Paper No. 291

AQUATIC BIO DIVERSITY MANAGEMENT OF KHWAR PROJECTS – A CASE STUDY

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ABSTRACT

The perpetuating curiosity of mankind to know about the different kinds of living organisms led him to discover the use of various organisms to improve his lifestyle. However, due to over exploitation and irrational use of natural resources man himself has created a critical situation for survival. The realization of this gloomy situation led him to take care of life sustaining systems of this planet. His strives materialized in the form of biodiversity conservation and sustainable development.

To take cognizance of both aspects, WAPDA while embarking on the hydraulic engineering activities on Khan, Duber & Allai Khwars in Khyber Pakhtoonkhwa decided to keep the biota of these Khwars in vulnerable downstream reaches intact and ensure such ecological/environmental flows that might sustain the aquatic biodiversity down-stream weir sites in critical lean water period. A study was conducted to calculate environmental flows that might not only fade the footprints of water diversion for hydel generations but also encompass the requirements of riparian users. This Paper is the outcome of that study.

INTRODUCTION

Etymologically the term ‘biodiversity’ appears to be a synthesis of two words bios and diversity. Thus biodiversity expresses variation to a whole hierarchy of levels expressed in terms of bio-molecules, genes, cells, individuals, populations, communities, ecosystems, landscapes and biomes. The Earth Summit at Rio De Janeiro 1992 defines the term biodiversity as the “variability among living organisms from all sources including inter-alia terrestrial, marine and aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within a species, between species and of the ecosystems. It may be interpreted as species richness (plants, animals and micro-organisms) occurring as an interacting system in a given habitat (Khoshoo, 1994). The same definition applies to aquatic biodiversity.

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The lotic aquatic biodiversity depends upon stream flow patterns i.e. discharge variability, flooding patterns and extent of drying. Fluctuation in water discharge has been used to characterize streams and linked to the community structure of organisms. However, hydraulic engineering normally changes the set seasonal flow patterns of the streams in downstream reaches. Few relatively prestine river stream systems are intact on the globe. Humans have had a major impact on the geomorphology and aquatic ecology of streams and rivers throughout the world via damming, channelization, and excessive water usage. This results in changes in flow fluctuation patterns, the heterogeneity response to floods and greatly influences the ecology of rivers and riparian zone's function as an inter phase between terrestrial and aquatic habitats (Naiman & Decamps, 1997). Most large rivers and streams have been altered significantly from their natural state. For example, 70% of the discharge from the 139 large rivers and streams in North America, Europe and Former USSR is affected by irrigation, diversion, or reservoirs. Most of the unaffected streams and river systems that remain in these regions are in the far North and remote areas. (Dynesius & Nilsson, 1994). It is estimated that there are 0.75 million dams (Google Earth) in United States. The biodiversity situation ensuing hydraulic engineering in Pakistan needs immediate attention. The Civil Engineering ventures without considering environmental sustainability have already declined the aquatic biodiversity to a precarious situation. The present phenomenon of climate change is further eroding the habitats of biotic communities. The environmental flows are suggested for Allai, Duber and Khan Khwar.

Keeping in view all pros and cons including present biotic species richness and status of species evenness, alpha diversity and beta diversity, Shannon Weiner diversity, flood pulse concept, autochthonous versus allochthonous production, inverted biomass pyramids (Allen's Paradox, nutrient spiraling and idea of discontinuity). The basic method involved includes present physical need / requirements of downstream riparian needs and maintenance of bare survival of biodiversity. The Tennant Method 1976, was applied with holistic approach to calculate the environmental flows, while physical survey judging downstream needs also coincided with the results obtained by applying Montana Method. It was finally sorted out that environmental releases from the weir sites of High Head Hydel projects would be particularly important during the lean period i.e. 15th November to 15th February.

Aquatic biodiversity of all three Khwar reveals that Khan Khwar has optimum range of ecological biodiversity. Duber has minimum ecological biodiversity with predominantly cold-water species. The Allai Khwar is rich in biodiversity. It has luxuriant life sustaining habitats. The conservation of biodiversity is of prime importance for future survival, continuity and viability of these lotic water regimes.

