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A Review on Factors affecting Aquatic Ecosystem of Fresh Water Fish Tilapia - Oreochromis mossambicus

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Abstract

The protein-rich *Oreochromis mossambicus*, often known as tilapia fish, is a popular species in southern India. It is a freshwater aquatic living species found in both rivers and lakes, but is more common in rivers. This species' high population density raises worries about its influence on other fish populations in the vicinity. Heavy metals, herbicides, and other contaminants affect the freshwater environment, where this fish species lives in. The most common contaminant is Ethoxyquin, which is a kind of pesticide. It is an acute toxic element. This paper extensively reviews, the various aquatic ecosystems, in particular with Kerala State, the ecological impact of Tilapia fish and the impact of toxicants on freshwater habitats.

Keywords: *Oreochromis mossambicus, Tilapia, Ethoxyquin, Fresh water, acute toxicants, fish model*

Introduction

Aquatic environments include those in and around bodies of water. They are likened to terrestrial ecosystems. Aquatic organisms are dependent on one other and their surroundings. Aquatic environments include marine and freshwater ecosystems [1]. Freshwater ecosystems are most common subset of the Earth's aquatic system. Lakes, meadows, ponds and rivers are examples of fresh water system [2]. Marine ecosystems, on the other hand, have a far greater salt content. Freshwater ecosystems may be classified based on a variety of factors, including temperature, light penetration, nutrients, and vegetation. Lentic (ponds, lakes, and pools), Lotic (streams and rivers), and Wetland (areas where the soil is saturated or inundated for at least part of the time) are the three kinds of freshwater ecosystems that may be found in nature [3 & 5]. More than 40% of all known fish species may be found in freshwater habitats [4]. Freshwater ecosystems

are critical for water purification, nutrient cycles, maintaining a healthy food chain, recreation, and the management of infectious organisms during disasters such as floods and droughts. Economic, social, and environmental consequences are far-reaching due to their activities. In this study an exhaustive review of the freshwater ecosystem particularly in Kerala State pertaining to the fish variety *Oreochromis mossambicus* has been attempted.

Kerala's Freshwater Aquatic System

Following habitat loss, invasive species have become a significant threat to the world's biodiversity. Water ecosystems may be permanently altered as a consequence of invasions, which may result in the extinction of species as a result of the invasion (6). Aquatic animals, such as fish, are both the most widely scattered and the most endangered category of animals on the world, according to the World Wildlife Fund - 624 species. More than 300 fish species have been introduced into India for a variety of purposes, including enhanced fish production, recreational fishing, aquarium trade, and mosquito bio-control (7). The Western Ghats, one of the world's 34 biodiversity hotspots, stretches along India's west coast over 180,000 km^2 and is home to a diverse range of plant and animal species (8). From the Western Ghats, Kerala's rivers run across the state. There is a lot of variation in these rivers. Even though Kerala is a relatively small state, its riverine wildlife is quite diverse. These rivers are home to different kinds of fish. An ecological hazard is present, not withstanding its importance to state socio, economic and ecological well-being. It is due to sand mining and the building of dams as well as invasive alien species, pollution and other factors. It is a monument to the region's tremendous biodiversity and economic importance that a total of 290 freshwater fish species have been identified, with 189 of them being indigenous to the Western Ghats (9).

Chalakudy River runs from the Anaimalai and Nelliampathy hills of the Southern Western Ghats in Kerala, where it is the fifth longest river in the state covering a distance of 144 kms. With 98 species of freshwater fish, Kerala's Chalakudy River has one of the largest freshwater fish variety populations in the state (10 - 11). The fish fauna of the Chalakudy River has been badly harmed as a result of habitat change and the invasion of exotic species, among other factors. The fish species *Oreochromis mossambicus*, *Gambusia affinis*, *Osphronemus goramy*, *Xiphophorous maculatus*, *Osphronemus goramy* and *Poecilia reticulata* are all new to this river

system (12). Exotic fishes are uncommon in Poringalkuthu Reservoir, despite the fact that the Chalakudy River has been proven to have a high ichthyofaunal diversity.

