TRAINING IN MANAGEMENT OF BEEL (OXBOW LAKE) FISHERIES

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CENTRAL INLAND CAPTURE FISHERIES RESEARCH INSTITUTE
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STRATEGIES FOR DEVELOPMENT IN BEEL FISHERIES

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India is enriched with diverse inland water bodies harbouring fast growing commercially and biologically important species. Those water bodies offer immense scope and potential for developing the capture fisheries. The inland fish production in the country has registered a phenomenal increase during the last four decades. As against 0.2 million t produced in 1951, the present production of inland fish in the country is estimated at 1.3 million t in 1987-88. The domestic demand of fish in the country is projected to be c 12 million tonnes by the turn of the century, a half of which has to come from the inland sector. It is a challenging task and to achieve this national goal, however a scientific understanding of the ecological management of all the suitable water bodies supporting capture fisheries is imperative to back up their optimum exploitation.

The ox-bow lakes, commonly known as Jheel, Beel, Tal, Maun, Pat etc. form one of the most lucrative sources of fisheries in the States of Eastern Uttar Pradesh, Northern Bihar, West Bengal, Assam, Valley districts of Manipur, Tripura, foot hills of Arunachal Pradesh and Meghalaya. The magnitude of the freshwater wetland and their distribution is estimated to be over 2 lakh hectare sprawling across the Ganga and Brahmaputra basins.

At present about 100 - 200 kg/ha/yr of fish is being realised from these water bodies though they are capable of producing 1 tonne fish per hectare.

Different categories of beels viz. closed beels, weed chocked beels, clear beels etc. exist in the country and need separate management practices for their development. In open beels, the natural populations, their recruitment and growth are monitored to obtain the desired production levels whereas in the closed ones stocking is the mainstay of management. Many of these beels have also became defunct and dead due to flood control measures like strengthening of the river embankments to protect low-lying areas. Most of the beels require provision of sluice gates, desilting and deepening of the connecting channels and clearance of the dense weed infestation. There lies a great scope to reclaim many of the dead beels into productive fish farms. Such converted fish farms are able to produce fish to the tune of 5-10 tonnes/ha/yr, if properly managed.

Strategies for development

Concerted research efforts by the Scientists of the Institute during the last one decade have resulted in the generation of suitable technologies for development of beel fishery. A new strategy called culture based capture fishery has emerged where the two system grade into each other. The art of optimum exploitation of the beel fisheries revolves round the concept of keeping the deeper zones as exclusive areas for capture fisheries. The marginal areas/pockets are renovated for the development of culture fisheries. For such excersises, the prime needs are desilting of the connecting channels and constructing the perimeter embankments. It is observed that most of the beels are dendritic and have pockets which retain water throughout or part of the year. By way of renovation and providing sluice gates these pockets can be gainfully utilized for carp culture. Intensive aquaculture practices can be recommended for such areas. A multidisciplinary farming approach is more advantageous to a farmer than the monocropping system to utilize the available resources in possession and for gainful employment of the weaker section of the society. In this direction, integration of fishery with agriculture, horticulture, duckery, piggery poultry etc. will prove more remunerative than mixed fish culture alone.

Weed management

The weed choked beels are mostly infested with submerged vegetation (Hydrilla, Vallisneria, Najas etc.) and free-floating weeds (mainly water hyacinth) to hasten the eutrophication. The submerged weeds can be controlled biologically by stocking herbivorous fishes like Puntius pulchellus, P. dobsonii, Ctenopharyngodon idella (exotic) etc. but the floating weeds still have a limited use and need eradication.

Technology demonstration in Takmu Pat (500 ha) in Manipur has resulted in complete removal of a dense mat of 1 meter high water hyacinth and grass. Application of 2,4-D sodium salt formulation (80% a.i.) has achieved 90% weed kill followed by Paraquat (Gramaxone) treatment to eradicate the grass. A commercial wetting agent (Dedanol) is mixed with the herbicidal spray solution to facilitate adhesion and spread of the solution on waxy and hairy leaf surface. The cost of clearance of water hyacinth from the Pat is worked out to be Rs.17.15/ha.

Stocking policy

By nature, the beels are extremely rich in nutrients and have immense production potential as reflected by their rich soil quality. Hence, a proper understanding of the complex relationships of soil quality, food chain, pattern of energy flow etc. will immensely help in formulating policies for stock manipulation. In this type of aquatic system, the energy flows through two main routes : grazing chain and detritus chain. Most of the macrophytes are not directly grazed by herbivores and the unutilized nutrients sink to the bottom contributing to the bottom detritus pool. This energy can be best utilized by strengthening the detritus chain through stocking of detritivores like *Cirrhina mrigala*, *C. reba*, *Labeo rohita*, *L. bata* etc. It has been demonstrated at the Kulia Beel, West Bengal that by increasing the detritivore population the fish production increased from 320 kg/ha/yr to 1077 kg/ha/yr in 1981-82.

Some of the beels are serving as the spawning gounds of the prized Indian Major Carps. The brood fish from riverine source enter the easily available shallow areas by taking advantage of annual flood channel. The spawn utilise ample nursery space and available food to grow and survive. This not only helps development of commercial fisheries of the beels, by the process of autostocking, but also saves heavy expenditure on transport

-tation of stocking material. Also some revenue can be earned from the sale of spawn collected from the beels.

Pen and cage culture

In recent years, the new techniques that have emerged for better utilization of the beels are pen and cage culture. In India, pen culture has been successfully tested for raising carp fry and fingerlings in reservoirs and to culture table fish in beels. Pen culture of common carp (*Cyprinus carpio*) in an indigenously designed bamboo screen, has yielded a production of 16 $kg/10m^2/5$ months with 80% survival. In Bihar, Indian major carp production to the tune of 4 t/ha/6 m has been obtained from a beel when stocked @ 5000 fingerlings/ha.

Rearing air-breathing fishes in cages offers avenues to culture these fishes in open water bodies. Productions varying from 0.19 kg/m^3 to 4.8 kg/m^3 in 90 days from Assam beels and 2.2 kg to 12.0 kg/m^3 from Bihar Mauns have been achieved.

Fishing

A rich assortment of traditional fishing gears both active and passive are used by the fishermen in beels. The big sized catfishes (*W. attu*) are generally caught by hook and line. The smaller fishes are bagged by dip nets and cast nets. The gill and drag nets are more efficient gears in low weed-infested beels during the winter season. Traps, chiefly made of split bamboo, are extensively used for catching fish in the beels. Effective fishing methods need standardization for better retrieval of fish and generation of employment.

Environmental monitoring

Environment is becoming more and more polluted due to disposal of industrial and urban wastes on land and water. The aquatic ecosystems have been the worst victims of environmental degradation, as the sullage generated on the land, intentionally or unintentionally, is ultimately disposed into the water courses. Apart from the increasing load of solids, through sewage, industrial effluents and land run off, the open water systems also receive toxic and hazardous substances such as pesticides, metals, polychlorinated biphenyls (PCB) and thousands of other chemicals inimical to aquatic life. Investigations on the effect of pollution show considerable damage to fish, larvae, juveniles and planktonic organisms. Considerable effective measures like treatment of effluent under ETP Norm (Effluent Treatment Plant) and necessary precautionary measures in agro-chemical application need be taken to check the hazards of pollution before it reaches the alarming level.

Developmental priority

The overall fisheries development of the beels require both micro-and macroplanning. The microplanning approach is project-oriented and involves important aspects like problem identification, financing, appraisal and implementation of the schemes etc. These in turn will pay greater attention to formulate the macroplanning process through sectoral approach. The major issues to be tackled under the development of sector approach are given below :

i) Formation of cooperative societies
ii) Available of finance
iii) Change in lease period policy
iv) Transfer of appropriate technology suiting local condition.
v) Transport and marketing
vi) Employment generation
vii) Insurance scheme
viii) Socio-economic development

BEEL FISHERIES RESOURCES IN NORTH-EAST INDIA

- Y. S. YADAVA

INTRODUCTION

Flood-plain lakes in the form of beels and pats constitute the most lucrative source of fisheries in the States of Assam, Tripura, valley districts of Manipur and foot-hills of Arunachal Pradesh and Meghalaya. By virtue of their unique position, location and carrying capacity, the lakes have emerged as major life sustaining entities. They form an integral component of the principal river systems (Brahmaputra, Barak, Iral, Imphal, Thoubal, Someshwari, Jinjiram) of the region and over the ages have acted as 'sink' for the flood waters, thus mitigating the devastating effects of floods. These versatile water bodies possess enormous fish production potentialities (> 1000 kg $ha^{-1}yr^{-1}$) and if managed scientifically would constitute the thrust areas from where the country would substantially meet it's demand of c. 12 million tons by the year 2000 A.D.

RESOURCE POTENTIALITIES

Located between the geographical ordinates of latitudes 22° to 29°30' N and Longitudes 89°46' to 97°30' E, the North-East region encompasses a vast area of 2,55,083 sq.km.Heavy rains, rugged topography and frequent earthquakes have made the rivers capricious and destructive during high floods, which at the same time leave behind rich and fertile flood-plains. The flood-plain lakes cover c. 1,19,875 ha in the region and their State wise distribution is depicted in Table 1.

Table 1 : Distribution of flood-plain lakes in N.E. India

States	Distribution (district-wise)	River basin	Local name	Area (ha)
Arunachal Pradesh	East Kameng, Lower Subansiri, East Siang, Dibang valley, Lohit, Changlang and Tirap	Kameng, Subansiri, Siang, Dibang, Lohit Dihing and Tirap	Beel	2,500
Assam	Brahmaputra & Barak valley districts	Brahmaputra & Barak	Beel	1,00,000
Manipur	Imphal, Thoubal and Bishnupur	Iral, Imphal & Thoubal	Pat	16,500
Meghalaya	West Khasi Hills, East & West Garo Hills	Someshwari & Jinjiram	Beel	375
Tripura	North, South and West Tripura districts	Gomti, Manu & Khowai	Beel	500

Assam : Assam, the largest of the seven N.E. States occupies a triangular area of 78,438 sq.km. (24°0'0" N Latitude and 89°45'0" - 96°0'0" E Longitude). It is divisible into two main regions, the Brahmaputra valley (56,449 sq.km.) and the Barak valley (6962 sq.km.). The flood-plain lakes are a conspicuous features of both the Brahmaputra and the Barak valley in Assam.

There are 1392 enlisted beels in Assam of which 423 are registered and the remaining 969 are unregistered and are under the control of both Government (505) and Public (464). Together these beels occupy an area of 1 lakh hectares and constitute c. 81% of the total fish prone lentic waters in the State (Table 2).

Beels in Assam are in the form of typical ox-bow types, lake like or true tectonic depressions. Lake like beels are wide, shallow and have an irregular contour. They are connected to rivers through channels and receive water supplies there from. Ox-bow beels are dead river or rivulet courses. Many of these, however, have connection with the main river through channels as in the case of lake-like beels. Ox-bow beels are relatively narrow, long and have either bent or serpentine shapes. The districts of North-Lakhimpur and Nagaon have the maximum number of ox-bow beels while lower Assam comprising the districts of Goalpara, Dhubri and Kokrajahar have batteries of the largest, commercial lake-like beels.

These beels, aptly called the 'back waters of Assam' are connected to the river Brahmaputra/Barak to help enrich their fish composition. The beels range in Area from 10 ha to more than 1000 ha and area wise they can be categorised as small (100 ha), medium (100 to 500 ha) and big (500 ha). Only 10% of the beels in Assam are in good condition, the rest being semi-derelict or derelict. Table 3 depicts the number and area of beels under different categories.

Table 3 : Beel fisheries under different categories in Assam

Categories	Number	Area	Good condition	Semi derelict	Derelict
Registered beel	887	60,000	10,000	15,000	35,000
Unregistered beel	505	40,000	Nil	10,000	30,000
	1392	1,00,000	10,000	25,000	65,000

Source : Directorate of Fisheries, Assam

Arunachal Pradesh : The State has c. 2,500 ha of flood-plain lakes situated mostly at the debouching point of the rivers and their tributaries. The beel fishery resources are spread over in East Kameng, Lower Subansiri, East Siang, Dibang valley, Lohit, Tirap and Changlang districts. Arunachal has 316.62 ha of registered beels with more than 92.0% of the area located in Lohit district. The rest are unregistered.

Meghalaya : The flood-plain lakes in Meghalaya encompass an area of c. 375 ha. Distributed in East Khasi Hills, East and West two Hills and Jaintia Hill districts, the beels lie in areas bordering Bangladesh. West Garo Hills district accounts for 95% (356 ha) of the area under beel fisheries. The district has 47 enlisted beels ranging in size from 0.67 to 82.3 ha with maximum number (21) of beels in Selsella block. The average size of the beels in the State is 7.6 ha.

Tripura : Distributed in the flood-plains of Gomti, Manu and Khowai rivers, the beels occupy c. 500 ha in Tripura. The beels are mostly ox-bow type and small in size.

Manipur : The Manipur valley is characterised by the presence of a large number of flood-plain lakes locally called pats. There are 113 registered pats (excluding Loktak lake) distributed in the 3 valley districts. The pats range in size from 6 to 3500 ha with an average area of 328.0 ha. Loktak lake occupies an area of c. 28,000 ha and can be treated as a separate entity itself.

LIMNOLOGY AND FISHERIES

Greater percentage contact of water with the sediments, deeper euphotic zone and longer sunshine hours culminating a warmer temperature regime exhibit intermediate to high productivity levels in the beels. They are quite rich in terms of organic detritus, nitrate and phosphate, but bicarbonate values are by and large low. The deposits of decaying weeds contribute to the richness of the soil which in turn supports a good bottom fauna comprising mainly molluscs. However the allochthonous materials in the form of alluvial silt, dissolved nutrients or decomposition products on inundated grounds contribute substantially to their productivity status (Yadava,,1987).

The beels favour extensive development of marginal and submerged vegetation. With optimum values of light quality and quantity, temperature and alkalinity, the submerged macrophytes play a major role in governing the biotic components and primary production in the beels. The weeds also adversely affect the nutrient budget, raise evatranspiration and foster eutrophication, converting the beels into swamps (Yadava, et al. 1987).

The beels generally possess high potential for *in situ* fish production. In contrast to average annual fish yield of *c*. 5 - 75 kg/ha/yr of the open water lakes and reservoirs recorded (Jhingran & Tripathi, 1969), the present average annual yield from beels is 160 kg/ha/yr. If small scale subsistence fishing is taken into account,yields higher than this can be expected. The importance of beels may also be judged from the fact that they directly act as the prospective spawning ground of the coveted Inaidn major carps. The rising flood waters carry young fish and brooders from the main river into the beels. These fishes breed and grow, utilising the high level of natural production in the beels.

PRESENT STATUS

The flood-plain lakes are highly productive from the fisheries point of view and able to produce c. 1000 kg/ha/annum if properly managed and exploited (Yadava, 1988). Unfortunately a combination of the processes of river bed evolution and the effects of extensive flood control and irrigation works in the river basins of the region have annihilated many of the original features and rendered them as ecologically fragile' ecosystem. Lest appropriate measures to rehabilitate the fishery are not taken up, the beels will dwindle beyond resurrection in due course of time.

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Table 2 : No. of registered and unregistered beels in Assam both at district level and sub-divisional level (Upto date 1985)

District	Sub-division	Registered	Unregistered G.S.	Unregistered S.G.P.	Total	Area (ha)
CACHAR	Hailakandi	11	Nil	18	29	8,000
	Silchar	34	21	179	234	
KARIMGANJ	Karimganj	26	21	12	59	
DARRANG	Mangaldai	17	13	1	31	13,000
SONITPUR	Tezpur	3	10	9	22	
DIBRUGARH	Dibrugarh Tinsukia	19	Nil	19	38	8,000
DHUBRI	Dhubri	37	75	Nil	112	19,920
GOALPARA	Goalpara	13	32	Nil	45	
KOKRAJHAR	Kokrajhar	4	22	Nil	26	
KAMRUP	Gauhati	23	9	14	46	10,000
BARPETA	Barpeta	48	25	2	75	
NALBARI	Nalbari	26	8	14	48	
KARBI-ANGLONG	Karbi-Anglong	Nil	Nil	Nil	Nil	Nil
LAKHIMPUR	Dhemaji	9	21	49	79	11,000
	N. Lakhimpur	13	36	25	74	
NORTH-CACHAR	Diphu	Nil	Nil	Nil	Nil	Nil
NAGAON	Morigaon	44	62	11	117	18,080
	Nagaon	38	120	14	172	
SIBSAGAR	Sibsagar	16	10	28	54	12,000
GOLAGHAT	Golaghat	20	1	47	68	
JORHAT	Jorhat	22	19	22	63	
TOTAL		423	505	464	1392	1,00,000

