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Assessment of Quality of the Chambal River Using Combination with That of Kota District

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ABSTRACT

The present study was conducted to understand the physico-chemical characteristics of Chambal River, in National Chambal sanctuary in Madhya Pradesh. The Chambal River is located in west central India and flows through three Indian states; Madhya Pradesh, Rajasthan and Uttar Pradesh. The Chambal also forms part of the Rajasthan-Madhya Pradesh boundary. The stretch of Chambal river contained in the National Chambal sanctuary (located at 25 º 23'-26 º 52'N, 76 º 28'-79 º 15'E) is extending up to 600 km downstream from Kota (Rajasthan) to the confluence of the Chambal with Yamuna river. On the basis of various parameters studied, Chambal River in this stretch can be placed under the category of Class C as per CPCB standards. The Chambal river water in the sanctuary area is pollution free and can serve as a good habitat for many aquatic flora and fauna including endangered species.

The Chambal River originates from the summit of Janapav hill of the Vindhyan range at an altitude of 854 m above the msl at 220 27' N and 750 37' E in Mhow, district Indore, Madhya Pradesh. The river has a course of 965 km up to its confluence with the Yamuna River in the Etawah district of Uttar Pradesh. It is one of the last remnant rivers in the greater Ganges River system, which has retained significant conservation values. It harbours the largest gharial population of the world and high density of the Gangetic dolphin per river km. Apart from these, the major fauna of the River includes the mugger crocodile, smooth coated otter, seven species of freshwater turtles, and 78 species of wetland birds. The major terrestrial fauna of the adjacent areas are Indian wolf, golden jackal, caracal, jungle cat, desert cat, ratel, small Indian civet and neelgai. Unlike other rivers of greater Ganges drainage system the Chambal River is relatively unpolluted.

KEYWORDS: *Chambal, kota, river, assessment, water, quality, habitat, CPCB standards, drainage*

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INTRODUCTION

A 600 km stretch of the Chambal River, between Jawahar Sagar Dam (Rajasthan) and Panchhnada (Uttar Pradesh), has been declared as the National Chambal Sanctuary primarily for the conservation of gharial and associated aquatic fauna. The Sanctuary is managed by the Rajasthan, Madhya Pradesh and Uttar Pradesh Forest Departments. During early 1970, four major hydro electric projects over Chambal River were undertaken namely Gandhi Sagar, Rana Pratap Sagar, Jawahar Sagar and Kota Barrage. This has reduced the flow of the Chambal River below the Kota barrage to zero during the lean seasons, leading to reduction in gharial habitat between Kesoria Patan to Chambal-Parvati confluence and dolphin habitat between Chambal-Parvati confluence to Rahu Ka Gaon. Thereafter, with inflow of water from Kali Sindh and Parbati Rivers and through ground water inflow, the Chambal River rejuvenates itself and

