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An Ecological Study on the Beel Joshi (Rajshahi District), Northern Bangladesh

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Abstract: The present study has been made on the assessment of ecological aspects of a beel, Joshi covering an area of 630.0 ha in the Rajshahi district, northern part of Bangladesh. Surface run-off and increase in flow of rain water from the upper stretch during monsoon cause inundation and resumption of connection between beel and parent rivers. The range of Dissolve Oxygen (DO) content (5.26-6.08 mg L^{-1}) and pH (7.5-8.2) were found. Lower values of total hardness and total alkanity indicated fewer nutrients in the beel water. Free CO_2 was relatively high in this beel. Phytoplankton diversity in the beel represented by 4 groups Viz. Myxophyceae, Chlorophyceae, Bacellariophyceae, Euglenophyceae in order of abundance. A total of 75 fish species belonging to 45 genera 21 families and 1 species of prawn were identified so far from the beel. About 14 types fishing method were found in operation. Seine nets (*Moshari berjal.* shono berjal) and gill net (current jal) were identified as detrimental gear killing juveniles of different species during post spawning period. Kua fishing was also found harmful due to dewatering nature. A total number of 12 species of aquatic weeds were identified from the beel. The eggs of *Macrobrachium lameri* were also detected during the study period.

Key words: Beel, ecology, aquatic weeds, species, Rajshahi district, Bangladesh

INTRODUCTION

The inland freshwater fisheries resources of Bangladesh have been among the most productive fisheries in the world, with only China and India reporting more inland fish production than Bangladesh. The flood dependent fishery has been notable for the diversity of its fish and prawn species and the primary source of fish for all Bengalis (Rahman, 1989). Inland open water capture fishery as a whole is in decline over the decades due to multiple causes. This capture fishery is made up of three inter-related general areas (riverine, beel/baor and floodplains), declines in one area are an indicator of problems in all areas (DoF, 2002). To mitigate the prevailing situation there is a search of new inventions, policies and future program should be designed to prevent the further decline and possible collapse of the existing fishery.

Beel is a saucer-shaped depression, which may hold water permanently or dry up during the dry period. A total area of beels in Bangladesh was estimated to be 114.161 ha occupying 27% of the inland water area. The number of beels in the northeast region has been reported to be between 3.440 (covering 58.500 ha with a mean size of 7 ha) and 6.149 (covering 63.500 ha with a mean size of 10 ha) (Bernacsek *et al.*, 1992). About 58% of the beels in the Northeast region are permanent and reminder is seasonal.

The World fish center of Bangladesh has been implementing a project (CBFM-2) in 115 open water bodies of Bangladesh in collaboration with the Department of Fisheries (DoF) and a number of Non-Government Organizations (NGOs) to promote sustainable use of open water fisheries resources by community management. Among 115 beels, the beel Joshi (N24°50', 24°10' and E88°20', 88°50') located in Northeast region (Rajshahi district) was selected to carry out the present study. This beel is leasted out to Beel Management Committee (BMC a community based local forum headed by a Chairman) for consecutive 4 years. The beel is managed by BMC with the co-operation of World Fish Center (WFC), DoF and Proshika. In this study we investigated density population of plankton and also diversity of plankton and fish. The fishing methods used for fishing in the beel Joshi also monitored.

MATERIALS AND METHODS

The study was carried out in the beel Joshi during September 4 to June 5. The research was based on both primary and secondary data, comprehensive literature review and extracts of local knowledge and information. Data collection was limited with the visiting schedule. Collection of primary data was made by field observation and different experimentations viz. experimental fishing in the beel. Survey of different fishing methods, survey of fish market adjacent to beel, monitoring of hydrological, meteorological, physico-chemical and biological characteristics of beel and fishers perception as well. Secondary data were collected from the fishers, lease

holders, Beel Management Committee (BMC), local administration, Water Development Board (WDB), Department of Fisheries (DoF), Bangladesh Fisheries Research Institute (BFRI), Meteorological Department and related NGOs.