Abbr. G.S. = Govt.Sector; S.G.P. = Semi Govt./Public Sector

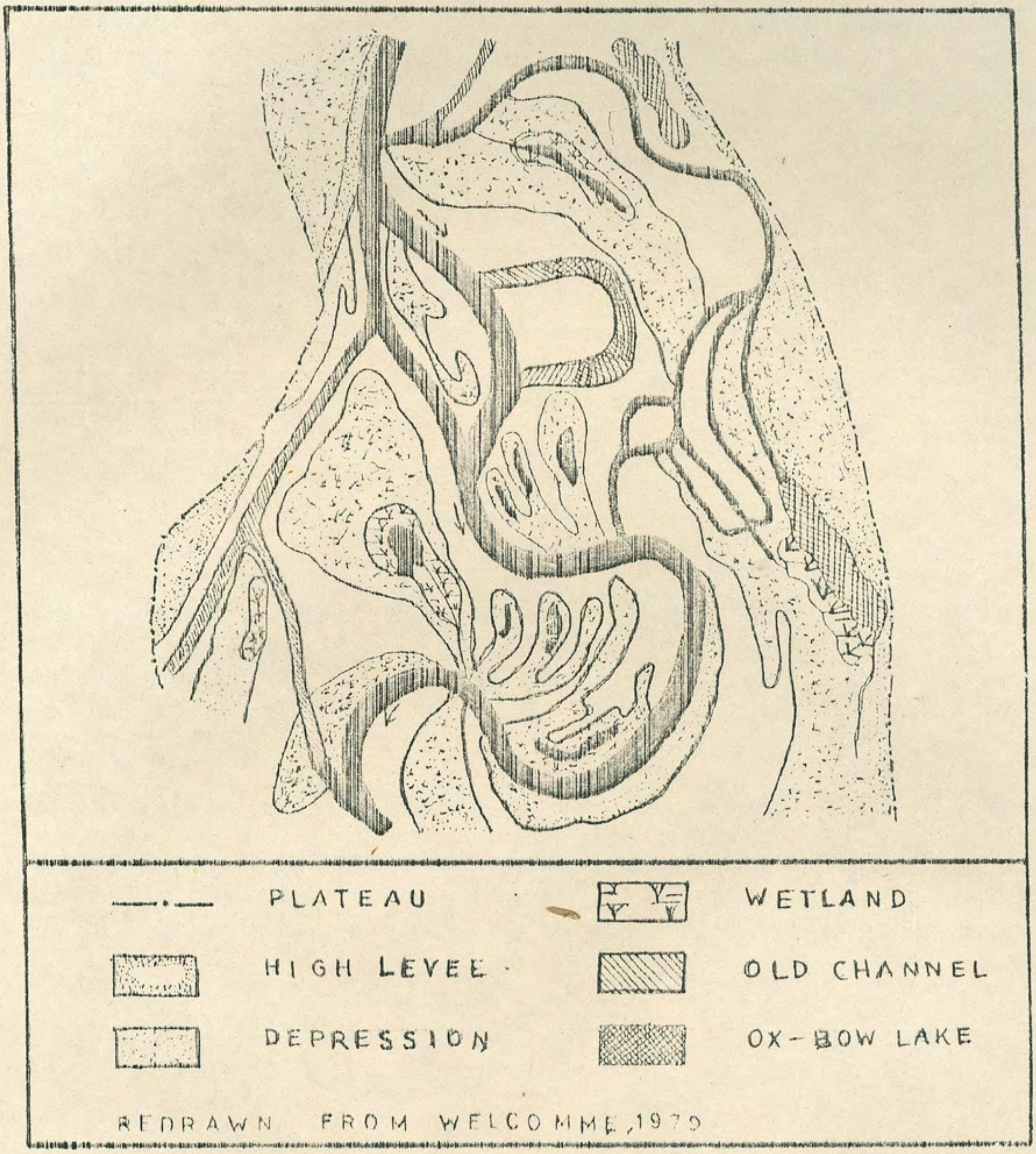

FIG. 1

Fig. 1 Geomorphological features of ox-bow lake ecosystem

BEEL FISHERIES RESOURCES IN BIHAR AND EASTERN UTAR PRADESH

——— B. C. Jha

INTRODUCTION

The state of Bihar and eastern part of U.P. (Longi. 83°20' to 88°17', Lati. 31°55' to 27°31') from one of themost fertile plains of the world, (the Indogangetic plain) and is bestowed with tremendous water resources in the form of rivers, lakes, chours, ponds etc. The lake in the area comprised both 'natural' and 'man made'. The natural lakes have found their origin due to the fluviatile activity of rivers, a characteristic of flood plain, as the rivers used to change their course very frequently resulting into the creation of many 'meanders' which have ultimately assumed the shape of lakes after getting cut-off from the rivers due to the pilation of silt. These natural lakes are known by different names in different places *viz*., 'Maun' (Bihar), 'Beel' (West Bengal and Assam), 'Tal' U.P.) but in general they are called ox-bow lakes (Jhingran and Jha, 1988).

The distribution of ox-bow lakes in Bihar is confined to North Bihar only as the South Bihar is a pl ateau having clavated land scape. The location of North Bihar is such that it actsas a receiving pot of water draining through a net work of rivers and rivulets, Gandak, Burhi Gandak, Koshi, Bagmati, Kamla balan, etc., originating from the Himalayas in Nepal and as a result flooded almost every year. The entire North Bihar can be divided into two river basins - 'Gandak basin' and 'Kosi basin' and these two basins alone accounted for about 12,000 ha of water spread area in the form of ox-bow lakes. The Gandak basin inparticular is more pronounced having as many as 38 well established lakes with an estimated area of about 7000 ha. The beels in this lake district are of varied shape - 'U' shaped to 'Serpentine', and of varied size, meagre 4 ha to more than 400 ha. Kosi lake district is comparatively smaller having a water spread area of about 5000 ha. Besides these, many more lakes are there whose process of assuming full lakes shape has been halted due to the raising of flood control measures, the embankments.

The ox-bow lake fisheries remained lucrative since their inception but unfortunately these resources suffer utter neglect in the past though their fish yielding potentialities are recognised. Most of the ox-bow lakes are becoming shallow and shallower due to the over population of macrophytes and subsequent pilation of cellulosic materials. These resources are also subjected to indiscriminate human interference and some of them, near the cities, have almost been converted into sewage pots. Carp fishery has gone down considerably and the niche has largely been occupied by uneconomical fishes. The economic value of such lakes erroded to the extent that fishing in these lakes has become subsidiary in nature. No systematic fishing practices are followed and unless concerated efforts are being made to revitalize their potential, the ox-bow lakes are moving towards slow but sure extinction.

PHYSICAL CLASSIFICATION OF OX-BOW LAKES IN BIHAR

The cluster of natural impoundments available in North Bihar can be classified as under.

i) Lakes with definite boundary and connected with the parent river by some kind of a channel.

ii) Lakes with definite boundary but without any connecting channel.

iii) Lakes fall in between the embankment and river and completely flooded during the monsoon.

iv) Half formed lakes fall in between the embankment and the river and become the part of the river during monsoon

An artificial classification of lakes thus can be made as:

i) The 'live' or 'open'

ii) The 'dead' or 'closed' lakes and

iii) the partially fluviatile lakes.

Characteristics of different lake types

Different lake types exhibit specific characteristics with regards to bioproduction in general and fisheries pattern in particular.

(A) Open lake types

i) Influx of flood water through the connecting channel help in keeping the massive proliferation of macrophytes in check by uprooting them.

ii) Influx of food water renew the allochthonous energy resource.

iii) Natural recruitment of prized fishes lakes place through the influx of water thus making the waters economically viable.

The open lakes are, however, certain disadvantages as they are silted at a faster pace and thus becoming shallower.

(B) Closed lakes

i) Absence of any connecting channel leads to vigorous growth of macrophytes indirectly as there is no uprooting phenomenon takeing place.

ii) No natural recruitment of prized fishes possible in these lakes and thus erosion in their economic value.

iii) Over growth of aquatic weeds make the fishing activities more difficult, resulting into poor yield despite efforts support good crop of primary producers, the phytoplankton in particular.

(C) Fluviatile lakes

The third category of lakes which fall in between the rivers and the embankment are strategically unsuitable for taking up any systematic fishery approches. However, these lakes are highly productive owing to high recruitment of fishes during the flood and are very lucarative capture fishery resource at least for six months in a year. These lakes are akin biologically to live lakes but more nearer to deep pools of any river. The existence of such lakes is quite vulnerable because of heavy siltation.

OX-BOW LAKE RESOURCE IN GANDAK BASIN

DISTRICT	NAME OF LAKES	AREA IN HA.
Muzaffarpur District		
1.	Brahamapur	45.50
2.	Manika	105.85
3.	Motipur	110.00
4.	Jhapaha	20.00
5.	Kanti	100.00
6.	Murra	35.00
7.	Rahuwa	30.00
8.	Bhoosra	45.00
9.	Bechaha	30.00
10.	Semera	16.00
11.	Matiha	20.00
12.	Rajwara	12.00

E. Champaran and W. Champaran

13.	Motijheel	100.00
14.	Kararia	100.00
15.	Basmanpur	40.00
16.	Sirsa	80.00
17.	Sajhi	40.00
18.	Rulhi	20.00
19.	Majharia	65.00
20.	Chilreon	40.00
21.	Turkaulia	80.00
22.	Sobnarsa	40.00
23.	Phulwari	80.00
24.	Sagaon	80.00
25.	Paswaw	20.00
26.	Chakin	20.00
27.	Pipra	40.00
28.	Matwali	105.00
29.	Barwalia Izamali	08.00
30.	Narmaida	20.00
31.	Sonwalia	40.00
32.	Karakatti	40.00
33.	Sirhachorwa	200.00
34.	Chaknaha	400.00
35.	Rajpur	80.00
36.	Bakya	160.00
37.	Piprao	164.00
38.	Rohna	20.00
39.	Samanjia	40.00
40.	Mati	40.00
41.	Pipra pakri	400.00
42.	Gobni	40.00
43.	Lal Sariya	230.00

44.	Jagarnathpur	40.00
45.	Amwa	26.00
46.	Bhawanipur	20.00
47.	Saraya	400.00
48.	Gahri	70.00
49.	Hardia	48.00
50.	Bhakubar	04.00
51.	Vaishali	40.00
52.	Piprasi	08.00
53.	Bishambharpur	45.50
Samastipur		
54	Muktapur	60.00
55	Dholi	08.00
Sitamarhi District		
56.	Bamanpura	15.00
57	Poaram	30.00
58.	Ilmasnagar	27.00

BIOTIC RESOURCES

1. Plankton

Net plankton is a scarce community in ox-bow lakes as compared to other primary producers viz. macrophytes, periphytons etc. However, 'nannoplankton', highly represented by 'bacterioplankton, is considerably high.

The lakes studied, so far, have revealed that the bulk of carbon fixed through the 'nannoplanktonic' chain and most likely certain 'baeterioplankton' which dominate the community structure at this trophic level might be photosynthetically active. The matter is of interest limnologically and needs further confirmation to unfold the exact position. Work in this direction is in progress in Central Inland Capture Fisheries Research Centre's laboratory at Patna.

The abundance pattern of plankton population in certain ox-bow lakes is presented below :

Lakes	Range of net plankton U/l	Range of nannoplankton	Dominant group
Brahampura	1000-3000 (178000)*	-	Diatoms, Dinophyceae
Manika	450-950	-	Diatoms
Kanti	230-1500	1800-35000	Diatoms, Bacterioplankton
Muktapur	505-950 (10,605)*	4890-23783	Blue greens, Dinophyceae, Bacterioplankton

(*Figs. in parenthesis represent number of plankton during the sporadic blooming of <u>Ceratium</u> and <u>Plecdirinia</u>).

2. <u>Periphyton</u>

In ox-bow lakes, periphytons are highly significant, as primary producers, next only to macrophytes. The lakes in North Bihar are generally shallow and practically choked with macrophytes and these hydrophytes act as the sheet anchor for the massive proliferation of periphytons, either in terms of substrata or as nutrient supplier to support the auxenic behaviour of many periphytons. The ox-bow lakes are little investigated in terms of periphytons.

3. Supplementary decomposers - The fungi

Limnologically fungi are very significant in an ecosystem as decomposers. Many aquatic fungi are the best decomposers of cellulosic materials and thus this group of organisms assume added importance in ox-bow lake ecosystems where accumulation of cellulosic materials is of high order owing to the massive growth of hydrophytes.

A survey conducted in Gandak lake district revealed the presence of 18 taxa belonging to 6 orders (Jhingran and Jha, 1988). The taxa thus identified were generally, saprophytic in characteristics. Some of the dominant organisms were as under :

Achlya prolifora, *Isoachlya unispora*, *Mucor mucedo*, *Syncephalastrum recemosum*, *Podospora* sp., *Laptospheria aquatica*, *Aspergillus phoenicis*, *Alternaria gomphrenae*, *Saprolegnia ferax* etc.

4. Macrophytes

The ox-bow lakes in North Bihar are highly infested with aquatic weeds. Most of the lakes are chocked with 'submerged' 'floating', 'emergent' and 'marginal hydrophytes. The extent of infestation found varying between 50-100%. Open lakes are comparatively less infested than the closed lakes

Aquatic weeds vis-a-vis lake characteristics

The role of weeds in fishery water is both direct and indirect (Jhingran 1971, Jhingran 1986; Jhingran and Jha 1987, 1988) and is described below :

i) That the lakes are over populated with forage and predatory fishes,

ii) That the prized fishes are alarmingly low in abundance with a decreasing trend,

iii) That the euplanktonic population is much lower than desired level,

iv) That a strong succession of weeds is in the offing, affecting the ecosystem adversely

Submerged ——— Emergent ——— Reeds ———
Grass land ——— Floating islands ——— Ready swamps

v) That the excessive growth of weeds disturbing the nutrient pathways, phosphate in particular, thus most of the lakes having phosphatic in traces.

vi) That the excessive proliferation of marginal algal weeds, the charales, precipitate calcium and inturn promote the growth of molluscans.

It is evident that most of the ox-bow lakes are reeling under tremendous pressure in the face of over growth of aquatic weeds and this is particularly so because of the absence of efficient macrophyte grazers. Macrophytes limit growth of planktonic algae either by shading or by locking the nutrients. Un-controlled growth of hydrophytes leads to constant accumulation of detritus at the bottom (Wetzel et al., 1972; Hobbic et al., 1972). The ultimate result of this is reflected in lower efficiency of zooplankton production and the fish yield.

Ox-bow lakes ecosystems in North Bihar are found almost in similar status when they are compared in respect of the most abundant community, the macrophytes. The comparision was made following Sorensen (1948) and this is essential to apply any management approach.

Similarity index (SI) and disimilarity index (DI) in ox-bow lakes

District	No. of hydrophytes sp.	No. of common species	SI	DI
Muzaffarpur	41			
E.Champaran	37	28	0.74	0.26
W.Champaran	35			
Samastipur	38			

Ox-bow lakes in North Bihar exhibited a total of 41 species and among them : Ceratophyllum, Hydrilla, Najas, Potamogeton, Myriophyllum, Nymphaea, Neelumbo, Ipomoea, Polygonum, Eichnorhia are most important. Taxa of Chara, Nitella and Tollypella of Charales are very common in these lakes.

Bottom biota

The benthic niche of ox-bow lakes is highly threatened due to the constant accumulation of cellulosoic materials. Greater proliferation of hydrophytes and canopy formation by algal filaments at the top prevents sufficient light to pass through and as a result almost a under water desert is created.

A survey of the lake districts revealed the greater dominance of molluscan shells in almost all the lakes, even upto 96% of the total population. High dominance of molluscans is indicative of unproductive character of these systems. The incidence of benthic population from different lakes varied between 220-6500 organism/m^2.

The qualitative spectrum revealed the presence of Trichoptera, Diptera, Hemiptera and Molluscans. The later was, however, most significant represented by 8 species - Melanoides lineaus, Vivipara bengalensis, V. variatus, Indoplanorbis sp., Pila globosa , Corbiculea striatella, columella, Gyraulus sp., Gobbia sp.

FISH AND FISHERIES

A recent survey of the ox-bow lakes in North Bihar found supporting wide diversity of fish fauna. A total number of 71 species of fish have been identified.

The medium sized fishes like Notopterus notopterus, Clarias batrachus, Channa gachua, Mastocembelus armatus, M. pancalus and bigger fishes like Wallago attu, Channa marulius and C. striatus dominate the fishery of these lakes, even upto 35%. Fishermen community, operating in these lakes are primarily depending on these varities for marketing. Indian major carps, Catla, Rohu, Mrigala and Calbasu too contribute to the fishery but their abundance is meagre 3-12% only. Miscellaneous fishes of smaller size like Nandus nandus, Oxygaster sp ., Puntius sp ., Mystus vittatus etc. are infact dominate the niche and are the main stay for ox-bow lake fishermen as their abundance is accounted upto 50%

or more in the daily catch and provide the basis for survival to the poor fishermen.

Shrimp fishery is also, very common in these lakes specially during summer months and at times found contributing even upto 30% of the total catch.

The pattern of fishery in certain ox-bow lakes of Gandak basin is presented as below.

LAKES	% abundance of different groups			
	Carp	Catfish	Miscelleneous	Shrimp
Manika	3.09-14.67	23.24-43.50	34.08-50.00	3.0-19.40
Brahampura	3.38-22.00	18.90-24.00	53.71-58.75	3.28-8.75
Kanti	8.00-12.35	53.81-62.16	18.48-22.99	7.11-10.35
Muktapur	8.00-10.00	10.00-12.50	50.13-60.60	3.00-4.60

GEARS AND NETS

The nets and gears employed in these lakes are of very primitive type and limited to 11 only. Nets made up of cotton and jute are more in practice though nylon nets are also introduced recently. Bamboo reeds and strips forming barriers (bari) across the width of the lakes are fairly common. Drag net fishing is not very common in these lakes because of high infestation of weeds. However, in recent years 'Chattijal' (2.0 cm mesh size) is used extensively and in the process juveniles of major carp are fished out completely, denying the lakes to build up any substantial fishery. Small meshed size gill net (Tier net) are the most sought after fishing gear in view of the dominance of smaller group of fishes. Cast net fishing is almost negligible.

Nets and gears operates in ox-bow lakes

Name	Mesh size	Fish commonly trapped
NET		
A. Drag Net (Chattijal)	2.0 cm	Small size carps, trash fishes and prawns
B. Gill net		
1. Tiar net (with foot rope)	6.0 cm	Wallago attu, Mystus seenghala, M. aor. etc.
2. Tiar net (without foot rope)	2.5 cm	Small fishes of all kinds
C. Cast net (Bhirkha jal)	1.0-3.0 cm	Small major carps, chela sp., Puntius sp., Mystus cavasius etc.
D. Scoop net		
1. Bisar jal	1-1.5 cm	Minor carps, trash fishes and smaller cat fishes.
2. Bisari jal	0.8-1.0cm	All kinds of small fishes including juveniles and prawns.
E. Bag net		
1. Kharail jal (multimeshed)		Fishes of different size and types
F. Misc. nets and gear		
1. Thapi net		Channa sp.
2. Arsi		Puntius sp. Trash fishes and other smaller fishes
3. Bari fishing		All sizes of cat-fishes, carps and other smaller fishes.
4. Birti		Channa sp., Macroganthus aculeatum etc.
5. Kanra		Big sized fishes specially cat fishes and Notopterus chitala.
6. Sahat		- do -

FISH FAUNA FROM OX-BOW LAKES OF GANDAK BASIN

Notopterus chitala, N. notopterus, Gudusia chapra, Gonialosa manmina Setipinna phasa, Chela laubuca, C. utrahi, Barilius bola, B. bendelisis, Danio rerio, D. dangila, Esomus danricus, Amblypharyngodon mola, Aspidoparia morar, Catla catla, Cirrhinus mrigala, C. reba, Labeo bata, L. gonius, L. calbasu, L. rohita, Osteobrama cotio, Puntius ticto, P. sophore, P. sarana, P. chola, Botia dayi, B. dario, Crossocheilus latius, Noemacheilus botia Oxygaster bacaila, O. gora, Lepidocephalichthys guntea, Mystus aor, M. seenghala, M. cavasius, M. vittatus, Rita rita, Ompok bimaculatus, Wallago attu, Ailia coila, Clupisoma garua, Eutropiichthys vacha, Silonia silondia, Bagarius bagarius, Erethistes hara, Nangara nangara, Heteropneustes fossilis, Xenentodon cancila, Chanda nama, C. ranga, Nandus nandus, Rhinomugil corsula, Glossogobius giuris, Anabas testudineus, Sciaena coitor,

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BEEL FISHERIES RESOURCES IN WEST BENGAL

—— K. K. Vass

INTRODUCTION

The country has extensive freshwater wetlands, called ox-bow lakes or beels, especially in the States of West Bengal, Assam, Eastern Uttar Pradesh and Bihar, formed due to change in river course, while some of these water bodies have retained their connection with the original river through narrow channels and others have lost it. They are estimated to cover an area of more than 2 lakh hectare approximately in the country.