Reservoir fisheries are very important to the economy because they have a lot of resources, jobs, and animal protein in them. Even though reservoir fisheries have a lot of fisheries potential, they don't do a lot for the inland fish population. The average yield of fish from reservoirs in India has been very low because of poor management practices caused by a lack of knowledge about the ecology and production biology of the reservoirs (13). The 11 fish species found in Poringalkuthu Reservoir came from both native and non-native species. They came from three orders and four families. There were a lot of native fish that were caught from this reservoir. These fish were *Tor khudree*, *Hypselobarbus kolus*, and *Barbodes carnaticus*. There were also non-native fish like *Cyprinus carpio* and *Gibelion catla*. From Poringalkuthu Reservoir, 8064 kgs of fishes are caught every year. In November 2016, 949.8 kg of fish were caught. In January 2017, 372 kg of fish were caught. For *O. mossambicus*, the highest abundance index was 31.71 percent. This is compared to the other fish fauna (14). Two other species that were found more often than any other were *T. khudree* with 17.81% and D. flilamentosa as 17.61%. The number of *C. carpio, G. catla, L. rohita*, and *C. mrigala* in the reservoir was very low. Every year an amount of 2592 kgs of *O. mossambicus* are fished per year. These statistics illustrates the wide presence of *O. mossambicus*, across the various reservoirs of Kerala State, and is evidenced as a fresh water fish species.

Oreochromis mossambicus

O. mossambicus, also known as Mozambique tilapia, is a salt-tolerant, mouth-brooding cichlid that lives in Africa. It has a lot of potential for aquaculture. It is on the Global Invasive Species Database's list of the 100 worst invasive species in the world. It has spread to more than 90 countries or territories on five continents (15). Mozambique Tilapia was first put into a pond ecosystem in India in 1952. Then, they were put into reservoirs in South India to help them grow (16). In the years after that, the fish started to breed naturally in almost all the reservoirs in Tamil Nadu, Kerala, Andhra Pradesh, and Karnataka. The zoological details of *Oreochromis mossambicus* are as follows:

- Kingdom: Animalia

- Phylum: Chordata
- Class: Actinopterygii
- Order: Cichli formes
- Family: Cichlidae
- Genus: *Oreochromis*
- Species: ***O. mossambicus***
- Binomial name: ***Oreochromis mossambic***
- Common name **– English – Mozambique Tilapia / Cichli - Malayalam – Thilapi / Tamil – Jelebi Meen**

Ecological Impact of *Oreochromis mossambicus*

Tilapia from Mozambique might have a significant ecological effect on several local fish species in natural water bodies (17 - 18). It is found that the prolific breeding behaviour and parental care of *O. mossambicus* helped it to increase every three weeks in Godavari, Krishna, Cauvery, Yamuna, Sharavathi, Ganga, Bharathapuzha and Chalakudy Rivers (12, 18 - 21). It is estimated that *O. mossambicus* has displaced all other fish species, including big carps, in the Vaigai Reservoir in Tamil Nadu (22). *O. mossambicus* has had a significant impact on the populations of Labeo kontius and Puntius dubius in Vaigai and Amaravathy Reservoirs, respectively (23). Many aquatic areas in Tamil Nadu where tilapia was introduced saw a decrease in the proliferation of Chanos chanos (7). The introduction of tilapia in Jaisamund Lake, Rajasthan has resulted in the displacement of Indian main carps (18). *G. catla, Labeo imbriatus,* and *C. mrigala* grew slower in Ayakulam Pond due to the presence of tilapia (24). As a result, *Cirrhinus reba,* an indigenous species in Kabini Reservoir, has decreased in abundance from 70% to 20%. (25). Toxic effects on Pseudetroplus maculatus chromide in the Chalakudy River may worsen the population of tilapia (12). *O. mossambicus* accounted for 15% of fish landings in Periyar Lake, which may pose a danger to Tor khudree since 78% of their diet was the same (26-27). It supplied 70% of the catch in Malampuzha reservoir in Kerala after the 1960's ranching was done (28). *O. mossambicus* is the most common fish species in Poringalkuthu Reservoir, according to the research. There is year-round availability of *O.mossambicus* fish, as well as frequent encounters of mature and ripe females, which shows that the species has successfully established itself in the reservoir, which might represent a danger to the indigenous fish, notably T. khudree. Since this possibly alien fish has a significant potential to affect the native fauna in a short period of time, it should kept a watch on its uncontrolled population expansion. Monitoring of the

tilapia population and a full examination of the bionomical features in the reservoir should be carried out on a regular basis in order to create a database that can be used to safeguard the unique and vulnerable fish species (14). Inspite of these effects of Tilapia, non-vegetarian and interested fish curry civilians of South India consumes this fish frequently. Nowadays, this fish species is grown in freshwater reservoirs, due to the increased consumption, by the people.

