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Changing water sources in Keoladeo National Park (KNP): an alarm for the world heritage site

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ABSTRACT

The Keoladeo National Park (KNP) is well known bird sanctuary of international repute. Presently, the ecosystem of the park is adversely affecting due to disturbance in natural water sources. The natural water supply sources for KNP were rainfall as well as the Gambhiri and Banganga Rivers. Due to the construction of various major dams, reservoirs, flood protection works and anicuts, the water supplied from Gambhiri and Banganga Rivers to KNP (through Ajan Dam) has been ceased during 2000 to 2010. As supplement sources, Chambal pipe line and Goverdhan projects have been planned for KNP but these sources are not satisfying the needs of KNP ecology. Thereby lowering numbers of migratory species in KNP was observed in last 4 years. The physiochemical parameters of water from KNP, Ajan Dam and Chambal pipe line has been tested and correlated with the park's ecosystem. The correlation suggests that the Chambal pipe line water, having negligible biological value, should not be used for long time as it may alter the park's ecosystem which may further reduce the number and varieties of the birds. The water from Ajan Dam is most suitable for the KNP's ecology.

Key words : Keoladeo National Park, Water sources, Physiochemical parameters, Ecosystem.

INTRODUCTION

The Keoladeo National Park (KNP) is one of very well-known world heritage site (since 1985) and bird sanctuary (since 1956) situated at NH-11, in Rajasthan state of India. KNP has been the attraction for tourists for long time. Presently this world heritage is facing problems due to the decreasing number and variety of arriving short and long distant water birds. The plant and the animal community existence, particularly bird's arrival and departure, are affected by the physical characteristics of the environment (Weiher et al. 1996; Euliss et al. 2004 and Gillis et al. 2008) in a wetland ecosystem dependent on the seasons and hydrology (Hussain 1995). A preliminary survey in- and around-the park revealed that the changes in water sources might be the responsible for adverse effect on ecosystem of the park. As literature suggests, the wetlands are susceptible to the amount and quality of supplied water (Erwin, 2009). Moreover, inconsistency of water supply in wetlands is responsible for changes in hydrologic outputs and inputs (McLaughlin and Cohen 2013). The changed water sources have altered the hydrological parameters of the wetland of the park and thereby the ecosystem of the park. The wetland has outflows and inflows and it is the equilibrium that affects the wetland (Kath, 2012 and Day et al., 2005) and hence the changes in water sources ultimately change the equilibrium parameters. The hydrologic processes and hydrological patterns have significant effects which are essential in conservation of wetlands. Climate change also affects the hydrology of wetland ecosystems through changes in temperature and precipitation (Paul et al., 2006 and Parish et al., 2006).

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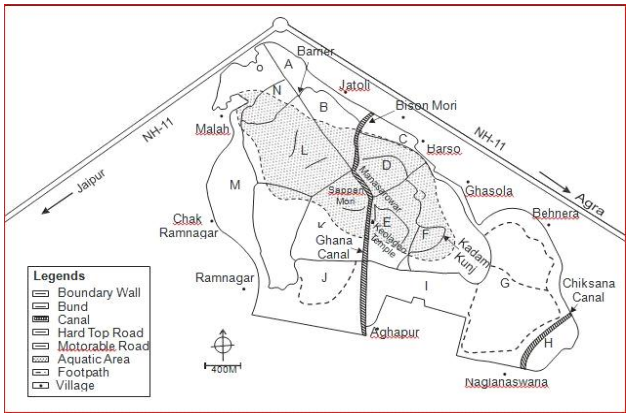
In view of the above, a study has been carried out to find out the reason why the bird's attraction is detaching from this park. The present study sought to determine the effects of the changing hydrological functions around Keoladeo National Park, Bharatpur. Water quantities and water chemistry were assessed. It is evident that hydrological alteration also has an impact on the conservation of wetland at Keoladeo National Park Bharatpur. The water samples from KNP, Ajan Dam and Chambal pipe line have been tested separately. The studied parameters involve water temperature, dissolved oxygen (DO), biological oxygen demand (BOD), hardness, salinity etc. These parameters from various alternative sources are significantly different which directly or indirectly affect the wetland, flora and fauna of the park. The study revealed that the changing water sources are not compatible for KNP's ecology and after a long time this may harm the image of the park at world map.