Ox-bow lakes or beels are generally of two types - open or closed. Open beels are wide, shallow with irregular contours and are connected to rivers through channels. Closed beels are dead river or rivulets which become disconnected from the main-stream following a change in their course.

RESOURCES IN WEST BENGAL

In the state, the beels cover an estimated area of 46,000 ha contributing 22% to the total freshwater area, excluding rivers and tributaries. Some districts of West Bengal have been chosen here to have an estimate of this important fishery resource of the state.

District Nadia

This district is potentially important in beel fishery in the state. The district has total water area of 21,874 ha of which beels and boars (42 in number) cover an area of 15,892 ha.

District Murshidabad

This district possesses sixth place among the districts of West Bengal in fishery resources. The district consits of 43398 ha water area of which beels and boars (45 in number) cover 13160 ha.

District Hooghly

This districts of the state, though possessing a vast area of fishery waters, has lesser area under beels/boars. In comparison to other districts, only six beels covering an area of 174 ha, have been reported.

District 24-Parganas (North)

One of the important districts of the state having both freshwater and brackishwater fishery. Amongh the freshwater fisheries, beels and boars have good contribution. The total water area of 24 beels and boars in 1741 ha.

District Birbhum

There is only one beel in the district covering an area of 100 ha.

The district-wise distribution of beels/ox-bow lakes is tabulated below in table-1.

Table-1 : Distribution of Beels in West Bengal

Sl. No.	PARAMETERS	DISTRICTS				
		NADIA	MURSHIDABAD	HOOGHLY	24-PARGANAS(N)	BIRBHUM
1	Number of Beels	43	43	6	23	1
2	Effective Area (h) of each (range)	2 - 130	7 - 210	3 - 75	12 - 600	100
3	Max. Depth (m)	2.5-7.0	3 - 5	2.5-3.5	3.5- 8	2.5
4	Drainage/Non-drainage	Both kinds	ND mainly	ND mainly	ND mainly	Drainage
5	Connected river	Ganga, Ichamati, Bhagirathi and Jalangi	Ganga & Sone canals	Farraka, Ganga	Ichamati	Mayurakhi
6	Total water area (ha)	15982	13161	174	1742	100

Table- 2 : Hydrobiological features of Beels in West Bengal

Parameters	Range	Ranks
A. Physical		
Water temperature (°C)	20 - 34.5°C	In Kundipur beel a definite stable thermal structure has been noted.
Section transparency	0.25-5.5 m	
B. Soil quality		
pH (units)	5.8 - 6.6	
Organic carbon (%)	2.5 - 9.0	
Av. Nitrogen (mg/100g)	56.2-98.5	
C. Water quality		
pH (units)	7.2 - 8.2	
Total alkalinity (ppm)	78.5- 157	
Dissolved oxygen (ppm)	1.2 - 7.8	
Specific conductivity (micro mohs/25°C)	318 - 762	
Dissolved organic matter (ppm)	1.2 - 2.4	
Phosphate - PO_4 (ppm)	0.03-0.12	
Nitrate - NO_3 (ppm)	0.12-0.75	
D. Biological communities		
Phytoplankton density (u/l)	300-1892	
Zooplankton density (u/l)	189 -632	
Microphytes (gm^2 dry wt)	310 - 892	
Benthos (gm^2 dry wt)	1.82-4.23	
Detritus (gm^2 dry wt)	20.8-394	

Physico-chemical factors

The surface water temperature vary in live with atmospheric temperature fluctuations, ranging between 20 - 34.5°C. In some deeper beels a thermal amplitudes of 4°C between surface and bottom zone has been recorded. The water transparency range from 0.25 to 5.5 m, low transparency is also due to high plankton at low macrophytes population in some lakes.

Beel waters are well oxygenated, some subsurface anoxic conditions have also been noted. Due to heavy infestation of submerged weeds in some beels there is a drastic diel variations in oxygen values of surface waters. The nutrient status generally range from moderate to high, the beels having less macrophytes have higher levels of phosphates and nitrates.

Biological factors

Aquatic weeds forms an important component of beel ecosystem. The communities are generally dominated by the submerged forms viz. Ceratophyllum demursum and Hydrilla verticellata apart from other life forms formed these systems. Due to dominance of macrophytes the macrobenthic fauna is mostly represented by mollusca. The major phytoplankton encountered in the beels are Chlorella, Eudorina, Melosira, Synedra, Navicula, Pediastrum and Ceratium. There is a complex relationship between pelogic and littoral communities vis-a-vis availability and release of nutrients in the system.

FISH AND FISHERIES

Fish fauna and composition

In boels, the fishery is mainly dominated by miscellaneous species followed by major carp, catfishes and live fishes. The contribution of detritus feeders is ·enerally poor. Most of the beels in West Bengal are culturable, the rights are vested with government but are leased out to co-operative societies for fishery exploitation. These Cooperatives in order to get renumerative prices have stocked the beels with major carps, this has increased their contribution significantly. Main species encountered in the beels are Catla catla, Cirrhinas mrigala, Cyprinus carpio, Hypopthalymictths molitrix, Ctenopharyngodon idella and Labeo calbasu among Indian and exotic carps. Catfishes are represented by Wallago attu and Mystus aor. Other groups present are murrels, feather backs and air-breathing fishes. The variations encountered in fish composition of beels in general, is given table 3 below :

Table- 3 : % composition of fishes in Beels (Average trend)

Fishery	Districts				
	Nadia	Hooghly	Murshidabad (% composition)	24-Parganas	Birbhum
Carps	30-35	30-65	33-55	30-40	20
Catfishes	5	Nil-2	5	3-5	9
Murrels	5	Nil-10	5	5-8	15
Feather back	-	-	2-3	2-5	3
Air-breathing	10-15	10-20	15-16	10-25	15
Miscellaneous	21-38	15-43	22-37	25-43	38

(ii) Craft and gear

Usually Dingi, Catamaran, and country boats are used by the fishermen to catch the fishes from these beels. The length range of these boats range from 4.8 - 18.3 m. Also a rich assortment of Traditional fishing gear is used by these fishermen. Active gear, like drag, gill, cast and scoop nets are used mainly during the season. Certain types of fish husbandry methods viz. Katal fishing, using branches of trees placed in different areas in the beel and subsequently enclosing the area with nets after a gap of 1-3 months and scooping the fish out of the enclosed area. However in weed infested areas the retrival of fishes poses many problems.

(iii) Exploitation and productivity

The beels in West Bengal are exploited by the recognised fishermen co-operative societies. The total number of fishing days in a year vary from 290 - 310 with inter leaning period of closed fishing. Nearly 250 - 375 fishermen are engaged in each beel. On an average in stocked beels the fish yield range between 107 - 12610 kg per month which estimated at an average catch range of 5.6 - 434 kg d^{-1}. By the planned stocking with suitable species mix of major carps, the production range has increased to 320 - 440 kg/ha/yr from an earlier average of 150 kg $h^{-1}y^{-1}$. However, the potential from these system would range from 1000 - 1500 kg/ha/y. Therefore, development of this capture fishery resource, can generate considerable additional employment.

PHYSIOGRAPHY AND HYDRO DYNAMICS OF BEELS IN INDIA

——— Y. S. Yadav

INTRODUCTION

Flood-plain lakes in the form of jheels, beels, mauns and pats form one of the most lucrative source of fisheries in the States of Eastern Uttar Pradesh, Northern Bihar, West Bengal, Assam, valley districts of Manipur, Tripura and foot hills of Arunachal Pradesh and Meghalaya. Together these lakes account for over 2.0 lakh hectares and contribute sizeably to the fish production. The present paper gives an account of the physiography and hydrodynamics of the beels in Eastern and North-Eastern India.

EVOLUTIONARY TREND OF THE FLOOD-PLAIN LAKES

The origin of the flood-plain lakes is as kaleidoscopic as the often changing tortuous course of the major rivers and their tributaries. The Brahmaputra and the Barak basins in the N.E. region lie in a zone of acute seismic activity. Frequent earthquakes due to crustal instability have induced local and sudden changes in the basement levels, resulting later in pertinent watershed changes of the fluvial environment (Jhingran *et al.*, 1976; Das, 1983). This adverse feature coupled with heavy rainfall and cutting action of the stream meanders have resulted in the formation of either typical ox-bow type, lake like or true tectonic depressions in the region (Figure-1).

Similar scenario prevails in Arunachal Pradesh and Meghalaya too. As the rivers and streams emerged from the hills into the flood-plains, the sediments were probably deposited in the form of alluvial fanspens (Glennie & Ziegler, 1964). The lateral erosion from the low gradient of the rivers brought in watershed changes, resulting in the form of flood-plain lakes. The pats of Manipur owe their origin to the cutting action of the stream meanders of the Iral, Imphal and Thoubal rivers in the mature valley of Imphal.

North Bihar in its entirety may be treated as a vast inland delta, as all the principal rivers emerging from the central Himalayas debouch in the plains and ultimately flow into the Ganga on the south. The Ghagra, the Gandak, the Kamla and the Kosi bring heavy silt and detritus load from east to west, both the Gandak and the Kosi rivers have changed their course ever so often, leaving behind varying stretches of water, the ox-bow lakes (Shetty & Malhotra, 1983).

PHYSIOGRAPHY

The beels are primarily of three types :

(i) Lake like beels : Lake like or lacustrine beels are wide, shallow and possess irregular contours. They are connected to rivers through channels and receive water from the parent river. During lean season the water area shrinks to the basin proper while in monsoon the entire neighbouring area get flooded making the beel a large sheet of water.

(ii) Ox-bow beels : Ox-bow beels are relatively narrow, long and have either bent or straight shapes and are formed from isolated loops of meandering mature rivers or streams. These crescent shaped basins are usually deeper than the lake like beels because they occupy old segments of rivers. They also have connections with the parent river through channel and during high floods submerge the neighbouring catchment area.

(iii) Tectonic beels : Some beels in the region owe their origin to tectonic activities. Faulting is a major result of tectonivity and is responsible for the formation of primary basins. The two great earthquakes of 1897 and 1950 in the region are memorable from the point of view of intensity and creation of many tectonic beels.

Physiographically the ox-bow lakes can be grouped into 2 main categories. Those retaining continuity with the river/tributary through connecting channel either throughout the year or atleast during rainy season are termed as live. Others which are completely cut off are known as dead and these mostly receive water from the catchment area. The Assam and Manipur beels are generally sprawling water sheets covering several hundred hectares. Most of them have functional link with their riverine source. The beels in other States are mostly ox-bow type and small in size.

HYDRO DYNAMICS

The dynamics of water balance as effected by incursion of river water, varying degrees of precipitation and nature of catchment are highly complex and present contrasting pictures of the beel area and depth within a year (Table 1). These water bodies expand and contract. Hydrologically the channel which brings and drains most of the inflow and outflow of beels having a riverine connection, principally acts as a 'spill way' to limit retention of excess water from storage.

Flooding originates from three sources (i) overspill from the river channel, (ii) local rainfall and (iii) catchment area. Due to the flatness of the terrain, increase in volume are achieved by lateral expansion rather than by increases in depth, and the water spreads slowly and diffusely outwards, hampered in its progress by the flood-plain vegetation. The lakes thus represent a combination of lotic and lentic habitat becoming at times a natural lake ecosystem. However, it never arrives at that relative state because it is always subject to manipulation of inflow and outflow.

The flood-plain ecosystem is composed of two complementary phases, the aquatic phase and the terrestrial phase, which alternate seasonally in dominance. During the terrestrial phase, the exposed unmodified plain may be occupied by agriculture or used for grazing, both of which benefit the fishery by enriching the aquatic environment during flood. The former in the long run may however lead to cultural eutrophication of the ecosystem.

Beels are characteristically shallow basins manifested by the aquatic macrophytes. Being shallow, the atmospheric temperature has a direct bearing on the water temperature and small reflexivity and penetration of incident radiation deep into the water are responsible for the physical microclimate of the flood-plain lakes.

CONCLUSION

The beels are a conspicuous part of the region's geography and have a long history of development with the reparian settlements. Beels are a complex natural phenomenon and to deal with them several geophysical, aquatic, biological and socio-economic variables like landscape, source of water, level of fluctuation and quality, aquatic flora and fauna, man's use of the beels, surrounding settlment pattern and land use etc. should be taken into account for their conservation and optimum exploitation.

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Table 1 : Location and physiographic details of some important beels of Assam.
(Abbr. NR - Not recorded)

Sl. No.	Beel	River basin	Location	Area (ha)	Depth (cm) Range	Depth (cm) Average	Transparency (cm) Range	Transparency (cm) Average
1	Dipak (Dey, 1981)	Brahmaputra	26°05' 26"-26° 09'26" N & 91°36'39" -91°41'25" E	146.3	13.5 - 461.0	224.0	3.0 - 295.0	149.0
2	Dora (Lahon, 1983)	Brahmaputra	26°04'19" -26°05'50" N & 91°26'05" -91°28' E	116.2	64.0 - 304.0	164.0	1.0 - 137.0	41.0
3	Salsala (Lahon, 1983)	Brahmaputra	26°03'48" -26°04'17" N & 91°26'27" -91°26'35" E	20.8	20.0 - 250.0	115.5	3.0 - 127.0	65.0
4	Sone (Kar, 1984)	Barak	24°36'40" -24°44'30" N & 92°24'50" -92°28'25" E	3458.0	20.0 - 569.0	147.0	NR	NR
5	Chandubi (Goswami,1985)	Brahmaputra	25°52'15" -25°53'45" N & 91°24'15" -91°27'15" E	311.0	167.0 - 265.0	205.0	NR	NR
6	Dighali (Yadava, *et.al.*, 1987)	Brahmaputra	26°28' N & 91°80' E	250.0	50.0 - 450.0	105.0	45.9 - 105.1	74.0
7	Dhir (Yadava, 1987)	Brahmaputra	26°25' N & 90°50' E	689.0	100.0 - 523.0	238.7	71.0 - 131.0	101.2
8	Siligurijan (Yadava *et.al.*, Ms.)	Brahmaputra	26°26' N & 91°81' E	14.4	80.0 - 471.0	220.9	25.0 - 122.1	54.3

LIMNOLOGICAL FEATURES IN BEELS - ABIOTIC FACTORS

——— V. Pathak

INTRODUCTION

The country has an extensive freshwater wetlands, locally known as beels or Mauns in Eastern U.P., North Bihar, Assam and West Bengal. These natural ecosystems are part of river complexes, located mainly in Ganga and Brahmputra basins (or their tributaries) and cover an estimated area of nearly 42,000 ha in West Bengal, 12,000 ha in Bihar and 48,000 ha in Assam. Strengthening of river embankments, as part of flood control measures, or change in river courses have resulted in many of these beels getting disconnected from the main stream. Thus, there are, two types of beels- open and closed. Open beels are wide and shallow, having an irregular contour, and are connected to river through channels, where as, closed beels are dead river or rivulet courses which became disconnected from the main streams following a change in their course.

Experience from a wide range of beels in different parts of the country, at different latitudes, has indicated that there are a number of factors common to them, for example, rich nutrient status of the soil, shallow nature, infestation of aquatic weeds etc. Workers like Jhingran and Pathak (1987), Pathak et al., (1985 and 1987), Yadava (1987) etc. have studied the productivity of some beels in Assam and West Bengal. But lack of understanding of ecological principles that cause aquatic plant infestation, the productivity characteristics and improper management practices have resulted in rather low yield of fish (100 to 200 kg $ha^{-1}yr^{-1}$) from most of the beels. The implications of ecology, the

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Experience from a wide range of beels in different parts of the country, at different latitudes, has indicated that there are a number of factors common to them, for example, rich nutrient status of the soil, shallow nature, infestation of aquatic weeds etc. Workers like Jhingran and Pathak (1987), Pathak *et al.*, (1985 and 1987), Yadava (1987) etc. have studied the productivity of some beels in Assam and West Bengal. But lack of understanding of ecological principles that cause aquatic plant infestation, the productivity characteristics and improper management practices have resulted in rather low yield of fish (100 to 200 kg $ha^{-1}yr^{-1}$) from most of the beels. The implications of ecology, the

(2) Dynamics of chemical constituents in beels and evaluation of productivity trends

From the point of view of biological production the water in an aquatic system consist of two fundamentally different regions, one below the other, in which opposing processes take place. These are the regions of photosynthetic production (trophogonic zone) over the region of breakdown (tropholytic zone). In the photosynthetic zone, carbondioxide is taken up from bicarbonate by the photosynthetic organisms resulting in decrease in bicarbonate and increase in carbonate and pH ($2HCO_3^- \rightleftharpoons CO_2 + CO_3^{2-} + H_2O$). Oxygen is liberated and increase in concentration. In the region of breakdown, oxygen is consumed, carbondioxide is liberated, carbonate is converted into bicarbonate ($CO_2 + CO^{2-}_3 + H_2O \rightleftharpoons 2HCO_3^-$) and pH decreases (hydrogen ion increases $CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$). The reactions taking place during night, when there is no photosynthesis, are same as that in the region of breakdown. If the rates of reactions in these two phases are high the water body will show sharp variation in the chemical parameters with the progress of the day (diel cycle) or in depth profile. In deep waters the two zones are seperated but in shallow waters the dynamics of chemical constituents reflect of reactions in both the zones. As the rate of the above chemical reactions are directly related to production (P) and consumption (C) processes the relative productivity of beels can be evaluated from the intensity of diel variations.