Factors affecting aquatic ecosystem

Individual species and ecological populations in aquatic environments are constantly adjusting to ever-shifting environmental conditions as a matter of course. Freshwater aquatic ecosystems may be affected by pollution, changes in the topography or hydrological systems, as well as larger-scale factors such as global climate change. It may be difficult to predict the impact of disturbances on aquatic ecosystems because of their complexity and interconnectivity. In light of these links, damage to one part of the ecosystem may have ramifications for the ecosystem as a whole. The understanding of aquatic ecosystems may lead to better management strategies that have less impact on aquatic environments. The main factor leading to disturb the aquatic ecosystem has been addressed as pollution. It is caused due to several reasons. Few may be noted as the availability of synthetic fertilizers and pesticides in water content.

Chemicals that are discharged into water bodies have an impact on the aquatic system. Many toxic chemicals produce oxidative stress in aquatic animals when they are introduced into water bodies and impact the xenobiotic of these creatures. If these toxic chemicals are discharged into water bodies, they may cause oxidative stress in aquatic animals. Toxins from waste water may cause aquatic life to die or induce varied degrees of disease in individuals who ingest aquatic animals contaminated with these toxins. The influence of chemicals on water parameters may have the following effects: a) Influence the population density of an aquatic environment; b) Affect the species variety of a specific ecosystem. There is evidence that a chemical or biological contamination from fish farms increases the chance of sickness or mortality in fish, (40 - 42). This causes a lack of animal protein in markets and reduces the profitability of fish aquaculture (43). Fish infected with *E. coli* and *Vibrio cholera* were thrown out. *Shigella dysenteriae* produced dysentery, cholera, shigellosis, and tubercular illness in humans, whereas *Aeromonas salmocida* damages the pathogen of fish species (43 - 44).

Fish Model

Human protein intake is mostly obtained from fish across the globe, as opposed to other animal products, according to the United Nations (38). Fisheries are very important as a source of animal protein components and as a means of contributing to the creation of agricultural goods, among other things (39). It is necessary to continuously monitor the quality of both the water and the fish throughout the whole aquaculture cycle in order to maximise production in the aquaculture industry. When it comes to fish development and survival, water quality is essential. It directly influences growth rate, fish health, and survival, as well as the economy and public health in general.

Aqueous pollutants in the environment contaminate water bodies, degrade water quality, and cause harm to both plants and animals in the aquatic environment. The presence of these pollutants is a hazard to aquatic life, and it may also be a source of concern for human health because of the potential for contamination. Heavy pollutant concentrations dissolved in water induce bioaccumulation in the tissues and organs of aquatic creatures. They are toxic contaminants, and toxic pollutants which are harmful to fish. It in turn is harmful to people who consume fish as a source of food through via food chain. Fish are increasingly frequently utilized in experimental research across a broad variety of habitats, and they have a long history of success. Fish account for more than 90 percent of all experimental animals employed in research. Aquatic species have a completely distinct physical habitat and are subjected to a variety of environmental variables that are seldom taken into consideration when designing research on them (29).

Water is significantly more important to fish as an environmental medium than air is to terrestrial species, and fish are far more dependent on it. Not only does it provide physical support for the fish, but it also serves as a supply of oxygen, electrolytes, and nutrition. As a medium for osmoregulation and the dilution of harmful metabolic wastes, it serves a dual purpose. Because of this, water quality is crucial in all fish research and must be recorded thoroughly in order for the experiment to be replicated elsewhere. The chemistry of the water changes drastically across different geographic distributions. The other variables impacting the fish utilized in research include; husbandry circumstances (30), feed composition (31), and the genetic background of the fish species (32). Fish respond to stress and other environmental stressors in a manner that is

similar to that of classic study animals, such as mice and rats (33-34). The impact of these external factors, not only on the complete organism but also on specific organs and even tissue cultures, has been thoroughly documented (35-36).