MATERIAL AND METHODS

Study Area:

There are 15 blocks A to O in KNP which are distinguished by dykes and are connected by canals for supply of water, as shown in Figure 1. Presently, the main areas characterizing status on global scenario for breeding and staging of water birds, are aquatic blocks namely K, L (L1 and L2), D, E and sometimes F as shown in KNP block diagram. These are the key area for quantitative and qualitative analysis of the study which influences vegetation and glory of park.

Figure-1. Different aquatic blocks in the Keoladeo National Park Bharatpur.



Peculiar activities of birds nesting, breeding, staging and growth of vegetation were discussed with local experts like guide, park guards and other officials. The perimeter and areas of aquatic blocks was measured and calculated as shown in Table-1. Surrounded drainage area of Gambhiri and Banganga River were also taken to describe physical boundary of study on the basis of current water problem in Keoladeo National Park area.

Many observational records and environment projections, as observed, provide ample evidence that freshwater sources in Keoladeo National Park are vulnerable and have the potential to be strongly impacted by environmental change with wide-ranging consequences for human societies and ecosystem. These governing factors as hydrological abstraction and subsequently changed sources have been taken to define boundary of study area.

Table-1. Confined Aquatic blocks & their area in KNP, for the present study.

Aquatic Block	Area (sq. Km)	Perimeter (in Km)	Containing Average depth of water (meter)
D	1.39	4.8	1.20
E	1.56	5.4	1.35
K	2.28	5.9	1.15
L1	3.06	7.6	1.20
L2	1.45	5.9	1.25

Collection of water samples and testing:

Extensive ground visit has been done at specified points to fix the appropriate different marked points and station for collecting water samples and depth in each aquatic block K, L, D and E. These samples were taken with utmost care. Water samples from different aquatic block were collected from schedule points as marked in KNP map. Water quality analysis was done both in-situ and in the laboratory using standard methods (APHA, WEF, AWWA, 1998).Water samples were tested for various parameters like pH, dissolved oxygen, BOD, Salinity, TDS, calcium hardness and others data in PHE laboratory.

Water sample were tested in laboratory of Public Health Engineering Department, Bharatpur, Polytechnic and Engineering Colleges Bharatpur. Regular field visit along drainage route of Gambhiri river, Panchana to Ajan earthen Dam was also done to check water flow, blockage and spill of water (from various stream of rivers was also done) in 2012 and 2013 when water was released through Panchana Dam. Thereafter, water application to Keoladeo National Park through Pichuna canal and its distribution to different blocks using dykes and gate of canals was also checked and exercised.

RESULTS

Water sources for KNP:

The KNP is needed 540 million cubic feet (mcft) of fish-rich water by the month of July to sustain and attract migrant bird population throughout the winter

months. Timely supplementation of water from June onwards is also important for proper growth of vegetation, adequate food and sufficient water level for attracting waterfowls. The main sources of water application in KNP are the rivers and rainfall. The KNP has witnessed drought during 1986-1987. KNP also faced equally difficult times in 2004, 2006, 2007 and 2009 when the monsoon failed. These years adversely affected the flora and fauna at the KNP and it took a lot of time for the park to recover (Pundir et al., 2014). Natural water resources for KNP were the Gambhiri and Banganga Rivers. Ajan Dan had been constructed in the flood plains of Banganga and Gambhiri Rivers just above 700 meter from KNP to protect the Bharatpur town from heavy floods brought by both the Rivers. The water from these Rivers was full of biological values (such as fishes, plankton, micro-orgasm etc). The study revealed that the water supply to KNP from these sources was gradually decreased. The observed reasons were (1) construction of Ramgarh dam (1903) in Jaipur at upstream of Banganga river which restricted the natural flow of water and completely seized in 2006 due to construction more medium dam and anicuts (2) construction of (started in 1979) Panchana Dam, in the flow area of Gambhiri River in Karauli, to solve the problem of flood in downstream. In second phase, the height of Panchana Dam was raised to increase the capacity up to 59.45 Million cubic metres (mcm) to fulfil the irrigation requirements in the upstream area. Due to the increased height of Panchana Dam, the overflow of water up to KNP was decreased. It was observed that from 2002 to 2010 water supply through Panchana Dam to KNP was completely ceased. Various major and minor projects constructed at these rivers are laid down in the Table-2.