The diel variations in chemical parameters in three beels are presented in Table- 2. A sharp diel change with respect to dissolved oxygen, pH, carbondioxide, carbonate and bicarbonate was recorded in all the beels with considerable difference in their magnitude (Table-2). The intensity of variation was maximum in Kulia beel (W.B.) and minimum in Muktapur Maun. The most important among the chemical changes is the diel oxygen cycle which is directly linked with the production and respiratory consumption processes of both macrophytes and phytoplankton. Dissolved oxygen, which was quite low in the morning (06 hrs) in all the beels, registered a phenomenal increase to 13.6 mg l^{-1} in Dhir beel, 15.5 mgl^{-1} in Kulia beel and 11.3 mgl^{-1} in Muktapur Maun. The dark phase (respiratory consumption), after 18 hours, showed a sharp reduction in oxygen. These findings clearly show that both production and consumption processes are quite high in beels. Other related chemical parameters also registered similar phenomenal diel variations. As has already been mentioned the changes in chemical parameters are directly linked with the metabolic activity of producers the diel oxygen curve can be used to evaluate the productivity potential of the beels.

NUTRIENT CYCLE IN BEELS

The effective functioning of an aquatic ecosystem depends on the circulation of nutrients. The nutrients enter the cycle through autotrophic photosynthesis. A portion of the material is passed on to the next trophic level and the remainder reaches the bottom after the death of the producer organisms. This process is repeated at each trophic level upto the top, which has no predator and now all material reaches the bottom. Here the organic material is oxidized by decomposers into simple inorganic compounds, nutrients are released and become available to be used by producers again.

The above cycle of nutrients is common in all the aquatic systems. But in beels most of the available nutrients (both from soil as well as water) are used by macrophytes and are locked by them and thus removed from circulation for quite long time. The nutrients are released only after the death and decay of the macrophytes or enter the cycle to higher trophic level through detritus chain. The cycle, which is mainly through the detritus pool, is thus reversed if there is no direct consumption of macrophytes. However, if the macrophyte cycle is broken (due to their removal), in the absence of locking, the circulation of nutrient is very fast. Studies in Kulia beel (W.B.) have shown that removal of macrophytes was follwed by sudden enrichment of nutrients and bloom of phytoplankton. It is important to mention here that the circulation of nutrients is much faster by phytoplankton than macrophytes.

ORGANIC BOTTOM DEPOSITS AND DETRITUS ENERGY

Beels are generally infested with macrophytes. Most of these macrophytes are not grazed directly by herbivores and the unused material gets deposited at the bottom after their death. When decay occurs, dead macrophytes contribute to the organic detritus pool which is very important in aquatic food webs (Odum and Smalley, 1959). In other words the energy fixed by macrophytes is not much utilised in the system and gets deposited at the bottom as detritus energy which is generally very high in beels. Organic detritus (dry wt.) ranged from 47.5 to 285.0 g m^{-2} (av. 178.6 g m^{-2}) in Dhir beel, 265.0 to 432.5 g m^{-2} (av. 328.0 g m^{-2}) in Kulia beel and 232.0 to 417.2 g m^{-2} (av. 291.3 g m^{-2}) in Muktapur maun. The detritus energy was on an average 16.4 X 10^4 cal m^{-2} in Dhir, 35.83 X 10^4 cal m^{-2} in Kulia and 26.19 X 10^4 cal m^{-2} in Muktapur beels respectively.

ENERGY TRANSFORMATION THROUGH PRIMARY PRODUCTION

The productivity potential of any aquatic ecosystem depends on the efficiency with which the photosynthetic organisms transform incident light energy into chemical energy. In beels primary production is contributed by both phytoplankton and macrophytes, the contribution of phytoplankton being comparatively much lower than macrophyte. The rate of energy transformation by two groups of producers and the photosynthetic efficiency have been presented in Table - 3.

In Dhir beel (Assam), the average rate of energy transformation by producers was 53,719 cal $m^{-2}day^{-1}$ (2.98% of the available light) of which 43,408 cal $m^{-2}day^{-1}$(2.34% of light) was fixed by macrophytes and 10,311 cal $m^{-2}day^{-1}$ (0.55% of light) by phytoplankton. In Kulia beel (W.B.) out of 60,279 cal $m^{-2}day^{-1}$ (3.24% of light) of energy fixed by producers the phytoplankton contributed only 2,796 cal m^{-2} day^{-1} (0.14%) and the rest 57,483 cal $m^{-2}day^{-1}$ (3.10%) was fixed by macrophytes. Similarly in Muktapur Maun, the energy fixed by macrophytes was on an average 49,129 cal $m^{-2}day^{-1}$ (3.30% of light) and that by phytoplankton was 6,482 cal m^{-2} day^{-1} (0.44% of light). Thus in beels, the contribution of phytoplankton as energy converter was only 5 to 21% and the key role was played by macrophytes.

FLOW OF ENERGY IN BEEL ECOSYSTEM

There are two main routes through which the energy fixed by producers flows to higher trophic levels in any aquatic ecosystem grazing and detritus chain. The energy of producers can be utilised either directly by consumers through grazing chain or the unused energy which gets deposited at the bottom as organic detritus may be used through detritus chain. Many workers both in India (Ganpati, 1970, Sreenivasan, 1972; Natarajan and Pathak, 1983 and 1987 etc.) and abroad (Juday 1940, Lindeman 1942, Odum 1962, Odum 1957 etc.) have studied the flow of energy in different water bodies and have highlighted the importance of both the chains.

In beels, where macrophytes are the main producers and the energy fixed by them is not utilised directly by consumers, the best way to utilise the vast energy resource of detritus is through detritus chain. Studies have shown that the managed beels where the main path of energy flow is through detritus chain have resulted in better energy output as fish than the unmanaged beels where the energy is utilised through grazing chain by unwanted miscellaneous species.

The productivity potential of beels, estimated from ecoenergetic studies, have been found to be 1000 to 1500 kg fish $ha^{-1}yr^{-1}$ and thus, by adopting scientific management practices and judicious utilisation of energy the fish production in beels can be enhanced considerably.

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TABLE - 1 : Hydrological conditions of beels

Parameters	Kulia beel (W.B.)	Dhir beel (Assam)	Muktapur Maun (Bihar)
Soil quality			
pH	6.4-6.8	5.1-5.8	6.7
Organic carbon(%)	4.0-9.0	2.8-5.9	4.8
Available nitrogen ppm	858-985	605-782	634
Available -P (ppm)	60 - 185	40-170	10
Water quality			
Dissolved oxygen ($mg\ L^{-1}$)	6.6-7.78	4.27-11.2	3.4 - 10.0
pH	7.6-8.0	6.4-7.4	7.9 - 8.15
Alkalinity ($mg\ L^{-1}$)	106.7-170.0	15.0-40.0	90.0 -110.0
Sp.conductance (μ mhos)	467.8-762.8	34.9-73.1	190 - 230
Dissolved organic matter ($mg\ L^{-1}$)	1.0-2.4	2.8-4.8	1.8 - 3.2
Phosphate ($mg\ L^{-1}$)	0.03-0.06	0.02-0.1	0.04-0.1
Nitrate ($mg\ L^{-1}$)	0.12-0.25	0.05- 0.4	0.12 - 0.3

TABLE - 2 : Diel cycle of chemical parameters in Beels

Time of collection (hrs.)	D.O. ($mg l^{-1}$)	pH	Free CO_2 ($mg l^{-1}$)	CO_3 ($mg l^{-1}$)	HCO_3 ($mg l^{-1}$)
			KULIA BEEL (W.B.)		
06	2.0	7.5	0.66	0.0	170.0
10	5.7	7.7	0.00	2.7	164.5
14	15.5	8.4	0.00	14.0	140.9
18	11.0	8.2	0.00	13.8	149.2
22	8.6	8.1	0.00	7.4	153.5
02	6.5	7.7	0.00	4.4	164.0
Total fluctuation (06 to 14 hrs)	13.5	0.9	0.66	14.0	29.1
			DHIR BEEL (ASSAM)		
06	4.2	6.3	8.00	0.0	36.0
10	10.4	7.0	2.00	0.0	25.0
14	13.6	7.4	0.50	0.0	16.0
18	11.6	7.2	1.00	0.0	19.0
22	10.8	7.1	3.00	0.0	24.0
02	6.4	6.8	6.00	0.0	28.0
Total fluctuation (06 to 14 hrs)	9.4	1.1	7.50	0.0	20.0
			MUKTAPUR (BIHAR)		
06	2.5	7.8	4.00	0.0	110.0
10	8.5	8.1	0.00	6.0	103.0
14	11.8	8.5	0.00	20.0	100.0
18	9.8	8.5	0.00	14.0	100.0
22	7.6	8.2	0.00	5.0	104.0
02	5.8	8.0	1.00	0.0	108.0
Total fluctuation (06 to 14 hrs)	8.8	0.7	4.00	20.0	10.0

TABLE- 3 : Energy transformation by producers in different Beels

PRODUCERS	DHIR BEEL (ASSAM)		KULIA BEEL (W.B.)		MUKTAPUR MAUN (BIHAR)	
	Range of variation	Average	Range of variation	Average	Range of variation	Average
PHYTOPLANKTON						
Gross (Cal $m^{-2}day^{-1}$)	7131 - 15673	10311	1950 - 3496	2796	3096 - 8838	6482
Net (Cal $m^{-2}day^{-1}$)	4105 - 10083	6974	975 - 2337	1822	1878 - 6628	4799
Efficiency (%)	-	0.555	-	0.140	-	0.445
MACROPHYTES						
Gross (Cal $m^{-2}day^{-1}$)	15702 - 71116	43408	31614 - 91728	57483	40213 - 62602	49123
Net (Cal $m^{-2}day^{-1}$)	9388 - 46321	30383	30345 - 50579	39372	16931 - 29791	22009
Efficiency (%)	-	2.34	-	3.10	-	3.30
TOTAL						
Gross (Cal $m^{-2}day^{-1}$)	-	53719	-	60279	-	55605
Net (Cal $m^{-2}day^{-1}$)	-	37257	-	41554	-	26808
Efficiency (%)	-	2.89	-	3.24	-	3.74

LIMNOLOGICAL FEATURES OF BEEL - MACROVEGETATION DYNAMICS

——— Dr.(Mrs.)K.Mitra

Hundreds of wide and shallow naturally occurring water bodies are found mainly in flood plains of Eastern Uttar Pradesh, North Bihar, Assam and West Bengal. These are usually formed by changes in the tortuous course of river and its tributaries. Locally these flood lakes are known as 'Maun', 'Tal', 'Jheel' and 'Beel', and together these cover an approximate area of 4 lakh hecters in these four North-Eastern States of India.

Because of the rich soil and nutrient status, and also because of the shallow nature and resultant good penetration of light with sufficient intensity, these water bodies in general support a dense growth of macrophytes certain of these macrophytes flourish in the moist swampy grounds along the margin of water. Some are rooted to the bottom in deeper water with floating leaves and flowers on the surface, while there are others which are also rooted to the bottom but remain completely submerged. Then again there are plants which are not attached to soil, and either spread over the surface of water or remain suspended underneath. Base on their life forms these aquatic macrophytes or hydrophytes are usually classed as follows :

A. Hydrophytes include the following types of plants :

i) Emergent hydrophytes : e.g. Cyperus exaltatus, Eleocharis dulcis, Monochoria hastata, Ludwigia adscendens, Ipomea aquatica, Paspalum paspaloides, Alternanthera philoxeroides, etc.

ii) Floating hydrophytes: e.g., Nymphoides cristatum, Myriophyllum tetrandrum, Potamogeton nodosus, Aponogeton natans, Nymphaea nouchali, N. pubescens, Nelumbo nucifera, etc.

iii) Submerged hydrophytes : e.g., Vallisneria spiralis, Ceratophyllum demersum, Hydrilla verticellata, Najas sp., Potamogeton crispus, Nitella sp., etc.

B. Free floating : These include Eichhornia crassipes, Pistia stratiotes, Spirodela polyrhiza, Lemna perpusilla, Azolla pinnata etc. (surface floating) and Utricularia stellaris and U. aurea (floating underneath).

Zonation of aquatic macro-vegetation

The most familiar feature of natural aquatic vegetation is the zonation of life forms. In the typical sequence, totally submerged communities in deeper water give way nearer the margin a zone of floating-leaved plants which are succeeded by emergent communities occupying the marginal zone. In many habitates because of various edaphic factors, these may be overlapping in the peripheral regions of each zone.

Functions of macrophytes

Through photosynthesis, respiration manner and rate of growth, aquatic macrophytes significantly affect such limnological factors as concentration of dissolved oxygen, carbon-di-oxide, mineral nutrients supplies, pH value of both water and soil, light penetration and rate of silting, etc. These in effect wield a direct or indirect influence on the lives of other aquatic organisms, noteably the microflora and fauna for which the macrophytes mainly provide support, shelter and food.

Macro-vegetation dynamics

Zonation of life forms in aquatic vegetation in fact represents their natural succession where one plant community changes into another with the change in their edaphic and biotic environments. The steady accumulation of inorganic sediments and organic debris in these water bodies gradually raises the substrate nearer and nearer to the level of water table. As a result submerged macrophytic communities give way to floating-leaved; these are in turn replaced by swamp emergent which ultimately pass over to marsh and terrestrial formations thereby oblitevating the habitat.

Thus, these water bodies having immense prospect for growth of fishery gradually lose their potentiality if left unmanaged.

PRODUCTIVITY STATUS OF BEELS IN INDIA

——— K. K. Vass

The term "biological productivity" ordinarily will mean the various productions of phytoplankton, zooplankton, bottom flora and fauna, macrophytes, fish and so on. Latter, Macfayden (1950) defined it as the quantity of organic matter produced per unit time through the utilization of solar energy. Ohle (1956) putforth the concept of energy cycle, taking into account metabolic pathways and replaced the term "productivity" by the word "bioactivity".

To estimate the total bioactivity of a beel, lake, reservoir or pond, it is necessary first to determine the magnitude of primary production and second the efficiency of energy utilization at different trophic levels.

PRIMARY PRODUCTIVITY

i) West Bengal Beels

The carbon fixation at phytoplankton level in beels varied significantly in relation to population density. On an yearly basis, carbon fixation ranged from 3.3 to 4.9 tonne C ha^{-1}. The daily production values usually range between 510-1660 mgC m^2d^{-1}. Some productivity profile studies at pelagic site indicated a production range of 94-125 mgC $m^{-3}h^{-1}$ at 5 m depth zone. The carbon fixation in respect of macrophyte range between 3.26 - 18.7 gC $m^{-2}d^{-1}$. The contribution of phytoplankton towards total primary production range from 15 - 30% only.

ii) North Bihar Beels

Ox-bow lakes (Mans) in the Gandak basin of North Bihar have a great potential for development but due to ecological degredation, these water bodies are turning into swamps. Four ox-bow lakes have been studied by the institute. Most of the beels have been evaluated with regard to their primary productivity potential. The Brahamputra lake registered a production range of 1000-1700 mg C $m^{-3}d^{-1}$ on the other hand in Manika lake low production range of 200 - 1090 mgC $m^{13}d^{-1}$ has been recorded. Highest production range of 2530-4540 mgC $m^{-3}d^{-1}$ has been recorded in Kanti lake. By and large in beels macrophytes constitute an important component in the primary production.

SECONDARY PRODUCTIVITY

In beel ecosystems, fishery are of both short and long chain, therefore, fish production in these systems has been taken secondary production

A. The beels in the Brahmaputra basin generally possess high potential for, in situ fish production. Singnificantly in contrast to average annual fish yield of c 575 kg $h^{-1}yr^{-1}$ of the open water lakes and reservoirs, the average annual yield from Assam beels is 160 kg $h^{-1}yr^{-1}$ and if small subsistence fishing is taken into consideration, higher yield can be expected.

Adult and juveniles of Indian major carps particularly C. catla, L. rohita, and L. gonius depict such migration during monsoon. The occurrence of both juveniles (32 - 80 mm) and adult (upto 534 mm) Hilsa ilisha in some beels envisage considerable prospects of its fishery in the region. The hilsa catches from some Assam beels level a support to the idea about /lentic adaptability of the species. The studies conducted on Dhir beel in Assam reveal the production range of 157-175.5 kg/ha/yr. The Species-wise production distributed from the system is given in table 1.

Table- 1 : Species-wise catch (kg) in Dhir beel (Assam)

Species	1982		1984	
	Total	%	Total	%
L. rohita	20172	16.66	13212	12.19
L. gonius	314	0.26	41	0.04
L. calbasu	592	0.49	1074	0.99
L. bata	276	0.23	398	0.37
C. catla	4318	3.57	3044	2.81
C. mrigala	2103	1.74	911	0.84
C. reba	531	0.44	424	0.39
W. attu	11664	9.63	5538	5.11
M. seenghala	1078	0.89	1537	1.42
M. aor	301	0.25	238	0.22
H. ilisha	715	0.59	46	0.04
G. chapra	40526	33.46	41380	38.18
E. vacha	893	0.74	36	0.03
N. notopterus	1176	0.97	1053	0.97
N. chitala	3351	2.77	5150	4.75
Live fishes	7412	6.12	12670	11.69
Miscellaneous	25680	21.20	21630	19.96
Total	121102	175.5 kg/ha	108382	157 kg/ha

B. Most of the lakes of North Bihar are chocked with weeds to the tune of 50 - 100% and as a result the prized Indian major carps are either completely eliminated or it lost their population dwindled to an alarming proportion. Unwanted and undesirable fishes of all kinds with little economic value have largely occupied the niche, along with the major dominance of predators.

The ox-bow lakes of Gandak basin exhibits diversity of fish fauna. the medium sized fishes like Notopterus notopterus, Mystus cavasius, Clarias batrachus, Channa gachua, Mastacembalus pancalus and big fishes like Wallago attu, Channa marulius and Channa striatus dominate the fishery even upto 35%. Fishermen community of the area are primarily dependent on these varieties for marketing. However, prized carps like Catla catla, Labeo rohita, Cirrhinus mrigala and Labeo calbasu contribute about 4-12% of total fish landings.

i) Manika lake

From this lake a total fish yield ranged between 2.73 to 2.5 tonnes. The catches are usually dominated by freshwater shrimps (37.8%), followed by major carps (25%), /murrels (7%), feather backs (4%) and air-breathing cat fishes (1.2%). The production has been estimated at 27.33 kg/ha.
/miscellaneous fish (25%).

ii) Kanti lake

A fish yield range between 5.50 - 7.50 tonnes has been estimated from this lake. The composition of this commercial catch has miscellaneous fishes (30%, N. nandus (20.5%), W. attu (16%), murrels (7.2%), catla (6.3%), mrigal (6%), rohu (5.1%), feather backs (4.2%), shrimps (3.4%) and H. fossilis (.4%). The per units production has been estimated to range between 55-75 kg/ha/yr.

a) Fishing rights

The ox-bow lakes in Gandak basin are largely, the public properties barring a few private ownership. The fishing rights of these lakes is vested with several Govt. or semi-govt. agencies. The bulk of the waters are under the State Deptt of Revenue. The Deptt. of Fisheries has only limited lakes under its control. State electricity boards have also control over lakes. The disposal of these lakes are done annually to the local fishermen co-operative societies by the respective agencies.

b) Pen-culture

These experiments were conducted in a 0.1 ha enclosures in all ox-bow lake in Bihar. The enclosure was stocked with fingerling of catla, rohu and mrigal @8000 numbers per ha. The experiment showed a great promise with a record yield of 4 t/ha in six months; catla, rohu and mrigal attained an average weights of 1100, 800 and 750 g respectively from the initial weight of 177, 75 and 102 g respectively.

