levels of cadmium and chromium were detected.

**Effect of heavy metals on fish health.** In fish tissues, heavy metals have been estimated by many workers and reported to have adverse effects. When copper intake is excessive, liver cirrhosis, dermatitis, and neurological complications can occur (Fairweather-Tait, 1988). It has been proposed that chromium (VI) is a carcinogen to humans by the World Health Organization (WHO).According to studies done in humans and animals, chromium (VI) compounds has estimated to be a potential carcinogen (Ishikawa *et al.*, 1994). Chen *et al*. (2001) reported that chronic exposure to inorganic arsenic may give rise to adverse health effects, including respiratory tract, cardiovascular system, gastrointestinal tract, skin, liver, nervous system and hematopoietic system. Emaciation, loss of appetite, and mortality in fish can occur when mercury concentrations in fish muscle exceed 5 parts per million (wet weight) (Eisler, 1987). Mercury (human toxicant) is contaminated in humans through eating fish is the main cause of minamata disease (Rashed, 2001). A lead poisoning in humans results in renal failure and liver damage (Emmerson, 1973). Electrolyte imbalance, lethargy, nausea and anaemia are the main symptoms of Zinc toxicity caused due to extreme uptake of zinc metal (Prasad, 1984). Metal-exposed fish are reported to have immune system malfunctions, becoming susceptible to contagious diseases and being at higher risk of mortality (Akgün *et al*., 2007; Al-Weher, 2008). Fish exposed to heavy metals exhibit pathological changes in fish, including a reduction in estrogenic and androgenic secretion (Ebrahimi and Taherianfard 2011). Furthermore, adverse effects include reduced fitness, growth, development, and interference with reproduction developing cancer, which eventually leads to death (Çiftçi *et al*., 2017; Govind and Madhuri, 2014). According to Elbeshti *et al*. (2018), heavy metal contamination of fish endangers fish health, ecosystems, and carries respectable health risks for humans.

**Wastewater Treatment by *Azolla.*** The aquatic fern *Azolla* is a small-leaved floating plant that lives in symbiosis with a nitrogen-fixing cyanobacterium (Anabaena) and fix nitrogen at a tremendous rate, enabling them to produce high biomass. Azolla has been extensively studied for its potential as a green manure in rice fields, as a feed supplement for aquatic and terrestrial animals, for human consumption, medicine, water purification, biofertilizer, insecticide for weeds and mosquitoes, or as a water purifier by eliminating nitrogenous compounds from water (Costa *et al.*, 2009; Sadeghi Pasvisheh *et al*., 2013). Aquatic water fern *Azolla* has been found to have a high capacity to biofilter various toxic metals Cohen-Shoel *et al*. (2002); Rai (2007) and as an effective biofilter for removing nitrogen and phosphorus, elements that cause water eutrophication in aquatic systems. Moreover, it is capable of removing sulfa drugs (Forni *et al*., 2001) and radioactive elements as uranium (Cohen-Shoel *et al*., 2002).

*Azolla microphylla* was studied for its biomonitoring potential for purifying sewage waste water by Noorjahan and Jamuna (2015). The *Azolla microphylla* were introduced into the tubs containing 100 percent untreated and treated sewage samples. The analysis of sewage waste water samples after 96 hours, physicochemical parameters and heavy metals were found to have been actively reduced. The biotreated water sample obtained from azolla treatment was used for culturing *Tilapia mossambica* for 60 days interval. It was found that biochemical constituents decreased over the period of 60 days in *Tilapia mossambica* organs exposed to untreated and treated samples compared to control samples, but an increase was observed in samples treated with 100 percent biotreated and biountreated.

Golzary *et al*. (2018) investigated the potential growth of *Azolla* in secondary effluents for removal of COD, phosphorus, and nitrogen. The result of the study revealed that the mixed solution of these two compounds resulted in a reduction in the amount of N and P by 33 and 40.5 %, while at 100 ppm of each component, N and P removal decreased to 36 and 44 percent, respectively. The COD removal potential of *Azolla* was found to be 98.8 percent after 28 days. During the study, values of pH changed within a range of 4.5-8.9, and temperature ranged from 24.4 to 32, with the optimum temperature being 20-25º C. The growth of *Azolla* in wastewater reduced the COD by 98.8 percent (from 4326 to 51 ppm) while this effect was 96 percent (from 1897 to 67 ppm) for the sample on which this treatment was applied. *Azolla* culture can significantly reduce the heavy metal concentration (0.035 mg/l) in sewage treated water after 21 days from 0.107 mg/l at 0 day (Reecha, 2021).

## FUTURE SCOPE

Aquaculture output is expected to increase 60%–100% by the end of the 20th–30th century to keep up with the population growth and increasing per capita fish consumption. To meet these demands, future food production must be intensified and integrated into other farming systems. And this can be achieved by various technologies available, but the involvement of sewage treated water into the system, not only satisfy the growing need but also reduce the pollution caused by it. Therefore incorporating sewage into makes the environment cleaner and safer. Through proper treatment of sewage water, the population of microbes can be controlled and proper testing of water for heavy metals before the culture start can help the farmer to diminish the harmful effects of the sewage water keeping contamination risks within the safe limits.

## CONCLUSION

The present review concludes that to reduce the dependency on freshwater aquaculture, different species of fishes are suitable to grow fishes in sewage treated water. In the context of freshwater scarcity, application of sewage in aquaculture ensures water conservation, apart acting as a fertilizer in the culture pond. One of the major hurdle in expanding aquaculture in the present day is the high cost of supplementary feed. And the implementation of sewage in the fisheries sector has proven to be a successful method in boosting the economics of the farmers because it enhances planktonic density and thereby, provides a huge amount of natural foods for fish along with sustainable water productivity. With a high growth performance and great survivability factor, there is an increase in overall yield of the fishes in a harvest season. It is also imperative to note that azolla culture can significantly improve the water quality parameters and reduce the heavy metal concentration in sewage treated water making the sewage treated water suitable for the culture.

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