During these years, due to the less rainfall and drought in 2002, 2004, 2006, 2007 and 2009 in Bharatpur, severe water crises was also witnessed in KNP. These environmental changes in KNP were responsible for hampering the vegetation growth and bird's diversity. Due to consistent problem of water scarcity in KNP, UNESCO also threatened to take back its world heritage tag, if the ecological value would not be maintained successively.

With this serious concern, the Government of Rajasthan has taken emergent steps to complete the project at the earliest and decided to supply water from Chambal pipeline (which is mainly a drinking water project in Bharatpur district) to fulfill the park's requirement. 297, 335, 81 and 201 mcft water from Chambal Project had been supplemented in 2011, 2012, 2013 and 2014 respectively. During 2011 to 2014 maximum portion of water supplemented from Chambal project but not seems to be useful for better ecology of KNP as having very low biological value.

Physicochemical parameters of water in KNP:

Physiochemical parameters (such as temperature, pH, TDS, DO etc.) of water at KNP have been tested and tabulated in the Table 3. These parameters were also studies for both the water sources (i.e. for Ajan Dam and Chambal pipe line) to check the overall effect on the water quality in KNP and a comparison is given in Table-4.

The pH value in Table-3 shows that the water in KNP is alkaline in nature. The average TDS value varied from 343 to 490 mg/L. The average DO concentration varied from 3.9 to 4.6 mg/L. The BOD ranges from 2.7 to 3.6 mg/L. Hardness was found around 150 mg/L. Comparative study of the water parameters indicates that water from Chambal pipe project is more alkaline than that of Ajan Dam. The Ca and Mg content in the water from Chambal pipe project were absent. As the water hardness is imparted by the calcium and magnesium ions which are in combination with bicarbonates and carbonates apart from sulphates, chlorides and nitrates (Sunder et al., 2015); hence, the zero value for water hardness in Chambal pipe line is obvious.

Table-2. Major, Minor Dam and Head works on rivers restricting water toward KNP

River	Major Dam	Minor Dam /Head works	Reason of construction	Construction Year	Consequence
Banganga River	Ramgarh Dam in Jaipur	Chokarwara protection bund, Jhalatala protection bund and Ramaspur protection bunds , Nekpur feeder	Drinking and Flood mitigation,	1903	Completely dried in 2006 due to climatic changes and impaired life supporting system of downstream
Gambhiri River	Panchana Dam in Karauli	Jagger, Ramgarh Dam, Senthal, Arvari and Kalakoh bunds Sevla head, Ajan Dam	Reservoir for irrigation, drinking and supply to KNP	1979-2003	35 villages on upstream getting water for irrigation whereas 425 villages on downstream witness water crisis and GW table lowered

Table-3. Physicochemical parameters of water in Keoladeo National Park, Bharatpur (2011-2014) taken from month August to April.

Aquatic area	Block-K		Block -L		Block-D		Block-E	
Parameters	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**
Temperature (^{0}C)	19.8-24.6	22.2	20 -25.9	23.7	20.4-24.5	22.8	20.7-26.4	24.2
pH	7.0-7.4	7.1	7.0 - 7.9	7.3	7.2-7.6	7.4	7.1-7.7	7.4
TDS (mg/L)	242-654	343	342 -980	489.3	224-655	430	287-765	470
DO (mg/L)	3.2-4.8	3.9	3.4 - 5.8	4.4	3.8-6.2	4.6	3.6-5.2	4.3
BOD (mg/L)	2.6-4.2	3.6	2.1 -3.5	2.7	2.8-3.4	3.1	2.4-4.4	3.3
Hardness (mg/L)	87-242	132	92 - 301	147	104-345	156	98-302	135
Cl (mg/L)	34-176	78	52 -214	94.3	38-178	74	48-188	65
Salinity (mg/L)	21-65	49	30 - 96	61.6	36-86	56	28-68	43
Ca (mg/L)	26-98	43	30 -132	45.6	27-94	47	34-78	48
Mg (mg/L)	32-134	49	41 -162	58.3	29-135	42	26-143	44

*(Source-Self study) TDS- Total dissolved solids, DO = Dissolved oxygen, BOD= Biological oxygen demand.