The ox-bow lakes are very potent biologically and thus are capable to generate better economic environment, provided certain management practies are employed.

The capture fishery from these lakes should be planned on the principal of culture fishery and thereby a stocking based crop should be given greater thrust. In the face of high incidence of macrophytes and predators proper startegy has to be evolved.

C. In West Bengal, the beels are usually under the control of registered fishermen co-operative societies. Before any management and stocking, the beel fishery constituted mainly of weed fishes - Puntius stigma, Cirrhinus reba, Nandus nandus, Mystus vittatus, Notopterus notopterus, Anabus testudinus and Hetropneustes fossilis.

After the societies were involved in beel programme, efforts were made to clear the systems from weed fishes and a regular stocking with the fingerlings of Indian major and exotic carps was taken up. This strategy initial, even though not on any previous scientific data, has paid dividends in increasing the per unit productivity. Beels are the systems where stock manipulation can be the only management tool. Some case studies are briefly explained here :-

i) Kulia beel

During the year 1981-82 the beel was stocked with major carps and common carp @ 102 kg/ha in the ratio of catla 40 : rohu 25 : mrigal 25 : common carp 10. The production achieved was estimated at 320 kg/ha. But during 1982-83 on the basis of scientific study, stocking diversity was increased to (158 kg/ha) and also to tap the macrophyte energy from the system, about 12500 fingerlings of grass carp were also stocked. The fish productivity increased significantly to 1077 kg/ha. In both studies the production of miscellaneous and other such fishes formed only 16-22% while rest was constituted by Indian and Exotic carp.

ii) Mogra and Garapota beels

Fishery of both beels is constituted by Indian major carps and miscellaneous groups constituted mainly by Gadusia sp. with maximum contribution from major carps. The food studies showed the maximum detritus (45.5%) in bottom feeding fishes.

Both the beels are exploited by the recognised fishermen co-operative societies. About 315 fishermen are engaged in Garapota beel and 387 in the Mogra beel. The gear mainly used were cast net, gill net, scoop net, hook & line.

The total carp landings in Garapota beel was estimated at 37281 kg with maximum of 12610 kg in November. On the other hand in Mogra beel a catch of 26755 kg. was recorded with a maximum of 533 kg.

In both the beels, stock manipulation as a tool for management, is employed to increase the productivity. In Garapota stocking is done @ catla 60%; Rohu 10%; Mrigal 10%; Cyprinus 13% and Grass carp 7%. By this planned stocking with different species mix of major carps the production increased to 320 kg/ha in this beel.

In comparison, stocking in Mogra beel was done @ catla 26%, Rohu 25%, Mrigal 29%, Cyprinus 3% and grass carp 18%. Due to higher detrital load C. mrigala / stocked /was at a higher density. This stock manipulation gave a production of 446 kg/ha from this beel.

Inspite of the stock manipulation the energy conversion efficiency for the primary carbon fixation to the fish production ranges between 0.19 - 0.235%. By proper scientific management, it is possible to increase this conversion efficiency in order to get higher fish production.

If properly developed the average fish production in beels/lakes can be raised to 1000 kg $h^{-1} yr^{-1}$. Therefore, development of this resource will generate suitable rural employment

ENERGY FLOW IN BEEL ECOSYSTEM

——— Babu Lal

Directly cr indirectly the source of all energy for life is the "Sun", which continually emits radiant energy into space. A tiny fraction of this radiation reaches the earth, where a considerable part is lost by reflection from the earth's atmosphere, clouds and surface. Probably a global average of about 40% of the incoming radiation is reflected. The remainder is absorbed by the atmosphere and the land and ocean surface, where its main effect is to cause the heating which generates the movement of atmosphere and watermasses.

However, despite the continuous absorption of solar radiation, the climate does not appear in the long range to become hotter. This indicates that there is overall an output of radiant energy from the earth equal to that received and the total heat content of atmosphere, surface of earth and water, remains virtually constant except for minor fluctuations due to the elliptical form of the earth's orbit round the sun and to changes in solar activity.

The incoming energy is received largely at wavelengths within the visible spectrum (3900 - 7500Å). The balancing emission from the earth is low-frequency heat radiation which passes out in all directions of space.

The route through which light energy can flow between penetrating the earth's atmosphere and re-radiation into space as heat are numerous and complex. A small amount, probably only about 1-2% of the light energy reaching to the earth's surface, enters pathways beginning with the absorption of sunlight by plants in photosynthesis. In this process radiant energy is transformed to chemical energy by an energy fixing reduction of carbon-di-oxide.

For instance, the synthesis of 1 g mol of glucose from carbon-di-oxide and water involves the intake of 709 Kcal of light energy.

$$6CO_2 + 6H_2O + 709 \text{ KCal} \xrightarrow[\text{Light energy}]{\text{Chlorophyll}} =$$

$$C_6H_{12}O_6 + 6O_2$$

This energy is then available in biological processes, for when 1 g mol of glucose is oxidised in respiration, 709 Kcal of energy is released. It is means of transfer and transformations of the energy of chemical compounds formed initially by photosynthesis that power is provided for the activity of living organisms. The movement of materials involved in nutrition occur almost entirely as means of effecting energy transfers. The global total of energy fixation by photosynthesis determines the total amount of biological activity which the earth can support. The intake of radiant energy into the living system by photosynthesis is balanced by a corresponding outflow of energy as heat through pathways of respiration and movement.

We have insufficient knowledge of the energy relationship of aquatic organisms to be able to trace with much certainty the passage of energy through beel ecosystem. Juday (1940), Teal (1957, 62), Odum (1957, 62 & 75), Pomeroy (1959), Ranwell and Downing (1959), Maun (1965), Odum and de la Cruz (1967), Macdonald (1969), Ganapati *et al.* (1972) and Natarajan *et al.* (1980) have studied the energy flow and dynamics of different aquatic ecosystems. However, no systematic information is available about the energy transformation in beel ecosystem. The present communication gives a general background of the flow of energy with particular reference to beel ecosystem.

BASIC PRINCIPLES OF ENERGY TRANSFORMATION

Energy is the capacity of doing work and all living organisms require energy for their growth and survival. Various forms of energy are interconvertible and the functioning of the ecosystems is directly related to the conversion, release and storage of one form of energy or the other. The first law of thermodynamics states that energy can neither be created nor destroyed but it can be transformed from one form (light energy) to another form (potential chemical energy). Second law states that no process involving an energy transformation will occur unless there is a degradation of energy from concentrated to dispersed form. First law recognises the interconvertibility of energy but does not predict how complete the conversion will be. As some amount of energy is always dispersed into unavailable heat energy, no spontaneous transformation e.g. light to chemical energy can be 100 percent efficient. Thus energy can neither be created nor be destroyed but it can be degraded, when used (transformed), to an unavailable form. The energy transformation within an ecosystem occurs in accordance with these two laws and there is always loss of energy in flowing from one trophic level to the other (lower to higher).

For the release and circulation of nutrients and functioning of the decomposers also energy is required.

This form of energy comes either from the release of energy during breakdown or decomposition of complex organic molecules (an exergonic process) or through chemosynthesis.

ENERGY FLOW WITHIN THE ECOSYSTEM

The flow of energy within the ecosystem takes place through different stages and it is essential to examine this process seperately.

Autotrophic Energy Fixation

Sun is the ultimate source of energy for all biological processes (average solar energy actually available to plants varies between 2.5×10^8 and 6.0×10^8 Cal $m^{-2} day^{-1}$). As much as 95 to 99% of solar energy is immediately lost from the plants and the remaining 1 to 5% is used in photosynthesis and transformed to chemical energy. Photosynthetic organisms store chemical energy in the form of energy rich organic molecules through the following reaction.

$$6CO_2 + 6H_2O + 709 \text{ KCal Solar energy} \longrightarrow C_6H_{12}O_6 + 6O_2$$

This redox process is . energonic requiring large amount of energy and consequently plants can store large amount of energy through this reaction. The transformation of energy from light to chemical by producers confirm the laws of thermodynamics, thus

Visible solar energy entering the system	=	Chemical energy fixed by producers	+	Energy lost to the environment
(λ_0)		(λ_1)		(H)

The efficiency with which photosynthetic organisms convert light energy to chemical energy is known as photosynthetic efficiency, thus photosynthetic efficiency =

$$\frac{\lambda_1}{\lambda_0} \times 100$$

A part of the energy fixed by producers is used by the plants themselves for their own metabolic activities and the remaining is stored by them as complex organic molecules.

Energy fixed by producers = Energy of growth of the plants + Heat energy of respiration

The energy fixed by photosynthetic organisms gives a measures of the potential chemical energy available to consumers.

Allochthonous Energy

If there is no other source of energy input then the energy represented by producers is the only available energy to the system. But in many ecosystems, especially in integrated farming pattern, considerable amount of energy enters from outside in the form of organic matter. Hence the available energy at the lowest trophic level includes both autochthonous as well as allochthonous sources

Energy of Decomposition

Decomposers get their nutritional energy from the breakdown of complex organic molecules, an energy releasing process e.g. $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 676$ KCal

During the process of decomposition nutrients are again released (alongwith energy) for reuse by the system. Some decomposers especially among soil bacteria, do not get energy from the oxidation of organic compounds but by the rearrangement of atoms e.g. oxidation of H_2, N_2, S, NH_3, NO_2 etc. (through chemosynthesis).

Pathways of Energy Flow

The energy available at the lowest trophic level can be channelled in two different ways and consequently two types of food chains have been described by ecologists. These two chains of energy flow are shown below:

Primary Energy (energy at lowest trophic level) → Herbivores → Predators → Grazing chain

Primary Energy (energy at lowest trophic level) → Detritus consumers (Detritivores) → Predators → Detritus chain

In case of grazing chain plants are consumed by herbivores which in turn are eaten away by predators and so on whereas in case of detritus chain plants are not consumed directly but are consumed as semi-decomposed/bottom feeder which are subsequently eaten away by predators.

A dynamic equilibrium exists between the producer energy and the energy assimilated by heterotrophs. The energy transformation in heterotrophs is represented by -

Energy of food uptake	=	Energy of growth	+	Energy of respiration	+	Energy of faeces	+	Energy of urine
(C)		(P)		(M)		(F)		(U)

/undecomposed plant remains (detritus) by detritus feeder/

Thus part of energy consumed by heterotrophs is used for their metabolic activities and lost as respiration, the other part is stored as energy of growth (P). The remaining energy is lost as faecal matters (F + U). The storage of energy in heterotrophs tissue is known as secondary production or secondary accummulation of energy.

ENERGY TRANSFORMATION THROUGH PRIMARY PRODUCTION

Energy flow studies in the beel ecosystem was initiated in the year 1980. During the year of initiation it was observed that Kulia beel was heavily choked with luxurious growth of aquatic macrophytes (Eichhornia, Hydrilla, Ceratophyllum, Najas, Azolla etc.) which resulted in very low (2500 Cal $m^{-2}day^{-1}$) fixation of solar energy by the primary producer (Table-1). As a scientific management measure, when the mat of macrophytes was removed in the subsequent year more water area was exposed to the incident solar radiation, fixation of energy by the primary producer was increased almost three to four folds. The rate of energy input through autotrophic primary production was only 2500 Cal $m^{-2}day^{-1}$, which subsequently increased to 38,050 to 1,94,460 Cal $m^{-2}day^{-1}$ in second and 61,160 to 80,000 Cal $m^{-2}day^{-1}$ in the fhird year of studies. This shows that photosynthetic efficiency of autotrophic organisms which was only 0.12% in the beginning of the studies was enhanced to almost ten fold immediately after the removal of aquatic macrophytes.

The energy input through primary production by macrophytes was noted to be 2.66 to 3.56% of light and the total biomass of macrophytes in the beel ranged from 20.08 to 37.47 X 10^5 Cal m^{-2} in the year 1981. The bottom organic deposits amounted to 335 to 432.5 g m^{-2} which is equivalent to 334 to 435 KCal m^{-2} or 40.44 X 10^5 K Cal ha^{-1} of detritus energy.

ENERGY BUDGET AT PRODUCER LEVEL FROM CHLOROPHYLL STUDIES

Chlorophyll studies made in the beel ecosystems reflected low concentration of phytoplankton ranging from 5.1 to 19.2 mg m^{-2} which is equivalent to 255.0 to 960.0 mg m^{-2} of phytoplankton carbon or 2,910 to 10,945 Cal m^{-2} of phytoplankton energy. After the removal of aquatic macrophytes in the subsequent year a thick bloom of planktonic organisms covered the vacuum created by removed vegetation, the chlorophyll concentration in the beel was observed to be very high ranging from 34.0 to 216.2 mg m^{-2} which is equal to 1,700 to 10,810 mg m^{-2} of phytoplankton carbon or 19,380 to 1,23,234 Cal m^{-2} of phytoplankton energy.

STUDIES ON DETRITUS AND BOTTOM ENERGY

Beel ecosystems are very rich in essential plant nutrients and depth of water is also very low, which results in the luxuriant growth of aquatic macrophytes. These are not readily grazed by most of the dwelling population, hence most of the macrophytes after completion of their life cycle and death get themselves deposited at the bottom as semi or undecomposed organic detritus. Organic detritus is very rich in nutrient with very high potential energy to be utilized by the bottom dwelling organisms. Studies made in the beel ecosystems reveal that organic detritus at the bottom was of very high order in most of the beels. The calculated value of detritus ranged from 262.5 to 368.2 g m^{-2} on dry weight basis which is equivalent to 257.25 to 361.84 KCal m^{-2}

of detritus energy. The high energy resource of organic detritus (25.72 to 36.2 X 10^5 KCal ha^{-1}) at the bottom can be utilized only through detritus chain.

ENERGY FLOW MODEL IN BEEL ECOSYSTEM

Energy flow diagramme is given in Fig.1. The energy flow model in beel ecosystem suggests that the gross ecological efficiency (ratio of energy input to energy output) was 0.293% and the flow of energy was mainly through detritus chain. Against 44.06 X 10^7 KCal $ha^{-1}yr^{-1}$ of energy fixed by producers, the energy output as fish was 12.92 X 10^5 K Cal $ha^{-1}yr^{-1}$.

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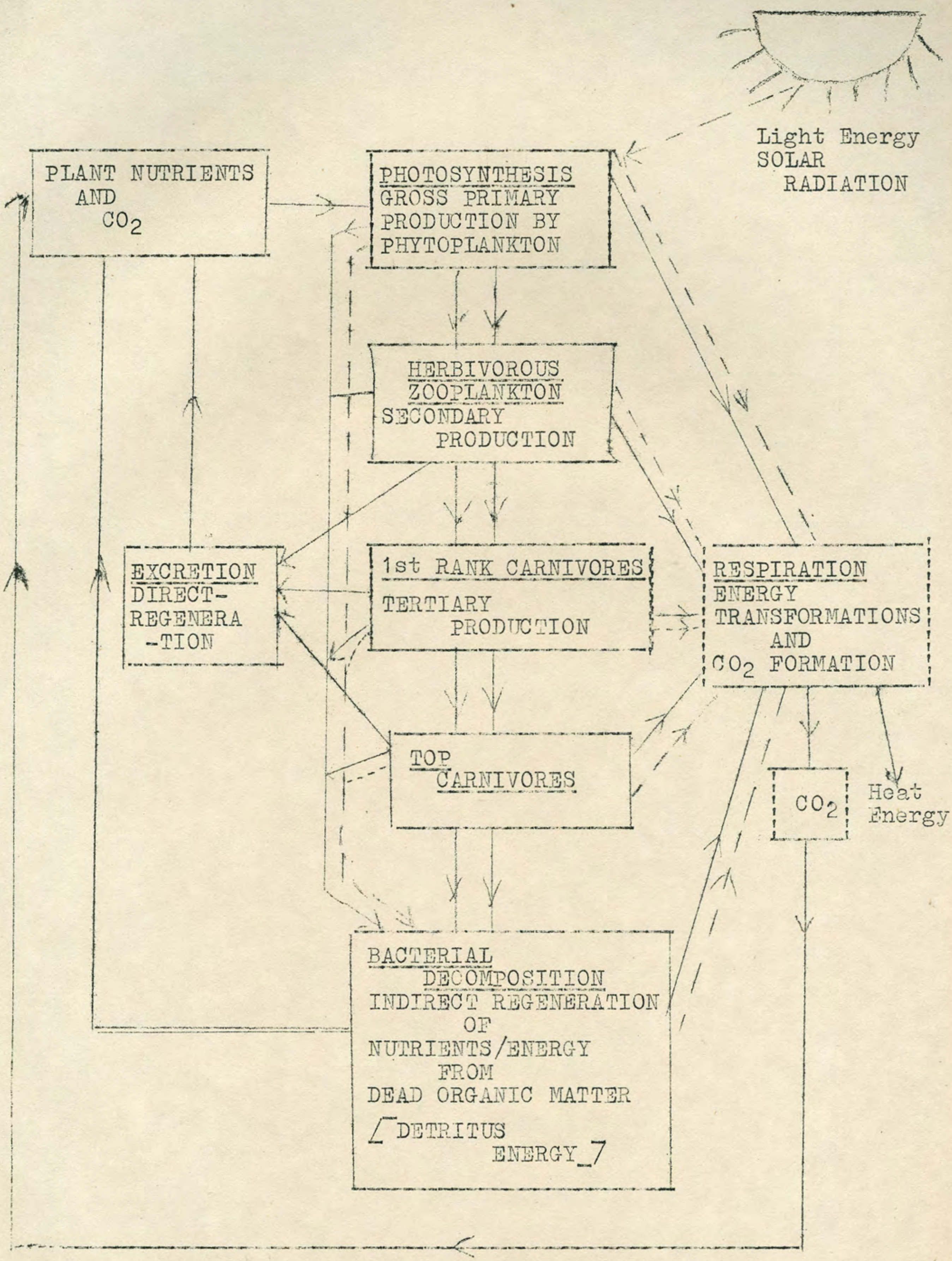

FIG. 1. FLOW OF ENERGY IN BEEL ECOSYSTEM

TABLE- 1

Transformation of solar energy to potential chemical energy in beel ecosystem (Kulia Beel) affected by aquatic macrophytes

Year of observation	Range of energy fixation per unit area by primary producers (Cal $m^{-2}day^{-1}$)	Photosynthetic efficiency (%)
1980	2,500	0.12
1981	2,716 - 9,700	0.14 - 0.5
1982	38,050 -1,94,460	1.96 - 10.0
1983	61,160 -80,000	3.15 - 4.12

DESIGN AND CONSTRUCTION OF PENS AND CAGES

—— A.B. Mukherjee

INTRODUCTION

The culture of fish in net pen enclosures or floating net cages has of late drawn much attention owing to score of advantages this system has over the conventional rearing fish in ponds. Besides helping reduce pressure on land resources, pen or cage fish culture offers scope for utilising maximum use of all available water resources, optimal utilisation of feed for growth and complete harvest of the fish production. The initial investment towards building and installation of the pen or cage structure being relatively small, the practice of growing fish in such netted enclosures is presently in a state of rapid development.