A bamboo (Nogi) made meter scale measured water depth. A secchidisc measured water transparency. Free CO_2 content was determined by phenolphthalein indicator method (Welch, 1948). Total hardness was determined by EDTA tritimetric method (APHA, 1995). HACH test kit (Model-FF-2, USA) was used to measure water pH, Dissolve Oxygen (DO), ammonia and nitrite only.

For planktonic study 15 L water was collected from the euphotic zone of the beel and passed through bolting silk plankton net of 50 μ (made in Germany). The filtrates were immediately preserved in Lugols solution. Qualitative and quantative analysis of both phyto and zooplankton were done following drop count methods (APHA, 1995). Microscopic identification was performed up to genera. Each sample was stirred smoothly just before microscopic analysis. Qualitative studies were done according to Presscott (1964) and Needham and Needham (1962).

Identification of fishes was done through collection of different species directly from fishers, catch experimental fishing, fishing through enclosure with bana (locally called pati), katha fishing, kua fishing and surveying local fish markets, catch effort survey was done through in situ observation of fishers nets. Resident fish species was recorded through experimental fishing in the deep pool areas in the beel and man made kuas where water remains during dry season (early January to mid April). Local knowledge as well as fishers perception has been considered also. Aquatic weeds were collected from the beel and identification was made into the laboratory.

RESULTS AND DISCUSSION

Morphometry and hydrodynamics: The main morphometric features that influence the productivity of beel ecosystem are shoreline, area, depth and slope. These in turn are closely linked with the hydrodynamics of wetlands. Generally there are three main sources of water input into the beel ecosystem viz. overspill from the river channel, surface flow and regeneration. River flows are determined by rainfall. The beel Joshi lies in Goalkandi union of Bagmara upazila, about 65 km Northeast of the district town. The Barnai river passes through the Southern side of the beel. This river is used to inundate as well as drain the beel. This beel is connected with the Barnai river. In dry season, almost all the areas of beel become dried up except the beel canals where water remains during mid January to mid April. Flooding originates from the Atrai river, the North of the beel. The average area of beel Joshi is about 630.0 ha. The bottom of the beel is uneven. Surface run-off and increase in river height due to inflow of rain water from the upper stretch, cause inundation of floodplains, often causing resumption of connection between beel and parent rivers. The more water gain or exchange of water in the beel takes place during Southeast monsoon when the floodplains are flooded. After recession of flood, water level in the river decreases snapping the beels connection with the river. The beel gets dried up through evapo-transpiration and seepage. Excepts deeper portion of the beel, the people use most of the area for crop practice by extracting water from the beel. The water loss by various means causes shrinkage of the effective water area and lowering of depth in the beel.

Water quality: The water quality profile of the beel Joshi is shown in Table 1. The color of beel water was found to be changed periodically. The nature of the beel bed was observed almost hard. The water level fluctuated between 0.3 and 2.29 m. The highest depth was recorded in September and the lowest in May. The mean water level obtained 1.24±0.75 m. The Secchidisc visibility fluctuated much; it range from 0.33-1.25 m. Surface water temperature ranged between 26.60-32°C. The mean water temperature was recorded 28.99±1.92°C. Water temperature showed an increasing trend in monsoon and post- monsoon season and decreasing in water is supported by Mathew (1975). Water temperature is influenced by the air temperature and it found highly synergistic with the air temperature. Rahman (1992) stated that the transparency of productive water bodies should be 40 cm or less and water temperature ranging from 26-31°C was found suitable for aquatic life. The range of water temperature of the studied beel indicating almost suitable for fish habitat and breeding as well.

Dissolve Oxygen (DO) concentration varied between 5.26 and 6.08 mg L^{-1}, the higher concentration was found in post monsoon period. The average oxygen concentration was recorded 5.83±0.21 mg L^{-1}. Banerjea (1967) reported that water bodies having a range of 5-7 mg L^{-1} DO is productive. while those having below this range are unproductive ones.