Table-4. Comparisons of Physicochemical parameters of water sample from Ajan Dam and Chambal pipe project in KNP, Bharatpur.

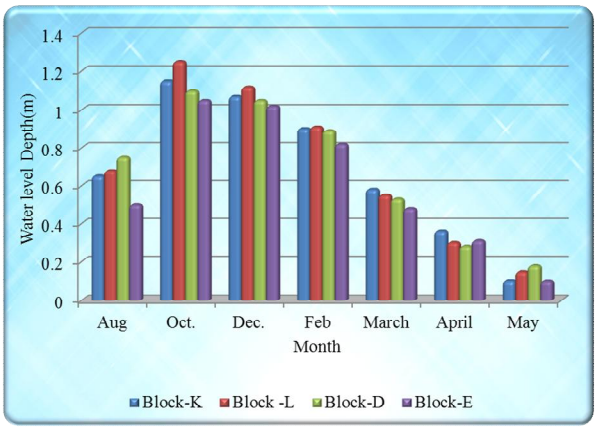
Parameters	Water sample from Ajan Dam		Water sample from Chambal pipe line	
	Range	Mean	Range	Mean
Temperature (^{0}C)	20.2-25.9	23.6	19.5-21.9	20.6
pH	7.2-7.6	7.3	8.0-8.3	8.1
TDS (mg/L)	673-987	746	247-449	394
DO (mg/L)	3.6-6.2	3.8	3.2-3.5	3.2
BOD(mg/L)	1.9- 4.5	3.1	0	0
Hardness (mg/L)	132-301	174	0	0
Cl (mg/L)	357-581	461	0	0
Salinity (mg/L)	31-89	59	0	0
Ca (mg/L)	21-67	46	0	0
Mg (mg/L)	29-71	54	0	0
Residual Chlorine	0	0	0.5-2.5	1.3

*(Source-Self study)

Dissolved Oxygen (DO) is essential to all forms of aquatic life including the organisms that break down man-made pollutants. As shown in Figure-2, water depth increases in rainy season and reaches to its maximum level which is due to the influx of rain and Ajan Dam. In winters the water depth remains almost constant. As time runs to the summer season, the depth considerably decreases which is attributed to the increased evaporation rate due to sudden increase in temperature March onwards.

Due to the decreased water supply from the natural resources of KNP, the other alternate sources are required to fulfill the water budget in KNP. The Chambal pipe line project was used in KNP as an alternate water source; however, some of physiochemical parameters are varied differently with respect to the water from Ajan

Figure-2. Monthly variation in the water level depth in different aquatic blocks.



Dam which due to the purification of Chambal River's water as it was mainly a drinking water project.

The addition of water from Chambal pipe line, off course, affected the overall water quality and hence the wetland of the park. The changed water quality in KNP adversely affected the flora and fauna and hence the ecosystem of the park which raise the question on the sustainable integrity of the KNP's wetland.

DISCUSSION

The integrity of the wetland and ecosystem can be understood in relation to the changes in various water parameters which are discussed in coming paragraphs.

Effects on the water quality:

Various water parameters have been studied in the work. Water temperature influences the production of food. Invertebrate production in the water column may ultimately depend on water temperature and the ability of a wetland to produce algae. In the present case, the water temperature in KNP was found in the rage of 22-24 ^{0}C. As can be seen from Table 4, the water from Chambal pipe line is colder (by 3 ^{0}C) than the water from Ajan Dam. As reported (Rober ES et al, 2014), cold water might not be a hospitable environment for small animals and plants that some wetland birds eat. However, the variations in water temperature may be due to different timings of collection, influence of the season and the effect of atmospheric temperature (Sharma R et al., 2010). Therefore, the water from Chambal pile line may not have a considerable impact on the food production.

