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Fish production in fresh water stream; A Review

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Abstract

Fresh water fishes are of major economic, nutritional, ecosystem-service, scientific, historical and cultural importance worldwide. In Africa, they are a main protein source to people living close to streams and rivers; and in Nigeria, fisheries within inland waters contribute about 86% of the domestic fish production. Streams are a major source of fish production to hinterland communities and this depends on the interplay of factors like hydrological regimes, environmental degradation, riparian vegetation/ natural food, fishing pressure; and sediments and pollution. The longitudinal connectivity of the hydrological regime with flooding of lateral plains without undue hindrances from barriers like dams and diversions are important to maintaining and restoring fish population. In addition, riparian vegetation/ natural food, fishing pressure, sediments and pollution have affected fish production in streams. It therefore calls for local communities along streams to deliberate on how to manage their local resources and environment. Government should also execute projects that would provide planned flow regime to mitigate and potentially enhance fish production in fresh water streams.

Keywords; Fish; Fresh water; Stream; Production; Factors

1 Introduction

The aquatic ecosystem comprise of water bodies stretching from fresh water to estuaries, lagoons and lakes; and salt water bodies called the marine water bodies, living organism and non- living component inclusive. A stream is a continuous body of surface water running within a bed and banks of a channel. The freshwater fish fauna represent about 24% of the global vertebrate diversity (Nelson, 2016) with over 10,000 valid species (Eschmeyer & Fong 2015); and an increasing number of taxa. The greatest taxonomic diversity of this group is housed in the tropical latitude (Winemiller, Agostinho and Caramaschi, 2008). Fresh water fishes are of major economic, nutritional, ecosystem – service, scientific, industrial and cultural importance worldwide (FAO, 2014). In Africa, fresh water fish contribute a significant proportion of the animal protein of people living close to stream and rivers (Welcome,2003). As of2000, the nominal catch of edible products on the African continent, including fish from inland water was 2.2 million tons which represents about 25% of the total world nominal production. About half of this is estimated to come from rivers and their associated wetlands. Real catches are assumed to be higher than the official figures recorded in nominal statistic due to under reporting of subsistence catches from many smaller stream (Lymer & Welcome,2012).Fisheries within inland waters in Nigeria contribute about 86% of the domestic fish production (FDF; 2003) in terms of fish production and livelihood support. Ademoye, (2003) further stated that Nigeria is well endowed with fresh reserve of 12.5 million ha. Streams are therefore to the hither land communities what estuaries and rivers are to adjoining communities (Francis, Nehibarine and Ihuoma, 2009). Streams contribute very well to the commercial fishery of communities around it. They are refuge sites and potential nursery ground for some marine migrant fishes and therefore contribute significantly to fish recruitment into bigger rivers and coastal fisheries (Odoidiong & king; 2000).

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Fishes exhibit enormous diversity in size, shape, color, biology and in the habitat they occupy. The type of species found in fresh water rivers vary between fast moving and slow moving streams (Ibim & Oswhonde 2017). Moreover fish need a place to live and reproduce, need oxygen, tolerable temperature, food and clean water free of excess sediment or pollutant (welcome 2003). The existence of good fish habitat in a stream depends on a number of factors like geology, climate, water flow, (flow regimes or hydrological regimes), passage requirements of dam, habitat structure (pools, riffles, shelter)), water quality management, pressure, sediment and pollution with many of the factors related. But this paper would focus only on five main factors namely riparian vegetation and natural food, water flow or hydrological regimes, environmental degradation, fishing pressure and sediment with pollution.

2 Hydrological Regimes

The natural flow regime of logic waters is known to give rise to the evolution of organisms found in the aquatic environment and ecological processes (Biggs, Nikora and Snelder, 2005). Every river has its definite flow regimes which determines the biotic communities associated with it (Naiman, Bilby and Schindler, 2002). Fish and other organisms are known to adapt to the monthly, seasonal, and annual and inter annual variations in flow (Thompson, Davies and Larses, 2004) which in turn influence flood water and local flow conditions.