forms the main aquatic wildlife habitat. Environmental water requirements also referred to as 'Environmental Flows' are a compromise between water resource development and the maintenance of a river at ecologically acceptable or agreed condition. Based on this principle, we assessed the minimum environmental flow of Chambal River taking Gharial and Gangetic dolphin as umbrella species using a combination of flow analysis and habitat modeling. We attempted to answer the following key questions pertaining to the environmental flow of the Chambal River (i) What is the mean monthly flow of Chambal River and its trend? (ii) Is there any relationship between flow and depth?(iii) In the present flow regime, what percentage of Chambal River is suitable for adult gharial and Gangetic dolphin?, and (iv) What will be the cumulative impact of proposed water harvesting projects on the habitat quality? To address the above mentioned questions, we have used monthly flow data from 1996-2004 from Central Water Commission for three stations namely Pali, Dholpur and Udi, located downstream to the Kota Barrage. We measured water depth at 440 locations between Dholpur (Rajasthan) to Panchhnada (U.P.) during February, April and June 2010. We also measured the actual flow during the same period at 29 locations to derive the relationship between flow and depth. Based on these data we have assessed the depth of the river stretch from Dholpur to Panchhnada with a view to appraise the suitability of the river stretch for gharial and dolphin. Our analysis revealed that the mean monthly flow of Chambal River for the period 1996-2004 varies between 2074. 28 m3 /sec in August to as low as 58.53 m3 /sec in April. During the last 20 years the flow regime of Chambal River has shown a declining trend of ca 3.5% per annum. The required water depth for gharial has been found to be 4 m and above, where as for dolphin it is 10 m and above. Based on the relationship developed by us from the actual data collected on depth and flow, we found that the minimum flow requirement for long term survival of gharial is 164.34 m3 /sec and for dolphin it is 289.67 m3 /sec. At present, this flow is available only during the months of July to October for gharial and July to September for dolphin in the river stretch between Dholpur and Panchhnada. Analysis of monthly data on mean flow suggests that there is reduction in flow of almost 50% or less in the month of February to June so far as gharial is concerned. For dolphin the reduction of 50% or less is noticed from November to June, i.e. for 8 months in a year. The cumulative requirement in post project scenario has been worked out and it is found that the pre-project reduction in flow by 50% or less is further reduced significantly in the months of November to March for both the species. The period of reduced availability of flow also corresponds to the breeding season of gharial. As the suitable habitat at present is already compromised by 50% or less in lean months, further drawl of water will negatively impact the habitat suitability for gharial and dolphin significantly. The declining trend of flow of 3.5% per annum recorded over the last 20 years needs to be factored in for future water management programme for Chambal River.

Discussion

Environmental water requirements, also referred to as 'Environmental Flows' (Dyson et al. 2003; Acreman and Dunbar 2004), are a compromise between water resource development and the maintenance of a river in some ecologically acceptable or agreed condition. An environmental flow is the water regime provided within a river, wetland or coastal zone to maintain ecosystems and their benefits where there are competing water uses and where flows are regulated. Environmental flows provide critical contributions to river health, economic development and poverty alleviation. It ensures continued availability of the many benefits that healthy river and groundwater systems bring to society (Dyson et al. 2003). For day-to-day management of a river, environmental requirements are often defined as a suite of flow discharges of certain magnitude, timing, frequency and duration. These flows ensure a flow regime capable of sustaining a complex set of aquatic habitats and ecosystem processes and are referred to as "environmental flows", "environmental water requirements or "environmental flow requirements", "environmental water demand" (Knights 2002; Lankford 2002; Dyson et al. 2003; Smakhtin et al. 2007). This report presents an assessment of minimum flow requirement of Chambal River taking gharial (Gavialis gangeticus) and Gangetic dolphin (Platanista gangetica) as umbrella species . The Chambal River originates from the summit of Janapav hill of the Vindhyan range at an altitude of 854 m above the msl at 220 27' N and 750 37' E in Mhow, district Indore, Madhya Pradesh. The river has a course of 965 km up to its confluence with the Yamuna River in the Etawah district of Uttar Pradesh. From the place of its origin the Chambal River flows for some 320 km in a generally northerly direction before entering a deep gorge in Rajasthan at Chaurasigarh, about 96 km upstream of Kota. The deep gorge extends up to Kota and the river then flows for about 226 km in Rajasthan and then forms the boundary between Madhya Pradesh (M.P.) and Rajasthan for about 252 km. Thereafter, the river forms the boundary between M.P. and Uttar Pradesh (U.P.) for about 117 km; enters U.P. near Chakar