Tilapia species are among the most widely scattered fish species on the planet in terms of geographic distribution, and they are also among the most profitable food fish to be found. According to the species' scientific name, it is indigenous to the African continent, more especially to the southern and southeastern areas of Africa. This substance has been extensively used in a broad variety of applications, including fish aquaculture, pest and weed control, leisure and commercial fishing as well as fishing lures and bait. Other distinguishing traits of this species include the presence of three or more anal spines, one nostril on each side of the body, and a disjointed lateral line, among others. Their ease of production and harvesting make them an excellent aqua-cultural species to utilize in aquaculture. These species have the capacity to resist a wide variety of water quality issues and degrees of contamination. They are employed as bioassay organisms to yield metal toxicity data for risk assessments of freshwater species in the surrounding environment. Under perfect conditions, Mozambique tilapia may live for up to ten years and grow to reach more than 40 cm in length, according to the World Wildlife Fund. They are particularly appealing for aquaculture because they may be successfully farmed in large numbers and in water that is often of poor quality.

Factors Affecting Life of Tilapia Fish

Tilapia fish are grown in water that is in poor condition, and the state of the water has a direct influence on their health and development in the future. For the most part, variables that influence fish growth and production in freshwater aquatic systems may be separated into three categories: physical factors, chemical/biochemical factors, and a combination of the above-mentioned elements. Temperature and concentrations of suspended and settle-able particles are two physical characteristics of water that are critical for fish production and development; pH, alkalinity, hardness, and metal concentrations are three significant chemical characteristics of water that influence fish production and development (37).

Treating contaminated water before feeding fish lagoons will reduce toxic effects of water (42). In order to protect fish from illness, such water must be treated. Researchers found that fish and aquatic habitats may spread bacterial illnesses to humans (45 - 46). Currently, there are no

microbiological or chemical requirements for water used in fish farms. For example, organic debris in water encourages harmful microbes, which may infect and kill fish (47 – 50). Pathogenic microorganisms, dirty water, and fish food negatively affect fish output. Organic debris in water boosts harmful bacteria, some of which may infect fish (51).

The presence of heavy metals was elevated in certain rivers the Moskva and Oka rivers of Russia (52). The heavy metals in these lakes have a huge impact on the fish's survival, leading to the emergence of illnesses such as white-eyes bream and liver bream, in addition to silver bream. As a consequence of this illness, infected fish succumb to death. In Malaysia (53) reported that, as a consequence of human activities, the water in the Semantan River and Kenyir Lake had been polluted with bacteria that might be potentially dangerous. Researchers revealed that these bacteria were present in fish picked at random from 30 tilapias organs such as the brain, eye and kidney. The scientists stated that this kind of fish is not presently accessible for human consumption because it contains germs that are harmful to humans. The bacteria *Streptococcus spp., Enterococcus spp., Micrococcus spp., Staphylococcus spp., Staphylococcus spp., Enterobacteriaceae, Aeromonas spp., Vibrio spp.,* and others have been proven to cause death in tilapia fish(tilapia (54 – 55). As a result of their presence in the ecosystem, heavy metals have an impact on the quality of the aquatic environment, which has a long-term effect on the species that dwell there. Some metals are not biodegradable and accumulate in a variety of organs in people and animals, as well as in plants, on a global scale, causing health problems (56 - 57). Heavy metal pollution of water in Qarun Lake of Egypt (58), has been shown to have adverse effects on histology organs and muscle composition as a consequence of the contamination of water in Egypt. Therefore, the researchers recommended that the water has to be cleansed before being dumped into the lake since it may have an influence on fish production as well as on the general public's health as a result of its contamination.

