A review on river damming in India and migratory fishes: the forthcoming aquatic tragedy

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Abstract

Floods, irrigation, power supply, and many more disasters man-made or natural create a misbalance in the natural ecosystem. Any artificial barrier that prevents migratory fish from freely traveling to and from their spawning grounds is inevitably harmful to fisheries because it will materially slow down or even prevent the reproduction and growth of stock. The construction of dams generally blocks the pathways of upstream fish migration, leading to the extinction of fish species. The quality of the habitat, the life-history stages, and the population dynamics of the standing biota have all been impacted by dams, which have changed the seasonal cycles of floods, the natural flow regime, and increased sedimentation in the downstream region. Advancement and installations of fish passes may influence these impacts on a positive manner.

Keywords: Dams; fish migration; habitat loss; river flow.

Introduction

The practical use of dams and barrages are to impound and regulate river system and have played a key role in human development. It aids in controlling floods, generating electricity and providing water for industry, irrigation, and municipal purposes (Wu *et al.,* 2004; Wang *et al.,* 2011). Fishes like *Tor tor* (Mahseers), *Labeo dyocheilus* (Silghoria), *Barilius bendelisis* (India Hill Trout), *Anguilla bengalensis* (Cuchia) and *Glossogobius giuris* (Patimutura, Tang Gobi) travels longer distance, especially in the hilly rivers (Talwar and Jhingran, 1991). It is triggered by water qualities and many other environmental factors for feeding or breeding purposes. The construction of Dams in rivers of India will obstruct these necessary purpose-specific fish migrations.

Issues and concerns

Unregulated flood pulse: Lotic to Lentic habitat

Fish yields per unit surface area are considerably greater in both temperate and tropical rivers. It is impacted directly by flood pulses and floodplains than in nearby sites where flood pulses are reduced or absent (Sparks, 1995). Flooding sets into motion incorporating of extra channel allochthonous organic material as well as nutrients of terrestrial origin into aquatic dimensions of the riverine ecosystem (Bayley, 1995; Thorp and Delong, 1994; Sparks, 1995). McCartney (2007) suggested that dams decreases the flow of river thus create stress over habitats, nutrients and population structure of aquatic life of downstream. When reservoirs fill, the habitat changes from lotic to lentic and there is generally a corresponding shift in the fish community towards those species specialized for lentic habitats (Gao *et al.,* 2010).

Discontinuity in river flow: descending productivity

A well-structured plan of futuristic world fisheries technologies and aquaculture prospects has yet to be accomplished (Das *et. al;* 2024). Dams may initiate a process like heavy discontinuity in the river flow causing an artificial habitat fragmentation. The construction of the Three Gorges Dam, Hubei, China for example, created a large reservoir in the main course of the Yangtze River affecting more than 500 km upriver and altering the structure and distribution of fish populations (Xie *et al*., 2007; Gao *et al*., 2010). There is also considerable evidence that the reservoir has prevented downstream movements of young and adult fish. Jiang *et al.,* (2010) showed that large quantities of eggs and larvae flow into the reservoir, but authors concluded that losses might occur due to adverse conditions in the impoundment. Duan *et al.,* (2009) recorded a marked decline in the larval movement of Chinese carps in the downstream stretch from the dam site of Three Gorges Dam. Researchers have addressed as loss of spawning ground and reproductive stimuli might result in the same. Carps continue to spawn in sites located upstream from the dam (Jiang *et al.,* 2010), but larvae captured downstream do not come from these upstream sites (Duan *et al.,* 2009).

Sedimentation

River Bhagirathi in Garhwal, Northern India was dammed at four locations. Namely Maneri Bhali Phase I, Phase II, Tehri Hydroelectric Dam and Koteshwar Dam. These were utilized for hydro-electric power generation. These dams have affected seasonal cycles of floods, natural flow regime and have caused increased sedimentation in the downstream region, thus affecting habitat quality, life-history stages and population dynamics of the standing biota. Such effects had been found to get increased in the lower stretch due to construction of dams and barrages in cascades. The consequent effect on the fishes was observed in that area. Most affected species found were *Schizothorax* (Snow Trouts), *Glyptothorax* (Cavia catfish), *Pseudecheneis* (Sucker throat catfish), *Garra* (Gara), *Labeo*, *Crossocheilus* (Burmease Latia), *Noemacheilus* (Loach), *Barilius* (Barred Baril), *Psilorhynchus* (Balitora Minnow), *Clupisoma* (Neria), *Mastacembelus* (Bami) and migratory *Tor spp.* (Mahseers), which were indigenous rheophilic species requiring distinct habitats to fulfil their life cycle stages. Fast flowing riverine species populations of many different groups collapsed and few even disappeared from many stretches of the river system (Agarwal *et al.,* 2014).