Nagar village and flows for about 40 km before joining river Yamuna

The Chambal River averages 400 m in width while depth ranges from 1 to 26 m (Hussain and Choudhury, 1992). During monsoon the water level rises 10 to 15 m and often spreads to more than 500 m from either bank. The mean maximum discharge of the river is 2074.28 m3 /s and the minimum 58.53 m3 /s as recorded during 1996-2004. Between 1960 and 1972 four multipurpose dams namely Gandhi Sagar, Jawahar Sagar, Ranapratap Sagar and Kota Barrage were built on Chambal River which have affected its flow considerably (Hussain and Choudhury, 1992). The Chambal River is one of the last remnant rivers in the greater Ganges River system, which has retained significant conservation values. It harbours the largest gharial (Gavialis gangeticus) population (Singh, 1985; Hussain, 1993), high density of the Gangetic dolphin (Platanista gangetica) (Singh and Sharma 1985; Rao, 1989) and besides being a staging ground for migratory waterfowls, it is one of the last remnant nesting ground for Indian skimmer (Rynchops albicollis) and small Indian pratincole (Glareola lactea). Apart from the gharial and Gangetic dolphin, the major fauna of the Chambal River includes, the mugger crocodile (Crocodylus palustris), smooth-coated otter (Lutra perspicillata), seven species of freshwater turtles, and 78 species of wetland birds (Sharma and Singh, 1986; Hussain, 1993; Hussain, 1996; Hussain and Choudhury, 1997; Sharma, 2006). The major terrestrial fauna of the adjacent areas are Indian wolf (Canis indica), golden jackal (Canis aureus), caracal (Caracal caracal), jungle cat (Felis chaus), desert cat (Felis silvestris ornata), ratel (Mellivora capensis), small Indian civet (Viverricula indica) and neelgai (Boselaphus tragocamelus).

Unlike other rivers of greater Ganges drainage system, the Chambal River is relatively unpolluted (Hussain, 1999). The water quality exhibits very low suspended solids and low Biological Oxygen Demand (BOD) and high Dissolved Oxygen (DO). There is no indication of organic matter discharge or eutrophication in the river as the value of Chemical Oxygen Demand (COD), ammonia (NH4) and phosphate (PO4) are below the threshold limits. The essential cations (Ca, Mg, Na and K) are also within the range to support the aquatic organism. On the basis of standards set by Central Pollution Control Board (CPCB), Government of India, the Chambal River water can be considered as `A' category. Also by comparing the water quality parameter with ranges given by Allen (1989) the Chambal River can be considered as clean.

This analysis is applicable to river stretch between Pali and Panchhnada (425 km) and it is based on surface runoff/flow only. Because of lack of information on ground water inflow and outflow and evapo-transpiration we have not taken these parameters into account. We have not taken into account how increase or decrease in flow will affect the prey (fish) availability for gharial and dolphin. Mean monthly flow of Chambal River between Pali and Chakarnagar To derive the mean monthly flow of Chambal River between Pali (Parbati – Chambal confluence at Rajasthan) and Chakarnagar (prior to the Chambal-Yamuna confluence at Uttar Pradesh) we used flow data from Central Water Commission of the stations situated at Pali (Sawai Madhopur District), Rajghat (Dholpur district) and Udi (Etawah District), for the period of eight years from 1996 to 2004 and the mean flow was calculated for each month. Relationship between flow and river depth To answer the question in terms of water depth and percentage of river stretch available for gharial and dolphin, we measured water depth of Chambal River between Rajghat (Dholpur district) and Panchhnada (Downstream to Chambal – Yamuna confluence) at every 500 m interval using Garmin depth finder during February, April and June 2010. Based on the published work on water depth preference of gharial, we calculated the percentage of river stretch having depth >4 m, because gharial >180 cm in length including sub-adults and adults prefer water depths >4 m (Hussain 2009) (APPENDIX I). We calculated habitat preference of dolphin using Bonferroni confidence interval and analysis was made taking water depth preference of dolphin at >10.0 m (APPENDIX II). During the same period i.e. February, April and June 2010 depending on the accessibility and ease of measurement, we measured river flow at 8 to 11 locations and mean flow for these months were calculated. Flow was calculated as m/sec and was multiplied by mean depth of that site to get the volumetric flow in m3 /sec (Chitale, 1974). At each site, the entire width of the river was divided into 6-7 locations, and at each location, depth was measured once and flows were measured five times and mean flow was derived. Liner regression was performed to derive the relationship between flow and river depth at each measuring location (n=29 locations). Percentage of river stretch optimal for adult gharial and dolphin To relate the percentage of river stretch optimal for gharial, liner regression was performed to derive the relationship between mean river flow and percentages of optimal river stretch during the sampling period.