Basic considerations in designing netted enclosures and cage structure

1. Net pen enclosure

1.1 Selection of site

The site in general should provide an ideal environment for favourable growth of the species to be cultures. The location and environmental factors largely decide the economical viability and success of the enterprise. The reason of poor fish yield may be attributed to low oxygen content in the culture medium. Faeces and food particles sink to the bottom, subsequently decay and pollute the fish farm. Hence there should be a moderate rate of flow velocity to dislodge the particulate materials from the netted enclosures.

It is important that detailed engineering survey of prospective sites for pen or cage be made before the actual installation is undertaken on the following aspects.

a) Physical characteristics of the water shed, nature of surrounding catchment area and kind of terrains.

b) River or stream discharge, maximum flood rise, incidence of flash flood flow velocity etc.

c) Shore characteristics.

d) Amount of shelter.

e) Soil properties of bed and sub-base.

f) Availability of constructional materials, accessibility etc.

g) Meteorological factors, and

h) Biological factors.

The shore line should ordinarily be stable with a gentle gradient towards the water shed. Locations confornted with ruggedness or close undulations should as far as possible be avoided.

1.2. Watershed and run-off

Storm water flow to the watershed from the adjoining catchment depends on duration of rainfall, time of concentration, shape and contours of the shore land. Evaporation and transpiration by vegetation and percolation also influence the run off. Floods from a large catchment area take longer time to rise than floods from a smaller catchment area.

2. Design loadings

The direct loadings and external forces which act on pen structure are principally as follows -

a) Self weight of the structure and occassional operational loadings.

b) Stresses due to impact of drift logs, aquatic vegetations and from sticking of fouling organisms, mud etc.

c) dynamic forces due to wind, surface waves, turbulence etc.

Dynamic loadings tend to buckle or uplift the structural components. Hence the magnitude of such thrusts should be correctly ascertained from meteorological and hydrographical conditions prevailing at site. Wind pressure near the ground is feeble due to frictional effect and its intensity is more on small areas than on large areas.

The exposed solid parts of the pen structure often experience wave thrusts. The wave height depends on wind speed, kind of wind field and the exposed fetch length, considering the factor of fetch length alone. Frevert et al. (1962) have presented the following equation for calculating the probable wave height -

$$H_W = 0.014(F)^{1/2} \text{ meter}$$

Where, H_W = Wave height in m
F = Fetch length in m

The net pen structure should necessarily be protected against the possible damage due to impacts of waves.

3. Planning and design

The netted pen enclosure should in general be well defined, either rectangular, oval or elongated horse-shoe shaped depending on the nature of shore land and water depth. The pen should invariably be aligned in the prevailing wind direction for effective aeration in the enclosure.

The chief components of the pen enclosure consists of main supports, framework spanning over the supports, horizontal and inclined bracings, stays and fish retaining nets.

Among the available wide range of constructional materials bamboo is found to be most suitable for building the pen structure specifically to be used in beels, mauns, shallow impoundments etc. in view of its strength, durability and relative cheapness. However for larger loadings sal bullah piles or galvanised iron pipe frames with g.i. weld mesh nets may be considered for rigidity of the structure.

4. Floating net cage

The cages for fish culture may chiefly be divided into three types :-

a) surface floating cage

b) partially or submerged cage in mid water, and

c) fully submerged cage.

In large impoundments or beels floating net cages are mostly used in view of their constructional and manoeuvrability easiness.

The shape and size of the cage may vary depending on the species to be reared, and physical properties of the materials to be used in their construction and management. Depending on the structural properties of the materials used in their construction, the economic size of the cage may be from 5 sq.m. to 50sq.m. Smaller cages are often grouped together in several rows.

4.1 Cage components & forces

A complete cage has the following components :-

a) cage frame with walkway
b) the floatation units
c) fish net enclosure
d) anchorage or mooring arrangements
e) sometimes the top covering

The main fish retention net is sometimes protected by a second net hung outside to prevent the attack of predatory fish.

The cage framework should be sufficiently strong and stable since the exposed solid parts of the cage structure and floats have to withstand the dynamic thrusts of wind and waves of varying magnitude. The wave height is related to wind speed, and the open fetch length where the cage is installed. The cage should normally not be exposed to thrust of waves more than 1m height for its stability and equilibrium. For all purposes the cage should be installed in a well protected area not exposed to excessive rocking.

4.2 Construction

The most simple design of floating cage consists of nylon bag nets of smaller sizes (2 m square to 9 m square) suspended from lattices of bamboo, canes or wooden battens. Bamboo frame work works out cheaper and if it is properly treated before use can serve satisfactorily for 3 - 4 years.

G.I. pipe or aluminium pipe frames with rigid collar ring at top is appropriate substitute for wooden or bamboo frame for locations exposed to severity as the above materials are reasonably strong and have higher flexural strengths.

The built up structure should be smooth and perfectly free from any uneven pocket.

4.3 Floating units

Asphalt coated bamboo poles tied in bundles serve satisfactorily as floats for smaller cages in calm water. Depending on the magnitude of dynamic forces the types of floats vary from hard plastic or styrofoam floats to heavy metallic drums. A 45 m^2 floating cage unit requires about a total of 48, 8 gallon fibre glass barrels for floatation in moderate waves. For larger cages it is advisable to provide more number of floats of manageable sizes at closer spacings which provides more flexibility to the frame to toss freely on the waves.

4.4 Anchorage facilities

Iron chains tied with metal anchore or heavy concrete blocks or stone boulders serve effectively as anchoring devices in strong current. Wooden peg driven firmly into clay base and tied with the cage by nylon ropes is a suitable mooring device for cages in calm and shallow waters. Similarly V-shaped spreader of 15 mm dia, nylon rope tied with 50 - 100 kg c.c. sinker is an efficient setting and anchorage device.

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PEN AND CAGE CULTURE IN BEELS

—— V. R. Chitranshi

INTRODUCTION

The potential value of beel, for the development of fisheries particularly through aquaculture has now been well recognized. It is regrettable to note, though the resource provide an excellent area for culturing commercially important carps and air-breathing fishes, no serious effort has been made to utilise the existing potential of these eutrophic lakes. Hence, these valuable water bodies are lying in derelict condition and going out of productive use.

MANAGEMENT PROBLEM

The management and development of fishery in the beel is a tedious task due to multiplicity of factors. Owing to a great number of uses and conflicts in the matter, the use of land and water control of aquatic weeds and predators are difficult. Improvement of lake condition is impossible due to high investment on reclamation. Leasing pattern and poor economic status are the other obstacles which has discouraged aquaculturist to undertake cultural operation in the Beels. These problems have to be resolved if the enormous potentialities of these water bodies are to be tapped for production of fish crop.

SCIENTIFIC APPROACH FOR AQUACULTURE MANAGEMENT IN BEEL

In order to alleviate these problems, CICFRI has formulated Pen and Cage culture technology through which entire culturable area of beel both in depth from surface to benthic zone and over entire surface area especially, weed infested and swampy pockets can be effectively exploited. These techniques enables the culturists to utilise his own portion. Thus, without disturbing the interest of other users, the autochthonous potentialities of the beel can easily be tapped. The worth of both technologies has been successfully demonstrated in many beels of Bihar and Assam.

PEN CULTURE

The pen is a fixed barrier, errected to prevent the entry of fish enemies and other unwanted elements from beel to the farming zone on one hand and stocked fishes to escape outside on the other. Thus, it is a protective devise through which stocks are kept out of danger. As the device ensure complete control over farming space, the management of fish stock becomes easier.

CONSTRUCTION OF PEN

The pen screen or enclosure is prepared from the bamboo strips. The strips are closely woven to a length of more or less 5 meters. Compact weaving is essential so that the invasion and escape of fishes can effectively be prevented.

INSTALLATION OF PEN

The success of pen culture to a great extent depends on the suitability of site and proper installation. Hence, great care need be taken on these two aspects.

Gentle slopping terrain where water level fluctuation is not extreme is the suitable site for the installation of pen. The areas, get drastically reduced and where floating weed islands are formed must be discarded as they may pose problem in the management.

From the economic point of view, pen is generally installed when water level is minimum. Before installation, selected area is demarcated, renovated and made free from marginal, floating and sub-merged weeds. Sufficient space must be reserved so that in case of emergency pen can be extended.

In the demarcated zone, supporting vertical poles are strongly fixed at suitable intervals. The pen screens are then set by stretching them from one pole to the other interturned or set inside or outside and inplanted in the beel bed firmely. To provide additional support, bamboo poles are also tied horizontally. An inner lining of nylon netting is provided to prevent the entry or escape of fishes.

IMPROVEMENT OF THE FARMING AREA

The prime purpose of pen culture is to ensure safety to the fish stock from enemies, competition and pathogens. Thus, before stocking, the condition of the farming area is improved by cleaning the undesirable elements and disinfection. Aquatic weeds are cleared by manual labour. The population of gastropods, insects, predatory and weed fishes are eradicated by repeated drag netting. To release the harmful gases and for prophylactic measures, excess muck need be removed and liming should be done.

Since nutrient status of the beel is very high, the use of manure and inorganic fertilizer for enhancing the fish food organism will be merely a waste. By turnover of bottom and use of lime nutrient, locked in soil phase, is made available to water phase and in this way high density of plankton can be formed in the farming zone.

CAGE CULTURE IN BEELS

Aquaculture in open waters through the use of cage is also a means of production in very limited space. Mostly the cages are used in those areas where fish culture and retrieval of stock is difficult. Thus, by adopting this technique, culture operation can be undertaken in weed infested areas, swampy pockets and deeper zones of the beel.

PREPARATION OF CAGE

Keeping in view of the hydrological conditions viz. organic and metabolite load, stagnant condition and poor quality; split bamboo mat cages are used for fish culture in Beels. The cages made from other indigenous materials such as Palm leaf, Cyperaceae mat and Phragmites stem may also be utilised for culture purpose.

A convenient size cage measuring 2M X 1 M X 1 M can be prepared from split bamboo. The mats are knitted, thick split bamboo sticks are provided on borders. Cross sticks are fixed on the mats and assembled to give a shape of a box. The inner side of cage is made smooth to save the fishes from injury. The top of the cage is half covered with a mat for feeding and inspection. To prevent the fish from jumping out of the cage, the rest portion is covered with a net made of coir rope.

The synthetic fibre mesh cages (12-20 mesh/inch) can also be used in beel but highly corrosive water condition would destroy the nylon cages.

INSTALLATION OF CAGES

Management of fish cages is more laborious because there are more risk in managing fish cages. Factors needing attention in selecting site are the water level fluctuation and nature of weed infestation. Before placing the cages, selected area is made free from weed infestation. The vertical staking poles are fixed at regular interval and cages are set over these frame work. To provide additional support, bamboo poles are also tied horizontally. Proper positioning of cage is very important to avoid accidental damage. Good circulation of water for adequate aeration and to flush out the accumulated metabolites, is very essential otherwise, fishes will be under stress condition and their growth will be affected.

SELECTION OF STOCKING MATERIAL FOR PEN AND CAGES

The economic viability of fish culture is largely depends on favourable factors. The beel provides an environment where growth of major carps and air-breathing fishes are equally high. A well cleared area within a pen provides ideal environment for major carps. Similarly hydrological features near weed infested and swampy pockets are most congenial for the faster growth of air-breathing fishes. Hence, carp culture in pen and air-breathing fish culture in cages will be more profitable in these beels.

Taking the advantage of favourable ecological conditions, Catla (surface feeder), Rohu (column feeder), Mrigal, Calbasu and Common carp (bottom feeders) can be selected for Pen Culture. Due to abundance of detritus, better yield can be obtained by stocking the detritivores fishes. The combination and ratio may be decided according to local condition, water depth and availability of stocking material. A combination of 3 species, viz. Catla, Rohu and Mrigal has proven to be the best combination for Pen Culture in the beel.

The hydrological potentialities of the beel can be harnessed effectively by culturing Singhi (*Heteropneustes fossilis*), Magur (*Clarias batrachus*), Koi (*Anabas testudineus*) and Murrels (*Channa marulius*, *C. striatus*, *C. punctatus*) in cages. The fry rearing phase of murrel is little complex due to cannibalism. It can be checked by intensive feeding.

For getting marketable size in shortest possible time, healthy size fry/fingerlings are stocked during warmer months of the year (April to September) so that growth period may fully be utilised. Availability of natural food in abundance make the carp and air-breathing fish culture more economical and thus the investment on input as feed and fertilizers, can be saved. Supplementary feeding is essential for better growth of the fishes.

COMMON PROBLEMS AND REMEDIES

During pen and cage culture operations, following problems are generally encountered :

1) Invasion of fish enemies and competitors

Due to constructional defects, unequal water pressure, rough handling and heavy downpour, undesirable elements may find entry into farming zone. Periodic checking must be done to eliminate these problems. The damage can be corrected either by repairing or replacing the material.

2) Silt and algal clogging

Due to silt and algal deposition, free flow of water is affected. The problem can be overcome by replenishment of water, cleaning and replacement of the material.

3) Net cleaning

Gastropods and algae make the net heavier. Net should be checked and cleaned regularly.

4) Incidence of fish disease

High organic load and unhealthy water condition provide congenial condition for multiplication and growth of pathogens in the Beel. Thus, chances of bacterial disease (Tail and Fin rot), fungal disease (Saprolegniasis), Protozoan disease (Myxobolus) is high especially when they are physically weak. Hence, health monitoring of cultured stock is very important.

ESTIMATION OF BEEL FISHERY RESOURCES

------- *R.A. GUPTA*

Introduction :

Beels constitute one of the important inland fishery resource in the states of Assam, Bihar and West Bengal. To give a boost in fish production from this resource, a number of development programmes are being formulated and executed in these states. To fathom the success of these programmes, it is essential to have a reliable data base which in turn makes the task of monitoring assessment and evaluation of the ongoing development programmes possible. The requirement of such a data base force us to take up extensive surveys of the existing and potential resources together with their deficiencies.

Planners or a fishery scientist may need current data on catch rates by key species, on species composition and current estimates of total landings by area captured in order to make an assessment of the state of the resource. Current estimates are also required on the number of boats actively fishing, the number of days fishing per trip and number of trips per month as well as the type of gear used to deliver the management advice for the water body, Hence resource estimation and creation of data base pertaining to these water bodies provide essential key for solving problems related to development and Management of beels.

Strategy for data collection :

The first thing to do is to identify on the one hand, the types of data needed, and the priorities and procedures for the collection of the spectrum of characteristics required, and on the other hand, the budget and manpower available for the implementation of the system of work for data collection in order to make reliable assessment of the resource.

Frame Surveys :

The first step in resource investigation of a water body is assumed having to conduct a frame survey in order to make a complete list of the characteristics of the fishery as a basis for designing a statistical sampling survey programme. A complete record of the main units (boats, fishermen, landing markets and Transportation routes) should be well documented for proper collection of information on the fishery resource. This component is essential for all approaches to information gathering that hope to draw conclusions about the whole system being investigated.

Catch assessment surveys :

After completing the frame survey, the second important aspect in resource estimation is the estimation of total catch, species-wise catch and effort. This job of catch assessment survey is to be ideally carried out by a number of Trained enumerators by sampling in space and time, The enumerator is asked to visit a randomly selected proportion of the landing sites, markets identified in the frame, at pre-assigned times and days. The operational and technical *aspects of this sample survey system may be divided into four main stages in the implementation of this programme.*

1. *Planning of the survey*
2. *Designing the survey*
3. *Field operations for data collection*
4. *Processing and presentation of the results*

At the planning stage of resource assessment under beels, following information needs to be documented:

i. *Scope and geographical coverage must be well defined.*

ii. *The hierarchy of units in the population must be well defined. In Beels, landing places or the fishing units as the case may be depending upon the circumstances should be taken as the ultimate sampling unit.*

iii. *The nature of information to be collected should be formatted in a well designed proforma along with efficient coding system. One such proforma applicable to beels is presented in the appendix.*

iv. *Source document such as lists, questionnaire, mapping material and other supporting documents must be prepared for the beels.*

v. *Two types of methods for data collection may be adopted depending upon the prevailing practices. They may be either census survey or sample survey and the method of obtaining the information i.e. by interview or physical observation may be adopted.*

Sampling design for catch estimation :

Sampling design for catch estimation may be one of stratified random sampling. The classification of fishery economic units or landing centres may be two-fold, one category may contain the units of high potential catch and the other of moderate to low catch. A sample may then be selected from each of the two categories with high sampling fraction (say 20%) in the potential catch units and low sampling fraction (say 5-10%) in the moderate to low units.

Calculation of sampling size :

Sample size in the survey largely depend on the availability of man power and finance. But a reasonable size of sample should be taken to derive the results within 10% of error of estimation. Important units may have larger sample days in comparison to other units.

Estimation :

Let n = *no. of units selected in the sample*
N = *no. of units in the population*
y_{ij} = *yield of the* i^{th} *unit on* j^{th} *day*
di = *no. of days observed for* i^{th} *unit*
Di = *no. of days of fishing for the* i^{th} *unit.*

then the total catch is gigen by;

$$\hat{Y} = \frac{N}{n} \sum_{i=1}^{n} D_i \bar{y}_i \quad \text{where } \bar{y}_i = \frac{1}{d} \sum_{1}^{d} y_{ij}$$

and the estimate of variance of $\hat{Y}$ is given by

$$\hat{V}(\hat{Y}) = N^2\left(\frac{1}{n} - \frac{1}{N}\right) S_b^2 + \frac{N}{n}(k-1) \sum_{1}^{n} D_i S_{wi}^2$$

where $$S_b^2 = \frac{1}{n-1} \sum_{i=1}^{n} \left(D_i \bar{y}_i - \frac{1}{n} \sum_i D_i \bar{y}_i \right)^2$$

$$S_{wi}^2 = \frac{1}{2(d-1)} \sum_{j=1}^{d-1} \left(y_{j+1} - y_j \right)^2$$

Analysis of results :

Calculated estimates overtime can be analysed by using proper statistical techniques. For example, regression analysis, time series analysis etc. can be used for assessing existing trends underlying the impirical time series and for forecasting purposes.