The values of free CO_2 were observed high at the advent of beel inundation, it showed wide fluctuation (0.9-18.9 mg L^{-1}) during the study period. The average value was recorded 11.5±6.28 mg L^{-1}. The high values (5-65 mg L^{-1}) of free CO_2 were also reported from the Surma-Kushiyara project area (FAP-16, 1992). Free CO_2 content >20 mg L^{-1} may be harmful to the fish and even

Table 1: Meteorological and physico-chemical parameters of beel Joshi

Parameters	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Mean±SD
Colour of water	Turbidity	Turbidity	Turbidity	Clear	Clear	Clear	Clear	Brownish	Brownish	Brownish-green	-
Depth of beel (m)	2.29	2.28	2.13	1.90	1.00	0.90	0.76	0.52	0.30	0.45	1.24±0.75
Water temperature (°C)	32.00	31.00	31.30	29.50	29.20	26.60	28.80	27.50	26.8o	26.70	28.99±1.92
Dissolveoxygen (mg L^{-1})	6.08	6.01	6.00	5.95	5.92	5.90	5.89	5.50	5.26	5.60	5.83±0.21
pH	8.20	8.16	8.15	8.10	8.00	8.10	7.85	7.50	7.90	7.80	7.98±0.21
Free CO_2 (mg L^{-1})	2.50	13.10	13.40	15.60	13.80	16.20	17.10	18.90	3.50	0.90	11.5±6.270
Total hardness (mg L^{-1})	21.00	26.90	29.20	32.60	29.00	18.00	15.30	12.80	10.70	9.00	20.45±8.09
Total alkalinity (mg L^{-1})	27.60	26.00	29.60	30.20	34.90	26.50	18.30	15.80	13.00	12.00	23.39±7.57
Ammonia (mg L^{-1})	0	0	0	0.30	0.20	0.05	0.15	0.01	0	0.18	0.15±0.09
Nitrate (mg L^{-1})	0	0	0	0	0	0	0.30	0	0	0.20	0.25±0.05
Nature of beel bed	hard	hard	hard-soft	hard-soft	hard-soft	hard	hard	hard	hard	hard	-

lower concentration may be equally harmful when dissolved oxygen contents are <3 mg L^{-1} (Lagler, 1972). Ruttner (1953) reported that very low values even 0 mg L^{-1} of free CO_2 the photosynthetic activities of phytoplankton occurs normally.

The values of pH were found alkaline range (7.5-8.2) suitable for aquatic life. Ruttner (1953) quoted that a eutrophic lake normally maintains alkaline pH. The highest and lowest values were found in September and April, respectively. The mean value of pH was 7.98±0.21. It exhibited a narrow range of fluctuation through out the investigation period. According to Swingle (1967), pH value of 6.5-9.0 is suitable for fish culture and >9.0 is unsuitable because free CO_2 is not available in this situation.

Total hardness varied between 9.0 and 32.6 mg L^{-1}. The highest and lowest values were observed in December and June, respectively. The mean value was 20.45±8.09 mg L^{-1}. Total alkanity varied between 12.0 and 34.9 mg L^{-1}. The highest and lowest values were recorded in January and June, respectively. The mean value was recorded 23.39±7.59 mg L^{-1}. The lower concentration of hardness and alkalinity indicated the beel water to be less nutrient enriched. Almost similar values of total hardness and total alkalinity were reported by FAP-16 (1992) from the Northern areas of Bangladesh. Banerjea (1967) reported that 60-70% of average to highly productive ponds have total alkalinity ranging from 20-200 mg L^{-1}. Lake water registering hardness as calcium carbonate below 24 mg L^{-1} is generally regarded as soft (Clegg, 1974). From the above study, it may be concluded that the beel waters were found as soft-medium hard type and moderately productive.