Rivers interact longitudinally (upstream - downstream), laterally with the flood plains and vertically with the soil and ground water below the stream (Nilson & Siredmark, 2002) Longitudinal connectivity allow fish to move freely upstream and downstream. This contributes to the invasion of stream by riverine and marine migrants *Monodactylus sebae, Bostricus africanus* (Udoidoing & king 2000). This are known to contribute to the community species composition of third & fourth order streams adjourning Major River. (Sikoki, Zabby and Anyawu, 2009; Penzak 1992) The flooding of lateral plains increase the area of flood rich habitat and shelter from predators and provide good site for spawning, nursery and growth for fish and other vertebrates (Bunn & Arthington 2002).High water level increase the size of the aquatic environment and enhance migration and breeding movement of some fish species. Excessive groundwater pumping may affect vertical connectivity by lowering the groundwater table disconnecting it form the stream bed and this can make the stream go dry (Thompson,*et al*., 2004).

The abundance, growth of fish species & fish catches from floodplain change from year to year depending on the strength of flooding. The delay between any flood event and the response in a fish community depends on the extent to which it is exploited as it is real for some African rivers like Shire, kafue, Niger rivers (Welcome 2003). In the late 1980sdata for the river Niger showed that catches were more closely correlated with flood in the same year and that 69% ofcatches consisted of young fishes indicating a general increase in fishing pressure. It has been suggested that the carrying capacity of streams is related to the amount of timing of high and low flows (Thompsom, *et. al*., 2004). This indicates that flow regimes usually increase fish production in streams; and it has been observed that in a normal humid African river, the flood component of the hydrological regime is the most important factor affecting fish production although the dry component of the hydrograph is also important (welcome 2003).

3 Environmental Degradation

Stream flows and morphology of stream provide living space for adult fish as well as juveniles. Stream habitats like pools, plain beds, riffles and cover are important for successful upstream migration, spawning and incubation of fish (Godinho, 2009). In the case of the salmonids, good stream flow create the required depth, velocity and temperature for upstreammigration of adults which usually takes months before spawning occurs ; cover is important to protect this fish from disturbance and predation (Thompson *et al.,* 2004)

Unfortunately stream channel degradation is a wide spread phenomenon throughout the world. Moyle (2002) stated that every large river and stream in California has been dammed and water from such rivers and streams is transported great distance from its source for use by municipalities, industries and Agriculture. Dams across rivers and stream channels provide benefits like flood control, hydroelectric power generation, navigation, water supply, commercial and recreational fisheries but with less consideration of its ecological impact. Some large river system have been transformed into cascads of reservoirs by stacking them in chains like the Missouri and Tennesse in North America, the zambezi in Africa (Miranda, 2021). In many parts of the world reservoir commercial fisheries are essential for subsistence and provide high quality and low cost animal protein contributing to the balance of human diet. Fish harvested from reservoir are sold to earn money and contribute to the livelihood of impoverished people and local communities. But reservoir fisheries impacts on fish habitat and environmental degradation (Miranda, 2021). Most large river of Africa have at least one main stream dam and there are thousands of small dams spread around the continents installed for irrigation, drinking water for cattle and as a reserve for human use (Lymer & Welcome,2012)

Alteration of the quantity and timing of river or stream flow can significantly affect fisheries resources (American fisheries society 2019). The fragmentation of rivers create barriers to fish migration and change flow regimes and water temperature. Flooding behind dams decreasehabitat types such as riffles, flowing water and flood plains, wetlands that favor native fishes and increase othertypes of habitat while slow moving water, warm water, and reservoir favor non – nature fishes (Thompson *et al*., 2004). Agostinho *et al*., 2008 further opined that reservoir (dams) with long stretches of riverine environment upstream with large lateral tributaries or both usually comprise of native potamodromous fishes. This is due to their low retention time and are generally not conducive to development of lacustrine fauna (Miranda, 2021"). Persistent feature of flooding has been recorded below the kainji dam on the Niger river and post impoundment flow value from the Benue river below the Lagdo River show that peak river discharges have decrease by 44% (ie 3330m squareto 1870m square) limiting the extent and duration of the flood (Neiland, Jaffry, Ladu, Sarch & Madakan, 2000),