Furthermore, the sources of oxygen gas in water include aeration from fast movement of the surrounding air and as a consequence of photosynthesis from watery plants. Some investigations (59-60) found that tilapia can live in ponds and fish farms with a dissolved oxygen content of 0.3 mg/L. Despite this, the optimal dissolved oxygen content is between 7 and 8 mg/L in most cases. In contrast, levels that are less or more than these values may cause illness in pond fish. In Egypt (61) discovered that elevated levels of ammonia on the shores of the Nile in the Delta region

(which originates from certain companies) were causing the demise of tens of thousands (if not millions) of tonnes of fish. It has been suggested by some researchers that heavy metals (from human activity) and hydrocarbons (along with pesticide-related materials) are frequently released into the aquatic environment; as a result, these materials are likely to pollute water and have an immediate impact on both morbidity and mortality in the fish farming industry (51, 62, and 48). The current heavy metal in the river Nile is found as Cu. It is present with high concentration, and effects both morbidity and mortality in fish farming. The analysis of the presence of this metal in fish showed its highest value in liver as well as Cu and Cd accumulated on some tissues of fish and thus harm for humans after consumption (48). As a result, research should focuses on periodic monitoring of water and fish farms by detection of viruses, germs, and certain heavy metals, as well as physiochemical parameters, in order to preserve public health, the national economy, and the ecology (63). It is possible that toxic substances in waste water may harm aquatic life and/or create varied degrees of disease in individuals who ingest these aquatic creatures. Chemicals that are discharged into water bodies have an impact on the aquatic system. Several hazardous chemicals may induce oxidative stress in aquatic animals if they are discharged into water bodies and have an effect on the xenobiotics of the creatures that are exposed to them.

Toxicity Testing in Freshwater Ecosystem

Toxicity is the study of the potential for a substance to have one or more detrimental effects on living organisms. By increasing our health and cleanliness, a wide range of materials made our lives better. Agriculture, industry, and most aspects of human existence have all benefited from these materials. However, certain compounds may cause harm to people and animals if they are inhaled or ingested. It is possible that a person's or a species' sensitivity, method of exposure, dosage, and length of exposure may determine how severe the effect is. This kind of testing is used to evaluate the effects of a single exposure to a chemical. Toxicology testing is done to see whether there are long-term effects that become apparent after a long period of exposure. Toxicity of materials, whether acute or long-term, must be determined so that preventative measures may be put in place to keep people safe (64). It is the responsibility of regulatory organizations affiliated with government agencies and enterprises to guarantee that the materials to which the public is or may be exposed are safe. Because the output of the source or test system

should allow extrapolation to people, one essential concept in toxicology is the use of systems representative of those found in humans while collecting data. Exposing animals to the compounds in issue has been used in the past to estimate the danger to people. Acute toxicology testing methodologies, humane endpoint concerns, and innovative initiatives to further minimise animal usage are all discussed in this article. Acute fatal toxicity, skin irritation/corrosion, and acute eye irritation are all considered as acute toxicity endpoints.

Aquatic Toxicity Testing

Toxicity studies have been carried out for many decades to evaluate the impact of different substances on the biota of the environment, and the results have been published. In order to identify the upper limit of unfavourable impacts on aquatic ecosystems by calculating the greatest amount of negative effects, aquatic bio-indicator species are employed to determine the maximum amount of negative effects. Algae and cyanobacteria are single-celled organisms that can only survive in the presence of water. Aquatic macrophytes are plants that grow in bodies of water and daphnia is invertebrates that live in bodies of water. Hydra is a kind of vertebrate that lives in water i.e., Fish.

Ethoxquin

The main component focused on this research work is ethoxyquin. In its viscous liquid form, ethoxyquin may be found in a variety of colours ranging from clear to light yellow to dark brown. It was approved for use as a pesticide for the first time in 1965. Antioxidants are frequently used because they limit the development of microbes on organic materials, which is why they are so effective. Since 2013, the use of ethoxyquin as a pesticide has been restricted in the European Union.