Ammonia varied between 0.01 and 0.3 mg L^{-1}, it was recorded zero in the month of September, November, October and May. The mean value was 0.15±0.09 mg L^{-1}. Nitrite concentration ranged from traces 0.3-0.2 mg L^{-1}. Low values of nitrite contents takes place due to rapid absorption of such nutrients by the infestation of macrophyte communities in the beel ecosystem.

Planktonic organisms: During the present investigation 12 genera of phytoplankton belonging to 4 groups and 13 genera of zooplankton belonging to 3 groups were recorded from beel Joshi (Table 2). The phytoplankton population was composed of algal flora belonging to the groups Cholorophyceae, Myxophyceae, Euglenophyceae and Bacellariophyceae. Among the planktonic algae Cholorophyceae contributed the bulk and the predominent genera were *Ulothrix* sp., *Spirogyra* sp., *Volvox* sp., *Closterium, Penium*. Myxophyceae included various species belonging to genera *Microcystis* sp., *Nostoc* sp., *Anabaena* sp., *Rivularia* sp. Bacellariophyceae was represented by various species belonging to genera *Navicula* sp., *Diatoma. Euglena* sp. is a single genera of Euglenophyceae group. Ehshan *et al.* (1996, 1997) and Hossain *et al.* (1998) reported the dominance of Cholorophyceae and Myxophyceae groups from different beel ecosystems of Bangladesh. Phytoplankton diversity in the beel of upper Assam zone represented by four groups in the order of cholorophyceae >Bacellariophyceae>Myxophyceae> Dinophyceae (Sugunan and Bhattacharjya, 2000).

Among zooplankton the represented genera were *Asplanchna* sp., *Brachionus* sp., *Keratella* sp., *Notholca* sp., *Trichocera*, *Daphnia* sp., *Moina* sp., *Diaphanosoma* sp., *Bosmina* sp., *Cyclops* sp., *Encyclops* sp., *Diaptomus* sp. and *Nauplius larvae* belonging to three groups Rotifera, Cladocera and Copepoda.

Rotifera was the most dominant group followed by Copepoda and Cladocera. Almost similar observations were also made by Ehshan *et al.* (1996) and Ahmed *et al.* (1997). Similar observation was also made by Sugunan and Bhattacharjya (2000) from the beels in Assam.

Ichthyo-diversity and fishing methods: Fish genetic resources in Northeastern regions are unique being a mixture of migratory, resident and exotic fish species. A total number of 75 fish species belonging to 45 genera 21 families and 1 species of prawn were detected and identified so far from the beel Joshi. Out of them 71

Table 2: Diversity of Plankton in the beel Joshi

Plankton	Groups	Genera
Phytoplankton	Cholorophyceae	*Ulothrix* sp., *Spirogyra* sp., *Volvox* sp., *Closterium, Penium*
	Myxophyceae	*Microsystis* sp., *Nostoc* sp., *Anabaena* sp., *Rivularia* sp.
	Bacillariophyceae	*Navicula* sp., *Diatoma*
	Euglenophyceae	*Euglena* sp.
Zooplankton	Rotifera	*Asplanchna* sp., *Notholca* sp., *Trichocera, Brachionus* sp., *Keratella* sp.
	Cladocera	*Daphnia, Miona, Bosmina* and *Diaphanosoma* sp.
	Copepoda	*Cyclops* sp., *Encyclops* sp., *Diaptomus* sp., Nauplius larvae