The pH indicates the water is acidic or alkaline in nature. More precisely, it indicates the hydrogen iron concentration in water. Water is considered acidic if the pH value is less than 7 and alkaline if pH value is higher than 7. At the value of 7 the water is said to be neutral. The recommended pH range for aquaculture is 6.5 to 9.0 (William et al, 1992). The average pH value in KNP ranges from 7.1 to 7.4. The water from Chambal pipe line possess high pH value (8.0-8.3) than that from Ajan Dam (7.2-7.6). With respect to water pH, the water form Ajan Dam is at more safe side.

Dissolved oxygen has been reported as a very essential part and most important parameter for the aquatic life of such park (Sunder et al., 2015). It also breaks down the man-made pollutants. Its concentration positively affects the park's life. In present case the highest DO was found to be 4.6 mg/L and lowest was found to be 3.9 mg/L. The average DO level was lesser in the Chambal pipe line water.

The TDS tells about the suspended solid content of organic and inorganic (mainly mineral salts) substances having size around 2 micron. The concentration of TDS influences the organism in the aquatic regions. Total dissolved solids are considered one of the best indices of nutrient availability for the aquatic plants being grown. The effect of high TDS has also been reported on different kind of fished and observed that there was no significant effect at different life stages. However, some reported adverse effect of high TDS at fertilization stage (Phyllis et al., 2007). Therefore, it can be said that some species might be more sensitive to TDS toxicity at certain life stages, and many species are during fertilization. In the present investigation, the average TDS concentration varies from 343-490 mg/L at different aquatic blocks in the park. The water from Ajan Dam is having TDS in the range of 673-987 mg/L. On the other, the water of Chambal pipe line is having TDS in the range of 247-490 mg/L, which is less than the Ajan Dam's water.

BOD level is related to the amount of dissolved oxygen needed by the aerobic biological organism to break down the organic material present in the water sample. If the BOD value is high the oxygen may depleted by microbial metabolism (Goldman et al, 1983), thereby, the fishes and insects may die due to the lack of oxygen. Therefore, a high value is not good for visiting birds in the park. In the KNP, during study, the BOD was found to vary from 2.1-3.5.

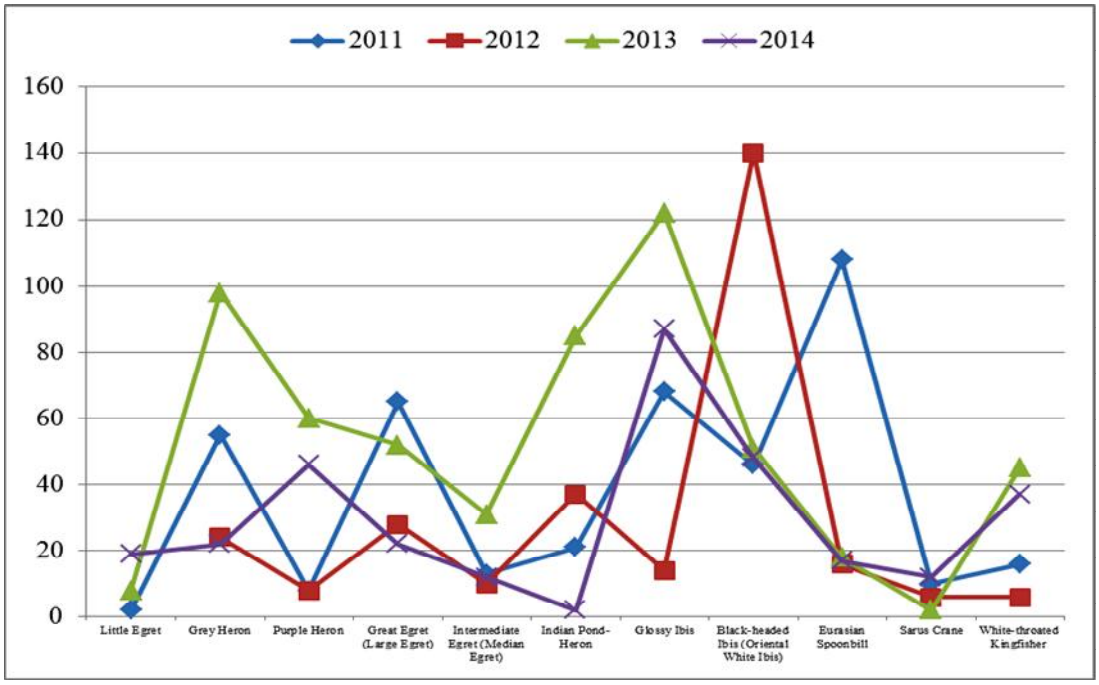
The hardness of water can be understood by the amount of divalent salts; however, the calcium and magnesium are the most common ingredients for water hardness. Calcium and magnesium are reported as the essential part of biological processes of fishes (bone and scale formation, blood clotting and other metabolic reactions) (Phyllis et al., 2007). Fishes can absorb calcium and magnesium directly from the water or from food. A recommended range for free calcium in culture waters is 25 to 100 mg/L (63 to 250 mg/L CaCO3 hardness). In present study the water hardness was observed in the range of 132-156 mg/L. The amount of Ca and Mg was nil in the water of Chambal pipe line, thereby having zero hardness value which not recommended for healthy environment of the KNP. With this regard, the Chambal pipe line is not suitable for KNP's ecosystem.