Ethoxyquin (EQ) - 1,2-dihydro-6-ethoxy-2,2,4-trimethylquinoline, is a synthetic antioxidant that scavenges free radicals formed during lipid oxidation (65 – 66. Ethoxyquin is a potent antioxidant that has been shown to reduce the formation of free radicals in the body. Excessive use of EQ as an antioxidizing ingredient in commercial food formulations for animals has been documented. This includes fish, cattle, and pets, as well as enormous amounts of fishmeal carried over the equator in order to keep it from burning. In Japan, the regulation of synthetic antioxidants in animal feed is identical to the legislation in the European Union. In combination with either or both of two additional common antioxidants, butylated hydroxy toluene (BHT) and

butylated hydroxy anysole (BHA), the upper limit of EQ alone or in combination with either or both of these antioxidants has been determined at 150 mg kg^{-1}. (67).

A relationship has been shown between several artificial antioxidants used in food additives, such as BHT and BHA, and an increased risk of cancer in humans (68). A concern exists as a result of this over the possibility that EQ, like other artificial antioxidants, might constitute a health risk. In addition to these effects, the antioxidant EQ has been shown to inhibit renal ATPases and electron transport in the mitochondrial respiratory chain (69). In addition, renal calcification and a renal calculus have been observed in rats treated with EQ (70), as well as neoplastic lesions on the kidney and bladder (71 – 73). These findings give some insight into the possible hazard to human health posed by this substance. The fact that EQ is used as an animal feed additive necessitates the investigation of whether or not it is safe for the animals in issue. Animals such as chickens, pigs, and mice have had their body weight reduced and their liver mass to body mass ratio increased after the administration of EQ, according to research (73 – 75). EQ has been shown to have an effect on sodium and calcium concentrations in Scophthalmus mazimus (76), as well as the enzyme-enabled lipid peroxidation system of catfish Silurus asotus (77). Human lymphocytes are cytotoxic to EQ. Certain studies made validated it (78). Overall, it is probable that the decreased immunity generated by EQ will result in a reduction of disease resistance in the body over the long term. At this time, however, it is unclear whether EQ in acceptable dietary levels is harmful or beneficial to fish immunity over the long run. EQ has been shown to have an effect on the immune system of tilapia, based on the conclusions presented on the research made on *Oreochromis niloticus (*67).

Outcome of Literature Studies

The literature reviews presented over here focused on the aquatic environment of Kerala state. The main fresh water aquatic habitat of the sates has been recorded as *Oreochromis mossambicus.* This species considered for the study originated from Africa and wide spread across southern states of India. The population of this fish can spoil the life of other aquatic biota. Researchers found that this fish species grows well in freshwater aquatic system. But these systems are nowadays been affected mainly due to the presence of heavy metals and pesticides. One of the most important pesticide was discovered as Ethoxyquin. The impact of this pesticide on the aquatic ecosystem has been analyzed. The literatures addressed so far, concentrated on the

impact of Ethoxyquin on other fish species than ***Oreochromis mossambicus.*** The following points can be summarized from the aforementioned literatures.

Oreochromis mossambicus – Thilapia fish is a common species and taken a s food by south Indians.

Thilapia is a fresh water aquatic habitat and can grew up in wide population
The population density of it causes other fish species to be affected.
The freshwater ecosystem is spoiled due to toxicants viz. heavy metals and pesticides.
The common pesticide that affects is Ethoxyquin (EQ) and so it is banned in Europe Union.
The impact of EQ on the freshwater ecosystem with Thilpai fish species is not widely presented.

Conclusion

In southern India, *Oreochromis mossambicus*, also known as Tilapia fish, is a common species that is highly prized by the local community for its high protein content. It is a widespread species. Tilapia is a freshwater aquatic ecosystem that has the potential to support a large number of people in its immediate vicinity. In freshwater, it may be found in both rivers and lakes, although it is more often found in rivers. In addition to having a negative impact on the populations of other fish species in the surrounding area, the high population density of this species raises concerns. Various toxicants, including heavy metals and pesticides, as well as other pollutants, have wreaked havoc on the freshwater environment, resulting in widespread damage and devastation of aquatic ecosystems across the globe. Ethoxyquin (EQ) is a popular pesticide that has this effect because of its extensive use, and it is now prohibited in the European Union as a consequence of this. There has been minimal debate in the literature on the influence of EQ on freshwater ecology, particularly on the Thilapia fish species, despite the fact that there has been much dispute on the matter.

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