Table 3: Fish species observed in the beel Joshi

Groups	Family	Scientific names	Fishing methods
Carps	Cyprinidae	*Catla catla, Cirrhinus mrigala, C. reba, Labeo cal-basu, L. rohita, L. bata, L. gonius, L. boga*	Enclosure with pati*, FAD**, gill net, Seine net, bar jal
Minnows	Cyprinidae	*Amblypharyngodonmola, Rasbora dani-conius, R rasbora, E. danricus, Danio devario, Oxygaster gora, O. bacaila, Chela atpar*	FAD, drag net, scine net, cast net, traps
Barbs	Cyprinidae	*P. sarana, P. sophore, P. ticto, P stigma, P. gonionotus, P. terio*	Gill net, push net, cast net, FAD, traps
Chinese carp	Cyprinidae	*Cyprinus carpio* var. commu-nis, *C. carpio* var. specularis	FAD, seine net
Air-breathing catfish	Claridae	*Clarius batrachus, C. gariepi-nus*	FAD, gill net
Fresh water shark	Siluridae	*Wallago attu*	Long line, FAD, Seine net
Butter catfish	Siluridae	*Ompak pabda, O. bimaculatus*	Seine net, FAD
Stinging catfish	Heteropneusti-dae	*Heteropneustes fossilis*	FAD, gill net
Catfish	Schibeidae	*Clupesoma garua, Eutropiic-hthys vacha, Ailia coila, Pangasius pangasius, Ailiichthys punctata, Siloni-a silondia*	Seine net, push net, FAD
Catfish	Bagridae	*Mystus aor, M. cavasius, M. tengera, M. seenghala, M bleekery, Rita rita, Batasio batasio, B. tengara, C. chandramara*	Seine net, push net, FAD, traps
Feather back	Notopteridae	*Notopterus chitala, N notopterus*	Seine net
Sardines	Clupeidae	*Gudusia chapra, Corica sobo-rna, Goniolosa manminna*	Gill net, SM seine net***
Freshwater spinyeels	Mastacembe-lidae	*Macrognathus aculeatus, Mastacembelus armatus*	Gill net, FAD, seine net, dragnet, cast net
Spinyeel	Mastacembe-lidae	*Mastacembelus pancalus*	Gill net, FAD, seine net, dragnet, cast net
Climbing perch/gouramies	Anabantidae	*Anabas testudineus, Colisasota, C. fasciatus, C. lalius*	Gill net, push net, FAD
Gobies/mud skipper	Gobiidae	*Glossogobies giuris*	Gill net, FAD, seine net, cast net
Mud perch	Nandidae	*Nandus nandus*	Gill net, FAD, seine net, push net
Perch	Pristolepidae	*Badis badis*	Seine net, push net
Glass perch	Centopomidae	*Chanda nama, C. ranga, Cbaculis*	SM seine net, push net, FAD
Loaches	Cobitidae	*Botia dario, Lepidocephalusguntea, L irrorata*	Seine net
Snake-heads	Channidae	*Channa striatus, C. morulius, C. punctatus, C. orientalis*	Cast net, FAD, hand and longline
Needle fish	Belonidae	*Xanentodon cancila*	Seine net, FAD
Puffer fish	Tetradontidae	*Tetraodon cutcutia, Chelo-nodon patoca*	Seine net, FAD
Mud eel	Synbranchidae	*Monopterus cuchia*	Gill net, seine net, drag net, cast net
Butter catfish	Engraulidae	*Setipinna phasa*	Gill net, seine net
Small prawn	Palaemonidae	*Macrobrachium lamarrei*	SM seine net, push net, FAD

*Fence made by bamboo splits and rope; **Fish Aggregating Device (FAD)-Fishing using Brush park and from Kua (dewatering); ***SM: Small Meshed