Alkalinity is measured by the amount of acid water can absorb before achieving a designated pH. A total alkalinity of 20 mg/L or more is necessary for good pond productivity (William et al, 1992). The water from Chambal pipe line indicates no salinity in the water and hence not suitable for KNP's ecology. The average water salinity in the KNP was observed to be in the range of 43-62 mg/L. The water from Ajan Dan possesses the desired salinity (31-89 mg/L). So, continue supply of Chambal's water may harm the water quality required KNP ecosystem.

Effect on biodiversity in KNP:

Due to changed water sources mainly Chambal pipe project water was mixed with Goverdhan drain and Ajan Dam water for fulfilling water requirement in KNP. This water was feed to aquatic block L and K. Water results and analysis showed that various parameter and their values from different sources were not suitable for

Figure-3. Variations of breeders water birds in Keoladeo National Park during 2011-2014.



proper growth of vegetation. The quality of supplement surface water in KNP is continuously declining as carrying low amount of fish and other nutrients required for nourishment for migratory birds. Changing water quality in KNP is reducing bird's variety and their density. Delayed water supplied in October onwards from Chambal project lower down breeding activities of resident birds so their bird's population decreased, as presented in Figure-3.

The utmost change and fluctuation in the results found in huge decrease in open water cover due to uneven supply of water in Keoladeo National Park during study. Presently, land cover area has reduced. Grassland by 2.3%, moist savannah reduced by 7.4% and scrub woodland by 3.1% has reduced. Thereby alien species and vegetation were increased which distract migratory birds. Irregularity of water and delay in release of water expanded the invasion of African Mangur fish and Prosopis juliflora worsen the current ecology of KNP. Overall 84 breeding short distant and 72 winter migratory water birds were recorded during study period in Keoladeo National Park among 375 species recorded earlier. These all changes are reducing the glory of KNP. Some of the resident and migratory birds which are now uncommon and rarely available in KNP such as Common Pochard, Black Ibis, Red crested Pochard, mallard and cotton pygmy goose. Dalmatian Pelican, Greater flamingos and Lesser flamingo are some migratory bird now become vulnerable and rare to Keoladeo National Park now because less fishes are available due disturbed natural water supply.

It has also been observed that a number of resident and migratory birds are shifting to the nearby areas of KNP, where the natural fish rich water is available. These nearby areas are known as satellite areas.

CONCLUSION

The study concludes that the water supply from the Ajan Dam to KNP has been reduced due to various obstacles. The water from Ajan Dam is full of biological values which is the main demand of KNP for sustainable ecosystem. With the efforts of KNP administration, the water from Chambal pipe line has been fulfilling the water budgets but not seems to be compatible for the ecosystem of KNP. The physiochemical parameters such as pH, dissolved oxygen, hardness salinity etc. of Chambal's water is significantly different from the Ajan Dam water and not suitable for the required marshy area due to which the KNP is known. The current survey reveals that the number and variety of migratory birds is continuously decreasing which is very serious concern for this world heritage site. It is recommended that the Chambal project's water should be used for drinking and agriculture purposes as it has good parameters required for drinking water. Minimum environment flow should be maintained by administration to supply water from Panchana dam to Ajan Dam. Water from these natural sources is necessary to conserve the KNP wetland and eventually to retain the world heritage crown for the park.