Smaller structures like bridges, culverts, low water crossing and weirs also block fish passage by not allowing migrating spawners to get through (NMFS 2001). Davies (2009) stated that dredging degrades habitat by destroying spawning, breeding, feeding or growth to maturity grounds of fin fishes. The American fisheries society(2019) opined that alteration of flow regimes of streams may lead to loss of steams habitats which can in turn result in decreased abundance, size and condition of fishes. Water velocities and amount of good substrate can be altered therefore sites become limited and in some species an increase in inter specific hybridization may occur. It can also give rise to competing non-native fishes to surface. Flood plains below major dams have been lost which consequently reduced catches accompanied by changes in species composition. This had allowedflow loving and flood plain spawning rheophilic species to be replaced by lenthic species that favor still water and those that breed in the main channels(Welcome, 2003) resulting in loss of local species. However, it affects fish production in a stream positively by blocking matured migrating fish which are trapped in dewatered section for collection. Therefore project proving planned flows can mitigate and potentially enhance fish production in some environments. Dams are also barriers to downstream passage of juveniles and adult that have spawned in upstream area (salmonid and some potamodromous species) or that are on their downstream spawning migration like Eel. The size, morphology and retention time of the reservoir may limit downstream passage of juveniles through increasedmigration time caused by reduced current exposure to less favorable water quality and habitat conditions and increase exposure to predators (Lin, *et. al*., 2017). Injury and mortality of juveniles occur in dams because of passage through turbines and sluice ways and such impacts with turbines blade, rough surface or solid object can caused death. Juveniles are frequently skinned and disoriented as they are expelled at the base of the dams making them vulnerable to predation (Miranda, 2021). Below hydroelectric facilities, nitrogen supersaturating may also negatively affect migration of fish by causing gas bubbles disease. Damming of riverscause changes that may be equivalent to the formation of a new ecosystem with several changes in abundance and composition of species. Thus species that represent generalist behavior in relation to reproduction and food requirement tend to show a marked population increased while species with more specific requirement like migratingfish species tend to reduce in population (Agostinho *et al.,* 2008).

4 Riparian Vegetation and Natural Food

Fish need suitable habitat and undisturbed riparian area along the stream which acts to stabilize the banks and provide inputs to the stream such as plant material (food for fish and other invertebrates) and logs (large woody debris) that provide cover for fish (Thompson *et al.,* 2004). Bjorn & Reiser (1991) observe that over hanging riparian vegetation or undercut banks, deep water, turbulent water, large rocks, aquatic vegetation and logs provides cover, space and protection to juvenile and adult salmonids. A variety of natural fish food organisms found in a water body depend on the productivity of the water body. Some of the fish natural food organisms include phytoplankton, zooplankton, annelids, worm, insects, mollusk(Naipagropediaraichur, 2012).It has been suggested by the marine biology organization (MBO 2007b) that plankton communities in water bodies serve as a base for the food chain that support commercial fisheries. This statement has been supported by Davis (2009) who discovered that the high abundance and distribution of phytoplankton and epiphyton (algae) of the lower reaches of Okpoka creek of Niger Delta favored the growth and abundance of fin fishes *(Sardinella maderensis*). This has also been reported by Nweke (2000) of Elechi creek and Ebere (2002) in the Okrika creek.