resident fish species belonging to 21 families and 1 species of prawn were identified. Of the 75 fish species recorded, 24 species were belonging to the family cyprinidae, 6 species were Scheilbeidae and 9 species were belonging to the family Bagridae followed by Anabantidae and Channidae of which each family belongs to 4 species. The identified fish species were categorized into 26 groups. A list of those fishes with their harvesting methods is shown in Table 3. This beel is inhabited by the carps, barbs, catfishes, snaksheads, eels, minows, loaches, featherbacks, gouramies, perches, gobies, puffer fishes needle fishes, sardines and small prawns. The common and more abundant fish species in the beel are barbs (*Puntius ticto*, *P. sophore*), glass perch (*Chanda nama*, *C. ranga*), gouramies (*Colisa sota*, *C. lalius*), loaches (*Lepidocephalus guntea*), fresh water spiny eels (*Mastacembelus pancalus*), gobies/mud skipper (*Glossogobius giuris*), catfish (*Mystus tengera*), needlefish (*Xenentodon cancila*), puffer fish (*Tetraodon cutcutia*), small prawn (*Macrobrachium lamerrei*). Haroon *et al.* (2002) identified a total of 92 species of fish and prawn from Sylhet-Mymensingh basin. He found the dominance of barbs, catfishes and major carps in the Sylhet sub-basin and catfishes, major carps and prawns in the Mymensingh sub basin. In India Sugunan and Bhattacharjya (2000) recorded 54 fish species belonging to 18 families from Dighali beel (Kamrup district), the common species contributing to commercial landings belongs to seven groups (carps, catfishes, murrels, featherbacks, air breathing fishes, prawns and miscellaneous fishes).

Local fisher, BMC members, Kua owners, Retailers of local fish markets, NGO workers, Fisheries officials and peoples residing along the immediate vicinity of the beel informed that species diversity and fish population of the beel ecosystem have declined, many species have been lost over time due to loss of fish habit, over fishing, siltration, use of fertilizer and insecticide in the rice field and use of destructive fishing gears during the post-spawning season.

In beel Joshi, 14 types of fishing methods were generally found in operation. Those included enclosure for fish trapping, Fish Aggregating Device (FAD) like Katha (brush park) and Kua fishing and other traditional fishing gears viz. Seine nets (purse seine net. moshari berjal, ghono berjal), gill nets (Chipala jal, puti jal, koi jal, shol jal, current jal), cast net (jhaki jal, khapla jal), push net (felun jal), drag net (moi jal), Traps (kholson, vair, charo) and long line (chara borshi). Fishing gears of different meshes (2.5-40 mm) were found to operate into the beel ecosystem. Catch per Unit Effort (CPUE) of different gears varied between 1.5 and 14.0 kg day^{-1}. Sugunan and Bhattacharjya (2000) found a wide variety of fishing methods (passive gear, active gear, FAD, falling gear, dewatering) employed in the beel of Assam, which are very similar to the present findings. Haroon *et al.* (2002) reported 18 types of fishing gears from the Sylhet sub-basin and 13 types from Mymensingh sub-basin. They also recorded many kinds and sizes of bamboo made traps.

Inundation of the nutrient-rich and food rich beel provides fishery habitat in the form of spawning grounds, nursery areas and a major feeding opportunities for a wide range of fin-fish and a prawn species. A few types of fishing gears viz. seine nets (moshari berjal, ghono berjal) and gill net (current jal) were so far identified for indiscreminate killing of juvenile fishes of different species in the beel during post spawning period.

Macrophytes: A total number of 12 species belonging to 12 genera of aquatic weeds were identified from beel Joshi (Table 4).

The identified macrophytes are 6 types viz. Branched, floating, emergent spreading, submerged and rooted plants with floating leaves. The weeds usually grow along the beel margins and absent in the deeper regions. The weeds are use as human consumption, buffalo food and main food items of cattle. Among the identified weeds *Najas najas* species was vegetation during April to September. Water hyacinth (*Eichhornia crassipes*) is usually used for covering a layer on the surface of brush park (FAD) installation, which provides shelter and