Implications

Maintaining environmental flows is a key step in achieving 'Good Status' of a river or stream. 'Good Status' is a combination of Good Chemical Status (GCS) and Good Ecological Status (GES). GES is defined qualitatively and includes populations and communities of large vertebrates, fish, macro-invertebrates, macrophytes, phytobenthos and phytoplankton. It also includes supporting elements that will affect the biological elements, such as channel form, water depth and river flow (Dyson et al., 2003). Our previous studies (Hussain and Singh 1999, Hussain 2009) suggest that because of natural setting, the Chambal River below Pali (Rajasthan) has Good Chemical Status; however its ecological status is extremely poor. As the discharge below the Kota Barrage is zero during the lean season, the river stretch below Kota barrage and Chambal-Pali confluence is ecologically dead. This has limited the occurrence of River dolphin above Rahu Ka Gaon and gharial above Pali. According to different ecological management options, there are four target classes or 'Environmental Management Class' that need to be identified based on existing empirical relationships between flow changes and ecological status/conditions, which are associated with clearly identifiable thresholds (Hughes and Münster, 2000; Hughes and Hannart, 2003). These are: A- Negligible modification from natural conditions. Negligible risk to sensitive species. B- Slight modification from natural conditions. Slight risk to intolerant biota. C- Moderate modification from natural conditions. Especially intolerant biota may be reduced in number and extent. D- High degree of modification from natural conditions. Intolerant biota unlikely to be present. Application of such objective-based approach necessitates that first the desired status of the river has been set. It is then possible to define threshold flow above or below which a change in status of the river in terms of its structure and functions will be evident. In Australia for example the probability of having a healthy river falls from high to moderate, when the hydrological regime is less than two-thirds of the natural flow regime (Scanlon 2002). Whilst this seems a reasonable figure, there is little scientific evidence to support it. Indeed from a theoretical point of view it may not be possible to define the flow regime that will maintain a desired river condition. From a practical standpoint, the assessment of an environmental flow remains a practical river management tool. However, it should be noted that, as long as knowledge of the aquatic environment remains limited, setting threshold for environmental flows will inevitably retain an element of subjective judgment. In the present study we have taken water depth preference of gharial, but we lack data on how this depth optimizes the prey availability of gharial thereby affecting its long term survival. In many streams in the USA, a threshold of 10% of the Mean Annual Runoff (MAR) is reserved for aquatic ecosystem/streams, which is considered to be the lowest limit for Environmental Flow (corresponding to severe degradation of a system). Fair/good habitat conditions could be ensured if 35% of the MAR is allocated for environmental purposes (Smakhtin and Anputhas, 2006). Allocations in the range of 60 - 100% of the MAR represent an environmental optimum (Tharme 2003).

Conclusion

The average quantity of water used for irrigation by Rajasthan and Madhya Pradesh through the creation of Gandhi Sagar dam and water abstraction via Kota Barrage has decreased by 22.6% and 41.4% respectively in last 17-18 years, whereas the use of water for non-irrigation (industrial and drinking water purpose) has increased three folds (Gupta and Attari, 2007) resulting in shortage of water in the downstream. By the year 2002-03 the net water use for non-irrigation purpose was almost 41% (Gupta and Attari 2007). In view of the foregoing discussion, it is not feasible to have new irrigation projects in Chambal River, as any further abstraction of water would adversely impact the conservation of the two major vertebrate species -the "Critically Endangered" gharial and the Gangetic dolphin which has also been designated as "National aquatic animal"

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