Stream flow and morphology, cover and pools provide living space for fish and increase fish biomass and therefore major factor controlling fish population. This suggest that the carrying capacity of streams are related to the amount and timing of the high and low flows (Thompson *et al*., 2004).Furthermore, fish need adequate conditions for reproduction. Bjorn and Reiser (1991) opined that cover and stream characteristics are important for the successful upstream migration, spawning, incubation and rearing of Salmonids. Many Salmonids migrates upstreams month before spawning which need cover for protection from disturbance and predators. However the water depth, velocity, substance (stream bottom materials), size and area needed for spawning depends on the species, age and size of fish;

Alteration of stream flow can lead to a growing community of primary producers especially species of floating macrophytes (Agostinho *et al.,* 2008). Macrophytes are known to harbor a high density of fish especially juvenile which explore these habitats as shelter and feeding sites (Bulla, Gomes, Mirandaand Agostinho, 2011). However high densities of these plants can produce intolerable conditions for aquatic organisms (Miranda & Hodges, 2000; Perna, Cappo, Pusey, Burrows & Pearson, 2012); restrictive for fish, especially nocturnal hypoxia generated by respiration of these plants and associated biota (Kauffman, Martin & Valentine, 2018)

Notwithstanding André & Marlene (2017) studying the effect of dredging and macrophyte management on the fish species composition in an old neotropical reservoir in Brazil; found out that after the dredging and management of the river impounded, the number and biomass of fish caught increased. Fishes that survive under high macrophyte density most have presented adequate features to cope with hypoxia in the water body. Such adaptation could include increase in the use of surface water, air breathing and changes in vertical and horizontal habitat (Perez- Alberti, Coranato, Costa-Cascus & Valcarcel-Diaz*,* 2008).

5 Fishing Pressure

Most fisheries in African rivers exploit a large number of fish species by using a range of fishing gears (consisting of lines, nets and traps), each adapted to particular species, life stages and habitats, (Welcome 2003). When every species and all life stages of fish are vulnerable to capture, it leads to decline in fish production in stream. Davies (2009) while studying the fin fish assemblage of the lower reaches of Okpoka creek, Niger Delta and found out that fishing was carried out throughout the year and non-selective cast nets were constantly used leading to low fin fish species diversity. This indicates that fin fish population were over- fished by the local fishermen. Rabo, *et al.,* (2014) also opined that by catch where low graded and unstable fish stock are caught, over fishing and indiscriminate fishing has led to over exploitation and extinction of our aquatic species like salmon, swordfish, blue fin fish, and many flat fishes. Catches in streams and river have been connected to floods as indicated by Welcome (2003) who stated that 69% of catches for river Niger in the late 1980s consisted of young fishes showing a general increase in fishing pressure. Many people have been forced into fishing as a result of growing population and shortage of land for farming. This has led to pressure on inland fishery over the last 2 decades (Welcomme, 2003). As fishing increases, the adult matured fishes are exploited leaving the smaller species and individuals. This has brought change in the nature and value of fishery. However the second international symposium on the management of large river for fisheries concluded that a fishery resource would not collapse due to fishing pressure alone except there is link to degradation in environmental quality due to altered hydrological regimes which usually leads to change in flow pattern of streams/rivers (FAO,2014). Management of fishing pressure should therefore be direction to local communities to deliberate on how to manage their local resources and environment. This entail enacting laws and bylaws, adopt policies to reduce indiscriminate and unauthorized fishing., seasonal fishery opening and closing; and critical habitat area closure to protect the breeding grounds of threatened fish (Rabo *et al*., 2014)

6 Sediment and Pollution

Different forms of pollutants coming from divers sources affects fish in streams. Some of such are waste water, pesticides, toxic chemical, acid rain, organic chemicals and sediments (Thompson*, et. al*., 2004). Sediments originate from erosion process that come from points and non-point source pollutants consisting of contaminants, (pesticides), particulate (silt and clay) and dissolved organic matter (Miranda, 2021). Also sediment in streams would come from mass failure (land slide), road construction, root throw and animal burrowing (Sidle, Ghestem & Stokes, 2014). The retention of sediment and nutrient contribute to alteration in flow regimes by river impoundment. (Agostinho, 2008)., and siltation is one of the dominant aging process of reservoir (Esguicero and Arcifa.,2017). Siltation reduces the heterogeneity of habitat related to depth and thereby alters the characteristics of the bottom and littoral habitat (Zeni, Perez-Mayorga, Roa-Fuentes & Brejao, 2019) and so reducing fish production and density.