The feature common to these High Head hydroelectric schemes is that they are going to modify discharge in terms of reduction in the quantity of downstream waters. The consequences are changes or fluctuations in wetted area, water depth, water velocity, bed scour, and fine sediment transport and deposition. The changes in wetted area may modify the area available for spawning or juvenile habitat and rapid changes may lead to exposure of eggs and desiccation or freezing and to the stranding of juvenile. The environmental releases suggested are essential to avoid any such likely biodiversity reducing havoc. These releases will ensure the survival of spawn and juvenile in critical period in vulnerable reaches of Khwars. This management technique in most cases will be more effective in small stream pools than in riffles, as, moisture held in the gravel interstices and the thermal insulation provided by the gravel in stream pools may sustain eggs and juvenile for several hours or even weeks (Hardy, 1963; Hawkes, 1978). Changes in water velocity and depth may modify the spawning sites for salmonids, Mahseer and snow carps. Changes in the amount and location of bed scour and sediment deposition from contributing tributaries may influence the survival of inter-gravel stages and the amount of cover available for juvenile and macro-invertebrates.

At some impoundments it is possible to make releases that equal or exceed the discharge of natural spates, such as flushing Allai weir site in March. At such structures it is important to ensure that these large releases, either during commissioning trials or during routine operations, do not wash out spawning gravels. However, in case of all three Khwars it is not possible to make releases that could even approach the spate discharges in the natural Khwars and over a period, the gravel between the dam and the nearest major downstream tributary may become compacted, in-filled, with fines and of considerably reduced value as a spawning medium. So it is suggested that minimum environmental releases may be directed through left and right bank channels in the Khwars to ensure continuity of downstream biodiversity in lean periods also.

MATERIAL AND METHODS

There is an ever-increasing awareness of the need to incorporate environmental requirements of aquatic ecosystems / biodiversity in the water resources planning process. A sound scientific methodology is required to assess the environmental flows. However scientific methodology of estimating environmental flows differs from country to country and is mainly based on the analysis of historical flow data of a stream or investigation of the relationship between a particular aspect of the habitat and stream discharges. There are many techniques to determine the quantity of water to be released from dam weir downstream to maintain ecological health biodiversity vigor, and state of sustainability of ecosystem in reach affected by the project. Some widely used techniques to determine environmental flows include:

1. Functional analysis method
2. Historical stream flow method
3. Habitat modeling method
4. Hydrological index method / Montana Method

The adopted approach for the present study encompasses both considerations i.e. water requirement for bare survival of aquatic biota in vulnerable reach and downstream stakeholder water needs. So, an approach based upon Montana Method (Tennant 1976) was adopted. This method includes analysis of river flow data to the more complex indicators of hydrologic alternations. Its application is holistic approach based i.e. which includes assessment of whole ecosystem, such as associated wetlands. The study is based on hydrological data approach augmented with aquatic ecosystem analysis for determining environmental flows for sustainability of biodiversity in lower reaches of Khwar projects. This method suggests environmental flows to the tune of a minimum of 10% of the average lean period flow, 30% for moderate aquatic life and 60% for no impact on aquatic biodiversity.

The estimation of environmental flows is based on the physical judgment and actual measurements at site which are made during the visit of Wapda Environmental Cell (WEC) Team. This estimate is very near to the estimate as described in the Montana Method i.e. 10% of Mean flows of lean period.

DISCUSSION

Hydroelectric impoundments usually have little effects on the total discharge but they can create highly unnatural discharge fluctuations in the downstream and such fluctuation often bear closer relationship to the demands of National Electricity Grid than to the needs of river biota. In case of Khyber Pakhtoonkhwa High Head projects more than 70% of total discharges of Khwars are to be diverted through long tunnels to generate (121+71+130) 323 MW hydel power for the national grid. Structures (1989) commented that molts of salmonids and juvenile of snow carps pass through low head turbines with negligible loss but that high head turbines can cause appreciable mortality.

However, the over abstraction of Khwar waters for hydel energy generation will cause diminished stream flows with subsequent damage to biota habitats. These diminished stream flows will cause increased siltation, low survival of 0-group trout and snow carps and downstream displacement of spawning activity (Giles et. al., 1991). To take stock of this hostile change for aquatic biota, the Rundquist et. al. (1986) and Cairns (1990) suggested the general principles for the planning and management of restoration of vulnerable reach.