Table 4: Aquatic weeds in beel Joshi

Common name	Scientific name	Type
Chara	*Chara* sp.	Branched algae
Duckweed	*Azolla pinnata*	Floating
Topa pana	*Pistia stratiotics*	Floating
Khudipana	*Lemna minro*	Floating
Kachuripana	*Eichhornia crassipes*	Floating
Water lily	*Nymphaea* sp.	Rooted floating
Arrow head	*Sagittaria* sp.	Emergent
Arial	*Leersia* sp.	Emergent
Malancha	*Enhydra* sp.	Spreading
Kolmilata	*Ipomoea* sp.	Spreading
Jhajhi	*Najas* sp.	Submerged plants
Hydrilla	*Hydrilla* sp.	Submerged plants

additional nutrients for fish species. FAP-16 (1992) reported less abundant macrophytes from Surma-Kushiyara floodplain project. Sugunan and Bhattacharjya (2000) found a rich growth of marginal and submerged vegetation in the floodplain wetlands of Brahmaputra basin. Rahman *et al.* (1997) could not find any floating aquatic vegetation from the spawning locations of Halda, Jumuna and the Brahmaputra river and there were no significant relationship existed between the aquatic vegatation and spawning of major carps. A unique feature of the floodplain wetslands is the rich growth of marginal and submarged macrophytes due to allochthonous and autochthonous nutrient loading, which often tend to replace the plankton community and hastens the pace of eutrophication. This is almost happened for closed beels, which are choked with floating and marginal vegetation. Open beels however, generally harboured less macrophytes which are favorably disposed for energy transformation through phytoplankton.

The abundance and succession of biotic communities occupying in the beels are influenced mainly by the unique water renewal pattern of the ecosystem. The high fluctuation in water level and the alternating seasonal riverine connections are the inherent characters of the beel ecosystem. Fluctuation of water leval in the beel ecosystem is an important parameter for fish spawning. The shallower areas of the beels were found suitable for the spawning of some resident species (viz. *Glossogobies giuries, Chanda* sp., *Heteropneustes fossilis*, *Channa* sp., *Xenentodon cancila*, *Anabas testudineus*, *Puntius* sp., *Mystus* sp., *Mastacembelus* sp.; *Macrobrachium lamerrei* etc.). Ali (1997) reported that most of the smaller sized fishes breed into the shallower water areas, mainly in beel/floodplain.

In floodplain wetlands, water quality is influenced to a great extent by inflow of water from the connecting rivers, local catchments areas and by the metabolic processes of plants and animals living with in the water body and the aquatic vegetation in particular. The turbidity in the beel water was mainly due to silt and organic debris carried by the run-off waters. The

weed-choked beels have the lowest turbidity. The basin and aquatic soil can influence the value of pH. The variations in the concentrations of DO and free CO_2 were mainly due to the rate of photosynthetic activity by aquatic vegetation and variation in the organic matter contents in the basin soil. The DO levels of beel water were fairly high and with in the optimal range for the growth of fishes. An evaluation of hydrology and physico-chemical properties of water indicates that in spite of low values of hardness and alkalinity beel Joshi is found to be conductive to enhanced fisheries, capture fisheries and biological production as well.

The Kua owners excavate ditches along the canals of the beel that connect the beel to the main river stream and have a tendancy to encroach khas lands. As such, most of the connecting canals of the beel become blocked off by the raised dyke of Kuas and siltration as well. So, it is an essential task to excavate the connecting canals from the mouth of the river to the tail end of the beel for easy access of incoming water. For the sake of sustainability of species diversity every one should avoid complete harvasting of fish (mother as well their progeny) from the kua by dewatering. Initiative should be taken to well circulate the harmful effect of dewatering through mass media.

The dry season represents the most critical season for all species of fish and the greatest impact occurs at this period, mortality rate is high. populations are at their lowest levels, fishery habitat is limited, predation is at peak and growth is slowed. In this period, a certain amount of fish can be conserved in the deeper pools of beel ecosystem with the installation of brush park for next years successful breeding and recruitment to the population. In addition, to protect growth overfishing (indiscriminate killing of juveniles of different fishes) during post-spawning season fishing regulation should be imposed properly on such destructive fishing gears, conducting awareness program for the fishers can reduce indiscriminate killing of juveniles.

CONCLUSION

Over all in this study, we say the capture fish production is increasing day by day to protect the beel management.

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