PROBLEMS OF HEAVY METAL AND PESTICIDE CONTAMINATION IN BEEL ECOSYSTEMS

——— H. C. Joshi

INTRODUCTION

The rapid expansion in the industrial and urban activities and the modernisation of agriculture have resulted in various types of waste materials causing gradual deterioration of valuables resources of aquatic productivity. The future plan projections envisage further growth in the use of metals and metallic salts as process materials in the industry and fertilisers and pesticides in agriculture. Presently about 10 million tonnes of NPK and pesticides are washed into the aquatic systems annually. With the anticipated increase of nearly four times of the present use, their consumption is bound to increase considerably by the end of this century.

The most direct impact of pollution in the aquatic systems is in the form of mass sdale fish mortality. In most of such cases, the depletion of oxygen to near zero due to highly organic putrifiable wastes such as sewage, sugar or distillery effluents happens to be the main cause of fish mortality. However, mortality alone should not be considered as the indication of pollution. The major damage to fish is caused by the biological changes brought about by the pollutants in the aquatic ecosystems. Eutrophication of lakes, stunted growth of fish, growth of undesired species reduced diversity, diseases, chronic disorders in fish, low production form the chain of biological processes that ultimately result in low fish yields from the aquatic systems. Apart from these, introduction of hazardous and toxic substances such as metals and pesticides pose long term threat to the aquatic life in the open water systems.

Recognising the general conditions of the beel ecosystems in the country, these water bodies can be termed as the 'abandoned lakes', since they have been isolated from the parent river due to change in its course. Eventhough, some of these water systems are connected to the river during flood. Such beels are known as live beels. Some beels, which are completely separated from the river have been termed as dead beels. The annual cycle of runoff from the catchment areas enriches the beels with nutrients, leading to growth of undesired macrophytes.

Alongwith the nutrients various kind of pollutants are also deposited on the beel sediments. Pesticides are the most prominent chemical poisons which stay in the beel systems for quite a long time.

The use of organometallic compounds in agriculture as plant protection chemicals leads to the release of metals into the beels which are very often surrounded by the agricultural fields. Lead from the road surface runoff and mercury from the atmospheric fallout are the other sources of metal contamination in the beel ecosystems. Some beels in the States of Bihar and West Bengal are being used as the dumping ground for the municipal effluents and in some cases fly ash from the Thermal Power Plants is dumped on the banks of the beels. Such dumping of sullage leads to direct contamination of beels by heavy metals.

POLLUTION IN BEEL ECOSYSTEMS DUE TO HAZARDOUS SUBSTANCES

Hazardous and toxic substances such as pesticides and heavy metals are carried to the beel ecosystems through sewage from the villages and semiurban areas, effluents from the cottage industries engaged in leather tanning, electroplating, pesticide formulation and runoff from the vast agricultural fields. Their entry into the beels can be checked by adopting suitable treatment or the diversion of the waste waters. However, it is very difficult to contain their transport to the beels through the land runoff which is a non-point source and is not amenable to conventional methods of treatment. These substances are highly persistent and thereby contaminate the entire biogeochemical cycle of the static systems like, beel ecosystems and perennial tanks. Biological factors also contribute to the ultimate effect of these pollutants. The potential for accumulation of toxic substances in the fish tissues increases the significance of some pollutants which may, however, be present in water in extremely low concentrations. It is now widely believed that even the traces of these xenobiotic substances effect the growth and reproduction cycles of the majority of aquatic animals. Such a situation does not only result in low fish output, but is also responsible for transport of toxic metals and pesticides in the human body through the contaminated fish.

The range of potential toxic substances includes organic poisons, metals and their organic derivatives, pesticides, PCBs, methylene blue active substances etc. However, the metals and the pesticides have the greatest potential for biomagnification in the aquatic food chain. The substances, like, mercury are transformed into their organic derivatives such as methyl mercury and become several times more toxic than the original compound. Similarly, pesticides like DDT and aldrin are also transformed into more persistent and potent metabolities.

Pesticide residues in Indian waters

In beel ecosystems pesticide residues have scarcely been studied in India. However, instances of pesticidal pollution in India are not less frequent. Nearly 1000 and 1300 ppb of BHC and methyl parathion in water in the river Cauvery near Srirangapatnam in Mysore and 20 - 200 ppb of BHC in drinking water have been reported from the Hasan District of Karnataka. A detailed report on the river Yamuna indicates presence of DDT residues in water (0.602-3.416 ppb) and fish (0.059 - 7.575 ppm) near Delhi. Although significant residues of DDT have not been detected in water in the Hooghly estuary, its presence has been detected in sediments (17 - 89 ppb), molluscs (65-953 ppb), fish (31-460 ppb) and plankton (15-130 ppb). DDT has been biomagnified by plankton, fish, gastropods and bivalves by 2500, 7500, 3660 and 15,800 times of its ambient level in water. Reports are available on the presence of other pesticides such as BHC, endosulfan, methyl parathion in water and sediment of fish ponds in the Sunderbans region of West Bengal.

Toxicity of pesticides to fish, prawn and fish food organisms

Most of the commonly used pesticides *viz*. DDT, BHC, endosulfan, ethyl parathion, methyl parathion, dimethoate, phosphamidon, ekalux and carbaryl have been screened at this Institute to evaluate their toxicity to fish, prawn and fish food organisms. It has been observed that fish food organisms such as plankton and benthos are very sensitive to these chemicals as compared to fish. Thus their presence in aquatic ecosystems not only affects the fish directly, but also affects adversely the availability of fish food organisms.

Metals in Indian waters

The environmental hazards to fishes originating from metal pollution are in evidence in our country. Reports of metal accumulation in fish (mercury) from the rivers flowing through the metropolitan cities of Bombay and Madras appear quite frequently. High zinc bearing wastes from a rayon factory have been found to cause complete wiping out of molluscs population in the discharge area in river Tungabhadra. Biomagnification of zinc by 14,755 times in the kidney and 7,340 times in gonads of Rita rita and 4,300 times in molluscs and 1,400 times in crabs have been reported from the Hooghly estuary.

Metals vary widely in their toxicity. Even the same metal may have varying toxicity under different environmental conditions and depending on its speciation. In combination metals show much higher toxicity than the toxicity of individual metals. In our studies, the combination of zinc, copper and chromium has shown several times more toxicity to Oreochromis mossambicus than their individual toxicities.

Conservation of fisheries in beels

The environmental management in relation to fisheries in the rivers as well as in other water bodies calls for an ecosystem approach, wherein the water use, land use pattern, pollution and modification of the river system do not impair the trophic structure and functions of the ecosystem. The fisheries management, which comprises the conservation of aquatic fauna and flora, natural recruitment and stocking and selective and controlled fishing in the open water systems, should have the adequate support of the agencies responsible for making considerable impact on the quantity and quality of water in these systems. In the beel ecosystems, which have a limited water spread area large scale abstraction of water for irrigation leads to drastic variations in the water quality.

The fisheries sector should not be isolated from any such activity which involves the use of water. It would be otherwise, very difficult to derive optimum yield from the aquatic systems in terms of fish production if the interference with them continues unabated showing least concern for fisheries. It is, therefore, imperative that besides, the other uses of water such as for irrigation, industry, thermal power generation, potable supplies, use of water for fish production in the natural system should be given utmost importance. This should be followed by the involvement of fisheries in urban and industrial waste management practices, judicious use of fertilisers in agriculture, afforestation and social forestry programmes.

There is also need for catchment modification for the control of soil incursions and transport of fertilisers and pesticides into the beels through agricultural runoff. These pollutants are not amenable to conventional methods of treatment. The control of such pollutants can be effectively be done by adopting best management practices (BMPs) in the agricultural fields and other lands falling within the catchment area of the beel. The BMPs involve managerial controls for precise and effective use of pesticides and fertilisers, vegetative controls for adoption of suitable horticultural practices and afforestation, structural controls for making grassed waterways, detention ponds and terraces for checking soil erosion.

The management, vegetative and structural BMPs as identified above can reduce pollutant losses in runoff. Detailed studies in the U.S. drainage basin to Lake Erie have shown that these practices constituted the best cost effective and acceptable technology for the control of soil erosion and non point source phosphorus losses. In India, and likewise in other developing countries, where the pollution problems mostly originate from the abuse or cocktail use of pesticides and overdose and untimely application of fertilisers, the conditions are very much different. Apart from the above practices, there is utmost need for educating the farmers about the ecological implications of the indiscriminate use of agrochemicals. It is therefore, imperative for the fisheries officials to acquaint themselves with the long term hazards associated with the blanket use of plant protection chemicals. This awareness should percolate downwards to the farmers and fishermen.

RESOURCE EXPLOITATION IN BEELS

——— M. Choudhury

INTRODUCTION

The optimum exploitation of the fishery resources in water bodies is the ultimate objective of the fishery management practices. The development of new theories and models further emphasise the need for judicious harvesting of the resources, lest over or under exploitation may take place. Therefore, the future of a fishery is very much dependent on the gear selection, intensity of fishing and the level of exploitation.

The resource exploitation in beels is very traditional and portray some fishing methods unreported from other water bodies. Some such methods have been reported by Yadava et.al. (1981), Yadava and Choudhury (1986), Choudhury (1987) and Bhagawati and Kalita (1987). The present paper briefly deals with the crafts and gears in vogue and their modus operandi in Assam beels.

RESOURCE AVAILABILITY

North Eastern region, North Bihar, West Bengal and Eastern Uttar Pradesh are well endowed with natural water resources in the form of beels, mauns, jheels, pat, etc. which form one of the most lucrative source of fisheries. These water bodies generally known as ox-bow lakes, possess high potential for fish production. Total area under beels is c. 2 lakh hectares out of which, Assam possess 50% followed by West Bengal 20.8%, Bihar 19.8%, Manipur 8.2% and Meghalaya 1.2%.

PRODUCTION

The average annual yield from the ox-bow lakes is > 160 kg $ha^{-1}yr^{-1}$ (Yadava 1988) as against the yield of 5-75 kg $ha^{-1}yr^{-1}$ of the open water lakes and reservoirs (Sreenivasan, 1965; Holt, 1966; Jhingran and Tripathi, 1969). A comparative account of the fish yield from few beels of Assam are given in Table I.

Table I : Fish production from few beels of Assam

Beel (Worker)	Catch (kg)	
	Annual Total	Catch/ha
Dora (Lahon, 1983)	18705	116
Salsala (Lahon, 1983)	5053	243
Sone (Kar, 1984)	335180	97
Dighali (Yadava *et al.*, 1987)	5246	36
Dhir (Yadava, 1987)	93160	377
Dipar (Singh, 1988)	3130	21
Siligurijan	6006	418

Beels support multispecies fishery of commercial importance. About 80 different species have been observed from Assam beels.

RESOURCE EXPLOITATION

Fishing methods in the beels are traditional yet very fascinating. The type of fishing methods in use are conditioned by three factors (i) physiography of the water body

(ii) the nature of the fish stock and (iii) the characteristics of raw materials from which gears are fabricated. Therefore, certain variations in the application of gears can be observed in different beels located in the region. However, there are many common gears extensively used in almost all beels.

Fishing methods keep on changing from month to month, yet distinct seasonal categorisation can be made. During monsoon very little fishing is done in beels. Hooks and lines and to some extent dip nets are used. Wallago attu, live fishes etc., are caught by hooks and lines. Catfishes and fishes of smaller varieties mainly caught by dip nets. Post monsoon witnesses the use of 'banas' in exploiting the current flowing back to the river, resulting in the catch of spawn and large fishes migrating back to the river. 'Katal' which is installed in monsoon in almost all beels, is harvested during winter. The use of gill nets and drag nets in beels less infected with weeds is also during winter. Hand operated triangular nets and traps are operated mainly during post-monsoon and winter.

Two categories of nets are mainly used for fishing in the beels (i) Moving nets (ii) stationary nets.

Moving nets : Prominant moving nets operated in the beels are Maharijal, Berjal, Horharijal, Moijal, Pantijal, Jatajal, Dharmajal, Ghokajal, Nayajal and Khewalijal, etc. While the first five nets are drag nets, the next four are dip nets and last falls under cast net.

Stationary net : Gill nets - Fansijal, Koi langijal, Puthi langijal and Goroilangijal, etc. operated throughout the year are included under this category. While fansijal accounts for medium and large size carps and catfishes, the other three chiefly entangle smaller varieties consisting of Puntius spp. Ompok spp. Nandus spp. and live fishes etc.

Hooks and lines : Hooks and lines are used round the year with greater intensity during monsoon. Earth worm, frog, prawn, small fishes, etc. are used as baits. Carnivorous fishes are mainly hooked.

Traps : Various types of traps chiefly made of split bamboo are extensively used in the beels. Some of these are polo, Sepa, Box sepa, Bhari, Khoka, Dingora, Jakoi, Boldha, etc. Channa spp., prawns and other smaller varieties of fishes mainly trapped.

Katal fishing : Katal fishing is an effective indigenous fishing method employed in beel fisheries. It is basically a lure since the motive behind is to entice fishes in accumulated mass of bushes, weeds and tree stumps for a certain duration of time. Katals are set by dumping tree branches, water hyacinth etc., in the form of a circle. Fishes make shelter in such katals. During winter, when water level substantially goes down, katals are encircled by drag nets and bamboo screens. Vegetation and tree branches are removed and gradually the diameter is reduced. Fishes are caught by cast net from this smaller circle. The catch includes medium and large sized major carps, minor carps, catfishes, featherback etc. In certain beels approximately 50% of the total catch during winter comes from katal fishing.

Banas fishing : Beels having connection with the rivers are ideal grounds for banas fishing. Banas are set barriers erected bank to bank in the channel connecting the beel to its riverine source. During monsoon, adults and juveniles of various species enter the beel along with the current for breeding, feeding and temporary migration. With the waning monsoon, the current starts receding towards the river and many species undertake their journey. At this stage, banas fishing commences. In the centre of the channel, a gap of 3-4 meter is left in order to instal a dip net. Behind the dip net another obstruction by banas is arranged. Alongwith the banas, gill nets are also fixed. Fishes are caught in the gill nets and dip net. The catch includes medium and large sized major carps, minor carps, catfishes, feather-back and other miscellaneous spp. Yadava *et al*. (1986) observed that banas fishing contributed 32.82% of the total catch during that period.

Dewatering

Small, shallow and derelict beels having pockets are convenient for dewatering. Dewatering is done by using pumps.

FISHING EFFORT

Modern fisheries management techniques demand certain basic information on the exploited fish stock so that optimum yield could be achieved without affecting the futher fishery. Amongst them the effect of fishing is of vital importance since it directly influences the total mortality and hence with the total abundance of stock and its age and size composition.

The effort put by man for fishing may be defined as fishing effort. This effort could be visualised in terms of time devoted, implements used, technology adopted and money spent. Fishing efforts are generally measured in terms of boat days, man days, length of gill net etc.

Management of fish stocks are done primarily through fishing effort. The most commonly employed stock assessment techniques rely heavily on the use of catch and effort statistics and thus the importance of fishing effort increases.

Fisheries where only one type of gear is used and whose efficiency is not likely to change over the year, the total effort can be expressed simply. But where more than one type of gear is used some method of combining effort is to be used. The total effort can be expressed as

$$\text{Total effort} = \text{Total catch} \times \frac{\text{effort by gear A}}{\text{catch by gear A}}$$

Apart from fishing effort, gear selectivity, maximum sustained yield, etc., are other important aspects, which constitute the management package for optimum exploitation of the fishery resources.

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PRE-HARVEST AND POST HARVEST MANAGEMENT OF BEEL FISHERIES

—— S. Paul

INTRODUCTION

Beels are said to be delinked parts of erstwhile rivers either retaining connection with the main river or no connection. However, they constitute important resource for fisheries particularly in the States of Assam, Bihar and West Bengal. In the State of Assam alone area under beels is roughly one lakh hectare. Varying estimates of yield and production have been given by various agencies and fishery workers but still contribution of beel fisheries to the total inland fish production of India is not precisely known. Yield rates are said to be in the range of 100-300 kg/ha/yr. Available data on production indicate low level of productivity per fisherman.

Existing management practices

Most of the beels in Assam, West Bengal and Bihar are with the fisheries cooperatives. Only management practice worth mentioning is limited to stocking that too on adhoc basis. No systemetic study has been made so far to raise their production and consequent income of fishermen by exploiting these beels. According to scanty research data available there does exist great potential for raising the level of productivity to 500 kg/ha/yr. Unlike aquaculture in water bodies of less than 2 ha beels are relatively large water sheets. Aquaculture practices like fertilisation and feeding are of no avail in beels. Therefore, it becomes necessary that stocking requirements of beels are determined on realistic basis after examining all the relevant ecological parameters.

Economic considerations

Pre-harvest management of beels means deployment of crafts and gears that generally owned by cooperative societies. Initial outlay on boats and nets are not very high. Labour of the fishermen seems to be chief input.

Post harvest operations

Selling of fish does not pose a very big problem since State having beels resources are also significant consumers of fish. However, in the event of large marketable surplus quick transport channels will be necessary to carry the fish to the wholesale/retail markets. Further, NCDC gives financial assistance to cooperative societies for building infrastructure comprising boats, nets, cold storages and ice plants.

Problem areas

Following aspects deserve close attention

1. Resource statistics of beel
2. Production estimates
3. Stocking policy
4. Studies on productivity
5. Adoption of aquaculture practices like cage and pen culture, their technical and commercial feasibility
6. Input and output relationship both in physical and economical terms.

Beels are akin to small reservoirs and lakes though they may differ morphometrically.

The degree of human intervention to out advantage is as limited as in lakes and reservoirs. Valuable data have accumulated in recent past on production potential of the beels but 1/4 of this potential is yet to be realised. What is necessary is that this important resource should be tapped for augmenting domestic availabilities.