These general principles apply to restoration work for fish and other aquatic biota and were summarized by Mann & Winfield (1992) as four points:

1. What is the aim of restoration?
2. Which environmental attributes need to be restored?
3. What are the environmental specifications for an alternative restoration schemes?
4. Would natural processes lead to restoration more effectively?

In case of Khwars water diversions, the restoration of downstream habitat depends upon dependable flows to ensure sustainability of aquatic biodiversity therein. Questions 3 & 4 are not applicable to the extent that there is no alternative restoration concept except releases of water from weir sites and it is not out of place to mention here that natural processes including contribution of flows by downstream tributaries could not lead to restoration more effectively. Therefore, it was decided to calculate the minimum flows from weir sites so that partial restoration and bare survival of biodiversity in vulnerable reaches during lean periods might be ensured i.e. 9 km reach in case of Khan Khwar, 12 km in case Duber and 16.5 km in case of Allai Khwar.

Where there is direct human control over flow regimes (e.g. at impoundments, water diversion facilities etc.) it is important that the compensation flow and the fluctuations flow are as ecologically sensitive as possible within the constraints of the engineering function of the structure. Keeping this concept in mind, this study was carried-out by WAPDA WEC Team. The outcome of the study regarding aquatic ecological status and biodiversity position and requirements of compensation flows w.e.f. 15th November to 15th March lean periods is elaborated in the below elucidation for all three Khwars respectively.

Allai Khwar tributary is the last upstream safe-haven for prize, gallant and enchanting Golden Mahseer in Indus. This species has established the spawning grounds in Siran, Brandu and Allai Khwar after the impoundment of Indus at Tarbela. Nature has endowed Allai region with wealth of flora, fauna and lavish water resources. The aquatic resources in the form of Khwars, serpentine rivulets, majestically falling stream, suddenly up-surging springs dot this reach after every 500 m. The aqua resources of Allai have been declining with the passage of time. The cold-water habitat, spawning and feeding grounds have been eroded to a great extent by frequent flashfloods, landslides (particularly during October 2005 earthquake). The present water diversion is further going to erode this precarious situation particularly for Mahseer (Tor putitora) and Swati (Schizothorax plagiostomus). Other species have an important role to play in biological aquatic food chains. Present aquatic biota of Allai Khwar is elucidated in Table-I.

Table-1: Aquatic Biota of Allai Khwar

Sr.#	Major Taxonomic Division	Name of Species
1	Phytoplanktons	• Scenedesmus • Peridinium • Asterionella • Fragilaria • Betrachospermum • Spirogyra • Chlamydomonas

Sr.#	Major Taxonomic Division	Name of Species
2	Zooplanktons	• Paramecium • Vorticella • Stentor • Dermatocarpon fluviatile • Keratella quadratica • Daphnia longispina • Palaemonias • Euglena
3	Aquatic Invertebrates	• Chironomous larvae • Mosquito larvae • Caddis fly larvae/nymphs • Mayfly nymph • Water mite • Stone fly nymph • Stonefly • Winged insects • Simulium • Unknown Hemiptera
4	Ichthyfauna	• Schizothorax plagiostomus • Schizopygae esocinus • Labeo dero • Glyptosternum reticulatum • Tor putitora • Schizothoracinae • Hypophthalmichtys molitrix • Cyprinus carpio

The fish species at Section-4 of Table-1 mostly remain of minnow size and commercially they are less lucrative. No specimen of any species above 600 gm is encountered in Allai Khwar.

To safeguard the biodiversity of Allai Khwar, the environmental flows are suggested particularly for lean period. However, during lean periods the Ichthyofauna normally inhabits the Indus and starts ascending Allai during April i.e. spate season for spawning and feeding. The water contribution of downstream tributaries i.e. Natai, Skargah and Pazang into main Khwar also help to create healthy water flows.

The Khan Khwar and its main upstream tributary Gorband Khwar are snow-fed and have low nutrient levels. Water temperature ranges from 4°C in Dec-Jan to 22°C in June (Karora gauge 2009). Low nutrient, low water temp regimes render this stream's biotic carrying capacity as low and limited. That is why, biodiversity of macroinvertebrates, benthos, phytoplanktons, zooplanktons, periphytons and neustons is limited in number which ultimately limit the terminal aquatic biotic product i.e. fish. Limitations in ichthyofaunic biodiversity are apparent from the fact that there are just four species of fish in this Khwar.