Hilsa Fishery and construction of barrage

After the construction of Farakka barrage, the upstream migration of Hilsa, *Tenualosa ilisha* (Hamilton, 1822) had been adversely affected and the Hilsa fishery, above Farakka barrage collapsed. During the pre-Farakka period the average catch of Hilsa from the Hooghly estuary was to the tune of 1551 t per year (1967-1975). The landing data at Farakka region collected from 1994-'95 to 2001-'02 revealed that the total catch of Hilsa gradually declined affecting thousands of fishermen in Uttar Pradesh and Bihar. Above Farakka barrage at Allahabad, Buxar and Bhagalpur, Hilsa landing declined very sharply in the middle stretch of river Ganga. Constructions of dams, barrages, weirs and anicuts declined *Hilsailisha* catch considerably on the Hoogly, Godavari, Krishna and Cauvery

Rivers. Mighty Mahseers*Tor putitora* and *T. tor* were no longer found above Nangal and Talwara dams. Fishways constructed in conjunction with dams were used as fish traps by local fishers.

On the Indus River, the construction of the GulamMahommed Dam deprived the migratory *Hillsa ilisha* by 60% of their previous spawning areas. Dam construction on the Sefid River (Iran) resulted in reduced streamflow, increased water temperature and decline in food items for sturgeon (*F. acipenseridae).*

Habitat degradation

Blockage of nutrient flow throughout aquatic ecosystem can be greatly affected by dams. Such cumulative effects of dams are significant in fisheries production in downstream reservoirs and river channels. Also catchment basins and tributary streams are vulnerable to dams. Loss of indigenous fishes in Colorado River was caused due to release of coldwater from dams. Water-chemistry changes also played a significant role for fish. Release of anoxic waters and untreated water mass from the hypolimnion caused large scale fish mortality downstream to dams.

In Northeast India, North Eastern Electric Power Corporation (NEEPCO) dam, Yazali, Arunachal Pradesh on Ranganadi River with a capacity of 405 MW have impacted Lakhimpur district, Assam since its commission. River flow and the sediment regimes are the physical element and driving factors of any riverine ecosystem (State Water Report of Victoria, 2004-05). Therefore it keeps a potential threat to alter or change the fisheries composition of the River.

Way forward: fish passes

Construction of dams or barrages may lead to loss or collapse of endemic fishes from the environment. Dams do hamper the natural dynamics of fishes and other aquatic organism in much different way creating a so called "aquatic tragedy". However, Fishways or Fish passes are some dedicated structures allowing migration of fishes on and across the barrage by acting as cardinal pathway to balance the ecologically sustainable aquatic population including fishes, snakes, bivalves, snails, planktons etc. in the river.

The Fishways or Fish passes are widely categorised into 3 (Hussain *et. al.,* 2021):

A. Close to natural type structure (Bottom ramp-slopes; Bypass channel; Fish ramp)

1. Bottom ramp slope- It possesses a rough surface viz., loose rock fill structure or dispersed constructions.
2. Bypass channel- Development of alternative path to the mainstream river a similar natural stream bypassing the barrage.
3. Fish Ramp- An integrated structure with the dam having a gentle slope and rough surface enabling both the downstream and upstream movement.

B. Technical (Denil pass; Pool pass; Slot pass)

1. Denil pass- These are U-shaped wooden and concrete channel and mounted at 45 degree against the flow of water.
2. Pool pass- It is concrete channel supported with cross-walls of wood or concrete which are fitted with submerged orifices and top notches on alternate sides.
3. Slot Pass- It consists of one or more vertical slots forming cross wall of wood or cement.

C. Special constructions (Eel ladders; Fish lock; Fish lift)

1. Eel ladders- Eel ladders are a typical construction of small channels with brush-type fittings, layers of brushwood or gravel, with water just trickling through them.
2. Fish lock- These are similar to a pit-shaped chamber with controllable closures at headwater and tail-water openings.
3. Fish lift- Fish lift involves lifting mechanism to transport fish from tailwater to headwater.

The passes should meet the biological requirements of fish in respect to hydrological, hydraulic & structural aspects as recommended by National Water Academy, Pune (2018). Collaborative actions between different institutions and relevant professionals from different backgrounds will surely help to ensure efficiency of the fish pass in near future. It will be highly effective if the models or structures are made customizable for better efficacy based on need, especially in India. However, since different fish species have different pattern of migration, as fishes possesses unique biological requirements for movement in terms water velocities e.g. swimming speed (Clay, 1995) and also dimensions of fishways (Porcher & Larinier, 2002); these results should not be directly applied to all the groups or species of fishes, meaning that concerns must be given to the targeted species.

Conclusion

The main research on fish migrations at power station bypasses originate from USA and focuses on Pacific Salmonids, *Oncorhynchus spp*. in relatively large Rivers (Clay, 1995; Williams, 1998; Roscoe & Hinch, 2010). Movement of fishes are observed based on various purposes for example local movement for food and shelter; daily movement for shelter and territory defense; seasonal movement for breeding and temperature variance; upstream movement to access new habitat and downstream movement as post spawning migration pattern and vice-versa; lateral movement for juvenile recruitment etc. It is to be suggested that every dam or barrage should have provisions for fish passes.

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