Sedimentation increase turbidity which caughts down light penetration affecting visibility of fish in water and so reduce fish feeding efficiency. However, a fish susceptibility to sediment depends on its species and life stage (Bilotta and Brazier, 2008). Suspended sediment can cause gill damage leading to dead of fish if in high concentrations. Excessive sediment in the stream bottom may act as a physical barrier that reduces pool habitat, preventing proper flow of water and stop the emergence of fry. Sediment also prevent good flow of down welling water that carries dissolve oxygen (DO) to incubating egg which in turn removes waste products from the developing embryo. Also when excess sediments is suspended in the water column, it leads to decrease in DO. A greater surface area of sediment is exposed to the water as bacteria decompose organic matter in the sediment..

Miranda (2021) also opined that instability of tributary stream produce negative effect on habitat for riverine fish and those that occupy reservoir but have riverine habitat to complete their life cycle. The extent and magnitude of stream bank erosion is greatly increased by activities that remove riparian vegetation, increase water flow, increase sediment movement or otherwise cause channel down cutting (Prosser, Rutherfurd, Olley, & Young, 2001). Another significant effect of sediment is their bioaccumulation process through food chain in fish. Yu- jan yi (2008) studying the effects of sediment pollution and its effects on fish through food chain at the Yantze riverfound out that heavy metals were concentrated in the following order; bottom material > demersal fish and benthic fauna > middle-lower layer fish > upper middle layer fish> water. Bioaccumulation of metals in fish tissue rends them unsuitable for human consumption (Rabo, Sudik, Dikwahal and Gulukun 2020). Fish are known to tolerate different sediment concentrations. It has been found that adult can withstand high sediment concentration for a short period of time without harm, but too much sediment on the stream bottom will reduce the survival of eggs and newly hatched fry (Beschta and Jackson 2008).

Mitigation of excessive sediments in streams can occur naturally. Fine sediment in stream can be clean from the stream-bottom gravel by scouring during peak flow and then washed downstream (Thompson *et al*., 2004). However this natural processes that remove substance require considerable monitoring and possible closure of some fisheries (Shank and Stauffer, 2015).In smaller streams, particularly those that seasonally become dry or nearly dry, bulldozing of streambed gravels against the bank retards erosion. While in rivers, the placement of rip-rap rocks, broken concretes and mixture of materials (rocks, soil and branches) along the bank reduces erosion. Also stream banks can be stabilized by grading or terracing, use of interwoven native vegetation, mats installed alone or in combination with structural measure.

However, erosion of banks is a natural process of rivers. River channel move freely from side to side across a flood plain by eroding the bank on one side while depositing sediments on the other. This dynamic characteristic results in constant creation of new fish habitat and many species depend upon a constantly changing river. However, impoundment has changed how the river erode its bank and in many cases, the erosion is occurring through down-cutting and new lateral habitat is not being created.

7 Conclusion

Fresh water fishes are of major economic, nutritional, ecosystem-service, scientific, historical and cultural importance worldwide. In Africa, they are the main protein source to people living close to streams and rivers. In Nigeria, fisheries within inland waters contribute about 86% of the domestic fish production. Streams are a major source of fish production to hinterland communities and this depends on the interplay of factors like hydrological regimes, environmental degradation, riparian vegetation/ natural food, fishing pressure, sediments and pollution. The longitudinal connectivity of the hydrological regime with flooding of lateral plains without undue hindrances from barriers like dams and diversions are important to maintaining and restoring fish population. In addition, riparian vegetation/ natural food, fishing pressure, sediments and pollution have affected fish production in streams. It therefore calls for local communities along streams to deliberate on how to manage their local resources and environment. Government should provide guidelinesfor protecting water quality and aquatic ecosystem as a vulnerable resource to prevent further pollution and degradation of freshwater resources. The Government should executeprojects that would provide planned flow regimes to mitigate and potentially enhance fish production in fresh water streams.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest anywhere concerning this paper.

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