1. Schizothorax plagiostomus
2. Schizopygae esocinus
3. Labeo dyochilus
4. Oncorhynchus mykiss

Schizothorax plagiostomus is abundant in the proposed reservoir area and downstream reaches of Khan Khwar. Labeo dyochilus and Schizopygae esocinus are encountered rarely in high flood season i.e. April to August. While Oncorhynchus mykiss is found in the upper reaches, where predominantly snow-fed water is available throughout the year.

In macro-invertebrates; Diptera of family Simaliidae are present in this reach.

The common Swati fish i.e. Schizothorax plagiostomus especially brood-stock size (more than 350 gm), move downstream from Khwar to Indus, average water temperature at that time remains 4°C (Dec-Jan). At the end of March water flows gain momentum and water level rises and warms upto the level of 9°C to 10°C; they return back to Khan Khwar.

As mentioned earlier, only weir site releases will ensure the survival of downstream biodiversity during lean months while tributaries' contribution will be less than 0.100 m^3/sec.

Duber Khwar carves a deep gorge in Duber valley. The nutrient level in this Khwar is lowest as compared to other two Khwars. Here the water are predominantly snow-fed throughout the year.

The deep canyons of Duber Khwar scarcely allow sun to shower its rays on valley bottom, which reduce the photosynthesis activity. This renders Duber a nutrient and biotic components deficient stream. The gushing and rushing crystal clear waters of Duber Khwar remain very cool throughout the year i.e. 3°C to 16°C. The Ichthyofauna is represented only by Schizothorax plagiostomus and Salmo trutta fario. Macroinvertebrates are represented by Chironomous and Pedicia rivosa, some Coleoptera and Hemiptera.

The recommended water releases from weir site downstream in initial lean flow season are important for the sustainability of biodiversity in vulnerable reach w.e.f. 15 Nov to March.

CONCLUSION

The aquatic biodiversity of any lotic hilly stream depends upon its water temperature, pH, nutrient content, stream bed constitution, pool / riffle ratio, stream gradient, catchment area, annual flow patterns, amount of flows, etc. However, any likely Civil Engineering venture can disturb all above parameters, resulting in drastic changes in biodiversity. Such changes can prove fatal for the biodiversity in lean flow periods. It is important to ensure minimum flows from water diverting facilities / impoundments to avoid a complete disruption regarding downstream biodiversity. Keeping in view, all pros and cons of water requirements in vulnerable Khwar reaches minimum water flows were suggested for bare survival of biota during lean periods. The outcome of the study / calculated releases from weir sites of all three Khwars are elaborated as below:

1. Allai Khwar 0.420 m^3/sec
2. Duber Khwar 0.943 m^3/sec
3. Khan Khwar 0.718 m^3/sec

These flows / releases are 10% of minimum average flow from Dec to Jan for Khan Khwar and of January only for Duber and Allai Khwars. These are selected as environmental flows, keeping in view other supportive factors, such as water depth for survival of aquatic life, velocity, contribution of water from downstream tributaries, etc.

RECOMMENDATIONS

- It is emphasized that proposed minimum flow requirements for Khwar weir downstream reaches are recommended to be released throughout the year in general and for lean period in particular (i.e. 15th Nov to 15th March)
- It is also recommended that relevant structural arrangements should be built on weir sites as well as in downstream reaches if possible.
- These Khwar may be managed with the concept of declaring them safe havens / sanctuaries for biodiversity conservation.
- Two pronged strategy may be adopted for the conservation of Ichthyofaunic wealth in downstream reaches of these Khwars i.e. by restoration of spawning and feeding grounds of various species and by imposing strict punitive measures against illegal poachers and culprits playing havoc against brooders and juvenile.
- An extensive research study of biodiversity trends may be carried out to encompass spatial and temporal changes in flora and fauna of these lotic regimes.

- It is finally recommended that the future needs of riparian users and biotic components must be kept in mind while making hydraulic structures on each weir site for downstream releases so that future needs may be met without further structural changes.

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