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Conflict of Interests

Authors declare that there is no conflict of interests regarding the publication of this paper.

References

[1]. APHA, WEF, AWWA .(1998). Standard method for the examination of water and wastewater, 20th ed., APHA, Washington, DC, USA.

[2]. Day JW, Narras J, Clairain E, Johnston J, Justic D, Kemp GP, Ko JY, Land R, Mitsch WJ, Steyer G, Templet P, Yanez- Arancibia A (2005). Implications of global climatic change and energy cost and availability for the restoration of the Mississippi delta. Ecological Engineering 24(5):253–265.

[3]. Erwin KL (2009). Wetlands and global climate change: the role of wetland restoration in a changing world. Wetlands Ecological Management 17: 71-84.

[4]. Euliss N, LaBaugh J, Fredrickson L, Mushet D, Laubhan M, Swanson G, Winter T, Rosenberry D, Nelson R (2004). The wetland continuum: a conceptual framework for interpreting biological studies. Wetlands 24: 448–458

[5]. Gillis PL., Mitchell RJ, Schwalba AN, McNicholsa KN, Mackiea GL, Woodb CM, Ackermana JD (2008). Sensitivity of the glochidia (larvae) of freshwater mussels tocopper: Assessing the effect of water hardness and dissolved organic carbon on the sensitivity of endangered species. Aquatic Toxicology 88: 137-145.

[6]. Goldman, CR, Horne, Alexander J. Limnology (1983). McGraw-Hill ISBN 0-07-023651-8: 88 & 267.

[7]. Hussain S (1995). Management for migratory waterfowl. In: Gopal B. (compiler) Handbook of wetland Management, WWF-India New Delhi, India.

[8]. Kath JM. (2012). Integrating hydrology and land use to understand the ecology of floodplain wetlands in the Condamine Catchment, southern Queensland, Australia (Doctoral dissertation, University of Southern Queensland).

[9]. McLaughlin DL, Cohen MJ (2013). Ecosystem specific yield for estimating evapotranspiration and groundwater exchange from diel surface water variation. Hydrological Processes: doi: 10.1002/hyp.9672.

[10]. Parish F, Sirin A, Charman D, Joosten H, Minayeva T, Silvius M, Stringer L (2008). Assessment on peatlands, biodiversity and climate change: main report. Global Environment Centre, Kuala Lumpur and Wetlands International, Wageningen 179-185.

[11]. Paul S, Jusel K, Alewell C (2006). Reduction processes in forest wetlands: trackingdown heterogeneity of source/link functions with a combination of methods. Soil Biological Biochemistry 38 (16): 1028–1039.

[12]. Phyllis K, Weber S, Lawrence KD (2007). Effects of total dissolved solids on aquatic organisms: a review of literature and recommendation for salmonid species. American Journal of Environmental Sciences 3 (1): 1-6.

[13]. Pundir A, Mamgain A (2014) Keoladeo National Park, Bharatpur, Rajasthan, Inida. A world heritage site natural.

[14]. Robert ES (2014). Technical aspects of wetlandsWetlands as Bird Habitat.National Water Summary on Wetland resourcesunited States Geological Survey Water Supply Paper 2425.

[15]. Sharma R, Capoor (2010). Seasonal variations in physical, chemical and biological parameters of lake water of patna bird sanctuary in relation to fish productivity. World Applied Sciences Journal 8 (1): 129-132.

[16]. Sunder S, Khatri AK (2015). Physico-chemical properties of water of ottu reservoir in district sirsa, haryana, india. research journal of recent sciences, 4: 190-196.

[17]. Weiher E, Wisheu I, Keddy P, Moore D (1996). Establishment, persistence, and management implications of experimental wetland plant communities. Wetlands 16: 208-218.

[18]. William A W, Robert MD (1992). Interactions of pH, Carbon Dioxide, lkalinity and Hardness in Fish Ponds. SRAC publication No. 464. 1-4.

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