FISH DISEASES AND THEIR REMEDIAL MEASURES WITH SPECIAL REFERENCE TO EPIZOOTIC ULCERATIVE SYNDROME

—— M.K. Das

Outbreak of fish diseases often impede our efforts for successful implementation of the various fishery development projects. Several fish diseases have been identified and successfully controlled. Most of these diseases so far have been reported from confined water systems. In contrast to this, the recent outbreak of the dreaded fish disease Epizootic ulcerative syndrome has been reported from all kinds of water bodies like rivers canals, beels, lakes, paddy fields and ponds in the eastern states of India.

Fish parasitologists know very well that parasitic infection usually increase when fishes are reared in artificial conditions. So when we discuss fish diseases we have to mention first of all those of cultivated fishes.

Effects of Environment on Fish

The environment where fish reside is of paramount importance for fish health. A deterioration in the environmental qualities often create stress to fish and favour multiplication of pathogens. Though the fish has defensive mechanisms against pathogens in the form of scales, epitheliol cells, acid and alkali media of alimentary canal which offers resistance to pathogens and finally the defense mechanisms regulated by immune system and phage-cells. Inspite of these mechanisms the pathogens predominate and disease manifestation occur in fish farming system.

Environmental diseases

The response of fish to stress from the environment is known as stress response. The most extreme response is mortality but below this level there may be several other responses viz. i) changes in fish behaviour ii) reduced growth/food conversion efficiency iii) reduced reproductive potential iv) reduced tolerance to diseases v) reduced ability to tolerate further stress. The environmental diseases diagnosed are :

a) Depletion of oxygen - The mouth remains open. Gills look pale. Bigger fishes die first.

b) Excess of CO_2 - Excessive secretion of mucus by epithelial cells.

c) Nitrogenous wastes and ammonia accumulation - Gills look dark red due to formation of methaemoglobin

d) Supersaturation of Oxygen or Nitrogen - Accumulation of gas bubbles within the body cavity of fish spawn

e) Excess of hydrogen sulphide gas - Pond muck smells rotten egg. The bottom dwelling fish die first.

f) Organic pollution - Drooping of pectoral fins in case of organo-phosphorus pesticide. Oozing of blood from eyes in some cases.

g) Eutrophication - Water body looks pea-soup green due to bloom of blue green algae.

Diseases caused by animal parasites

Protozoan diseases - It is most commonly encountered in cultured fishes. Members of this group of parasites are found to infect all the organs of fish and cause pathogenic manifestation in acute cases.

Gill spot disease - Gills covered with whitish cysts thereby reducing the absorptive surface, with excessive secretion of mucus. Gills become pale. The fishes surface and die. Causative organisms are Thelohanellus catlae & Myxobolus bengalensis.

Scale spot disease - The scales covered with whitish cysts. In acute cases scales become perforated, degenerated with abnormal mucus secretion. Scales become loos. The causative organisms are Myxobolus sphericum, M. rohitae.

Trichodinosis - Mainly caused by the species of the genus Trichodina and Tripartiella. Heavy infection of these parasites are accompanied by excessive mucus secretion in gills. Fishes suffer from respiratory distress.

Helminth disease

Dactylogyrosis and Gyrodactylosis caused by the species of the genus Dactylogyrus and Gyrodactylus. They infest the gills and body surface of carps. Common symptoms are fading of colours and excessive secrection of mucus. Often infection occur in combination of Trichodinis causing mortality of fishes.

Grub spot disease - Black spot disease is caused by metacercaria of Uvulifer sp. and Diplostomum sp. white grub disease caused by Posthodiplostomum sp. are sometimes recorded from the body of fishes while yellow grub caused by Clinostomum sp. are encountered from musculature.

Ligulosis - Very often fishes exhibit bulging stomach pleurocercoid stage of Ligula intestinalis found to be the causative agent. This tape worm burrows through stomach into the body cavity.

Crustacean diseases

Argulosis - The causative organisms of this disease the species of the genus Argulus. They crawl freely on the body surface of fishes and cause extreme irritation of the host. Argulus draws blood from soft portion of fish by penetration of its probscis. Fishes get emaciated.

Lernaeosis - The causative organism of the disease is Lernae sp. It attacks the host by thorn like hooks and sore develop at the point of attachment. Fishes get emaciated and loose weight.

Ergasilosis - The disease is caused by parasites of the genus Ergasilus. The parasite attaches itself to the gills by its strong clawed antenna.

Bacterial diseases

A number of bacterial diseases have been recorded from fishes.

Tail and fin rot - In young fishes myxobacters cause this disease condition, especially during transport. Catarrhact, loss of barbels, dropsy and ulcers - The bacteria Aeromonas sp. and Pseudomonas sp. have been implicated in these disease conditions.

Black spot disease - The disease in P. monodon is caused by Vibrio sp.

Fungal disease

The fungal diseases commonly encountered are gill rot caused by Branchiomyces sp.

Tail and fin rot or ulceration - caused by Saprolegnia Ichthyophonus sp. and Achlya sp.

Epizootic ulcerative syndrome - This dreaded disease of freshwater fishes broke out for the first time in India in 1988 in all kinds of water bodies like rivers, beels, paddy fields and ponds.

Symptoms of the disease - In the initial stages the infection appears to commence in the form of multiple inflammatory areas on the body of fish causing localized haemorrhage. In advanced stages of infection, the inflammed ulcerative areas spread forming bigger areas with sloughing of scales and degeneration of epidermal tissue. With further advancement of the disease, the ulcers become deep haemorrhagic and neerotic, often with black melanistic rim. Large and deep ulcers are very commonly seen in snakeheads in all parts of the fish involving head, abdomen and peduncle, and often complete peduncle degeneration occurs.

Fish species affected : Most species of murrels, catfishes and carps were affected of which the wild species were Channa striatus, C. punctatus, C. gachua, Clarias batrachus, H. fossilis, Puntius sophore, P. ticto, Amblypharyngodon mola, Mystus vittatus, M. aor, Mastocembelus pancalus, M. armatus, Ambassis ranga, Nandus nandus, Gadusia chapra and A. hexagonolepis. The cultured species affected are Cyprinus carpio, Catla catla, Cirrhinus mrigala, Labeo rohita, Puntius javanicus Ctenopharyngodon idella and Labeo calbasu.

Causative agent : Studies on the disease conducted in various South-East Asian countries uptil now could not pinpoint any specific causative agent of the disease. However the viruses rhabdovirus and birnavirus;bacteria, predominantly Aeromonas hydropilia have been implicated to be the probable causative agents. Moreover, since the outbreak of the disease was predominantly in waters of low alkalinity and hardness it is respected that these environmental factors to be the predisposing factors for disease outbreak.

Investigation conducted by scientists of CICFRI on the affected fishes in the affected states revealed the presence of the bacteria Micrococcus, Staphylococcus epidernidis E. coli, Pseudomonas flourescence. Of these Micrococcus was the predominant bacteria from the diseased fishes in all the affected states. This bacteria was cultured and innoculated into disease free fishes and manifestation of ulcers took place within 24-72 hrs. Disease manifestation also occurred when bacteria cultures were kept in association of healthy fishes. The fungus Saprolegnia was found invariably associated with the ulcers. Investigations conducted on the physico-chemical parameters, heavy metal and pesticides in affected water areas showed it to be predominantly characterised by low alkalinity and hardness.

The emergence of the disease can be traced to the diseased fishes entering from Bangladesh,where the disease outbreak occurred in February/March 1988, along with flood waters to the affected are s in India.

Socio-economic implication - The social impact of the disease was serious as market demand for food fishes with such repulsive lesions slumped and the consumer were avoiding fish fearing disease transmission. The question of foremost concern to the general public was whether fish can be consumed or not. The disease cannot directly affect human beings because of our cooking method of frying and boiling. However, consumption of rotten fishes or for that matter any rotten material can cause gastro enteritinal dis- /by the disease. The symptoms of the disease are external in the form of red or amber coloured lesions on the body and as such it can be easily identified. /orders. It is absolutely safe to consume fishes unaffected

Remedial measures

For successful management of fisheries, control of fish diseases is an important aspect for obtaining sustained yield of fishes. For fish health management the following aspects are taken into consideration.

a) Environmental monitoring : It is extremely important that water used for pisciculture should be made pollutant and pathogen free. For optimum conditions of the ecosystem the pH of water should be near 7, dissolved oxygen level should remain close to 5 ppm, water should be almost free from heavy metals, BOD level should be restricted to 30 ppm. Care should be taken so that the resultant metabolites accumulated by use of manures, supplementary feed and other chemicals remain within optimum limits. Lime upto 500 kg/ha is used for sanitation purpose with proper spacing. $KMnO_4$ being an oxidising agent can be used as and when necessary @ 2 ppm.

b) Stock manipulation and nutrition : The different ponds have different ecological and productive potential. As such the stocking density of fish is dependent upon its primary productivity. Over stocking always affects fish health. The role of supplementary feed is also very important. A nutritive food will help in good growth while a deficient food will impair fish health.

c) Chemotherapy :

Bacterial diseases : Antibiotics (Terramycin or sulpha drugs ; sulpha merazine, sulpha-diazine etc.) are used @ 100 mg per kg of feed.

Fungal disease : Affected fish eggs or fishes are dipped in 0.5 ppm to 1 ppm Malachite green or 3% bath of NaCl respectively.

Animal diseases : For animal parasites bathing in 2.3% solution of NaCl for 3-5 min. have been found to be effective. 250 ppm formalin solution has been found effective in combating flukes. Moreover a mixture of 0.25 ppm malachite green and 100 ppm formalin can help in combating protozoan diseases.

Remedial measures for Epizootic ulcerative syndrome : Lime and sodium chloride application in manageable water areas is suggested. It is evident that the ulcerated fishes are infected by bacteria and fungus. A microencapsulated feed containing 30% protein Nalidixic acid, Erythromycin along with Vitamin A and C had been formulated by CICFRI. Initial trials with the pelleted feed to diseased fishes have shown encouraging result.

ROLE OF EXTENSION IN THE DEVELOPMENT OF BEEL FISHERIES

——— Utpal Bhaumik

Beel, Jheel, Tal, Maun, Pat, the Ox-bow lakes form one of the most lucrative sources of fisheries in the States of West Bengal, Assam, Bihar, Eastern Uttar Pradesh, Manipur, Meghalaya, Arunachal Pradesh and Tripura. The magnitude of these freshwater wetlands and their distribution are estimated to be over 2 lakh hectare. At present about 100 - 200 kg/ha/yr of fish is being retrieved from these water bodies though they are capable of producing 1000 kg of fish per hectare per year.

The modern revolutionary technologies on Management of beel fisheries developed at the Central Inland Capture Fisheries Research Institute have not yet reached to the ultimate users to the required extent. Among the various lacunae one of the main reasons for this is probably the inadequate extension effort.

The concept of inland capture fisheries of the country as a way of life has undergone profound changes in the recent years. Many factors, in this process have been playing their roles, of which inland fisheries research and education systems, backed by efficient extension machinery have been the most vital. Fishery extension, as in any other field, aims at improving the efficiency of the human capital in an effort to rapidly increasing, the rate of fish production. The fishery extension programme, thus, seeks to impart the necessary skills to the fish farmers/fishermen for understanding improved fishery operations to make available to them timely information on improved practices in an easily understandable form suiting their level of literacy and awareness and to create in them favourable attitude for a desirable change. This also necessitates a further understanding of the social system in which the technology is to be introduced.

Transfer of technology starts after its perfection and ends in its utilization by the target consumers. Effective transfer of appropriate technology to the clientele ideally involves the following activities.

i) On specific subject areas, understanding the present level of usage of technology in different regions/ areas and identifying the types of technology needed to meet the problems of rural people in general and the weaker sections of the society in particular.

ii) Based on such feed back, generation of appropriate technology in the field of inland fisheries and its pertinent problems of rural life.

iii) Appraisal of the technology by having required field trials under different geographical and socio-economic condition.

iv) Establishing appropriate systems for ensuring proper linkage between Research and Extension System.

v) Organising extension and educational efforts for the diffusion of the technology in the rural social system.

vi) Creation of necessary infrastructure for accelerating the input supplies, including credit as also the management of the output resulting from the use of such technology.

vii) Actual implementation of the programmes related to transfer of technology in selected areas.

These can be condensed into 4 sets of basic activities involved in the task of transfer of technology. Each set of activities is performed basically by a system which is interlinked and other for running the process. The 4 systems are:

A) Research system

Research system takes care of production of technologies. In inland fisheries, the Research Institutes in general and the CICFRI in particular have sincerely developed technologies on capture fisheries relevant to all categories of clientele. The CICFRI is directly involved in fundamental as well as applied research in inland capture fisheries. The complex mechanism of Indian Research System has proved to be an effective instrument in solving intricate problems and has made an impressive breakthrough in fisheries research and technology.

B) Extension system

The extension system consists of change agents, extension personnel belonging to Government and Non-Government agencies who act as links between the research and client systems. With a view to bridging the gap between innovations and their field adoptions the extension personnel have to make use of a number of extension methods for contacting and motivating the fish farmers. To sustain fisheries advance and to impart stability to yield, a continuous flow of economically viable technologies from the laboratories to the ultimate users, the CICFRI is involved in issuing self explanatory extension literature, organising short-term training course, maintaining advisory service, participating in exhibitions, organising fish farmers' days, organising demonstrations and utilizing Mass Media etc.

C) <u>The Client System</u>

The ultimate purpose of extension system is to provide useful and timely technological information to the farmers/fishermen. The fish farmers/fishermen, particularly in big country like India differ in their socio-personal, socio-psychological, economic and communicational characteristics and behavior which have to be taken into consideration for transfer of technology. If the benefits of research can be transmitted to the fish farmers/fishermen, the inland capture fisheries can play a greater role in creating job opportunities besides producing protein diet.

D) <u>Support System</u>

The task of dissemination is not complete by merely trickling down the information on innovations from research organisations to the farmers. The actual adoption of improved practices needs some supporting services too. Inadequate credit and aqua-support are some of the limiting factors in the spread of the technologies of inland fisheries. Liberalized financing policies aided by legal support for favourable leasing arrangements and provision of local input availability obviously will provide better support to popularise the technology among the fish farmers/fishermen.

Role of extension in the development process

It has been established that fish production from the beels could be substantially raised if the various factors contributing to modern techniques of inland fisheries and input requirement are planned out in details and adopted to meet the needs of that area.

Extension is a system which is used as an instrument to bring about a desirable change, be it sociological or technological. It is a multidimensional system with inter-relationships, linkages and transactions between and among interval and external domains. It aims at causing planned change or progress in the target field as per the greater sociological and economical changes designed by the political will of the people. In view of this crucial role, any programme planning development has to include the extension system as an integral part.

In regard to beel fisheries, research carried out by the CICFRI has laid due emphasis on the dynamics of productivity of the beel ecosystems and clues to their managements.

Inadequate communication of scientific information has added a problem in the expansion of research.

One of the important factors that have influenced the utilization and development of the beel fishery resources of the country, is the socio-economic condition of the fishermen community. Fishing is generally considered a low profession in India and practiced mainly by the members of a number of backward communities who, though very largely illiterate, superstitions and extremely poor. On account of their poverty and social status, they are forced to depend on midlemen. The fishing craft and tackle do not belong to the fishermen and he has to give away a good portion of his income as hire charges of the equipment. The low standard of their living conditions, the unhygienic surroundings in which they use to sell their produce and the poor cultural status have resulted in their social isolation. The vicious circle of circumstances has crippled the fishermen community both socially and economically.

Even during the very early days of the fishery development in India, it was realised that the socio-economic advancement of the fishermen is essential for the proper development of the fishery industry. In view of the nature of the economic problems faced by the fishermen, it was obvious that the elimination of middlemen by organising training course, group discussion, fish farmers' days, demonstrations, distributing literatures, credit facilities, marketing of produce and the purchase of domestic as well as production requirements through co-operatives, would go a long way in emancipating the fisher-folk. Minor ways of direct help includes purchase and operation of boats and gears which are either cheaper or long lasting. Extension work may encourage self-helping schedules for village improvements viz. health, transport, education, family planning etc.

Experience has shown that uncontrolled fishing and highly destructive devices of fish capture in beels deplete fishery resources and are followed by great economic distress. Mass communication on protective legislations for conservation of fisheries needs utmost importance.

Approach of extension in development

When we think of new strategies to approach the weaker sections, it would be always better to consider the ways and means to touch their socio-psychological group behavier.

The management of beel fisheries are mostly done at cooperative level. Since the fishermen are by and large economically backward and socially at lower strata of the society despite of their unstined efforts, dexterity and skill, their earnings on the whole are still at a lower level when compared with other industrial and professional workers. Organisation of fishermen co-operative societies on sound line may solve some of the economic and social problems of the fish farmers/ fishermen.

At present most of the fishermen cooperative societies of the country have been existing by name only. To revive the activities of these societies investment on management of beels are required to be brought under the cover of Insurance.

To handle extension work effectively training facilities are required to be extended to the fishery extension personnel.

Inadequate availability of finance including credit facilities has been identified as a bottle-neck for the development of beel fisheries in India. The smooth flow of finance in easier and simpler way will motivate clientele in adoption of the technology.

The beels are largely vested on the Government barring a few having private ownership. The fishing right is remains mostly with semi-government and private agencies. Thus, the management and disposal of these beels anchor lot of problems. For proper development, all the waterbodies need be brought under one agency like panchayat etc. for effective management.

The beels have substantial impact on the economy of the area in general and fishermen community in particular unless they are managed more judiciously. The fishermen will continue to remain below the poverty line.

The beels are very potent biologically and thus are capable to generate better economic environment vis-a-vis employment.

The fishery of the beels need be planned on the principal of capture-cum-culture fishery and thereby a stocking based crop should be given greater thrust and popularisation of Pen and Cage culture also need be given attention.

To enhance the level of adoption of improved practices it is essential to utilise information sources like publications, demonstrations, radio, news paper, fish farmers' days, exhibitions etc.effectively.

Increase of the productivity of the water bodies of the vast masses of fish farmers/fishermen, is possible only by regular transfer of technology by establishing proper and effective linkage between research, extension, inputs and credit.

LIMNOLOGICAL FEATURES OF BEELS-BIOTIC FACTORS

---- V.V. SUGUNAN

The 'environment and the 'biotic communities together constitute an ecosystem. Community refers to the living parts of the ecosystem and the environment embodies the total physical and chemical factors which exert an effect upon these living assemblages. In biological production systems like fisheries, the ultimate aim is to optimise the production of target communities. In aquaculture systems, where fish husbandry is practised under totally controlled conditions, both the environment and the biotic communities are manipulated. On the other hand, in capture fisheries, there is little room for altering the environmental parameters and the management norms centre round the manipulation of biotic communities. In any case, a sound knowledge on the structure and dynamics of various biotic communities is essential to manage the ecosystem effectively.

Beels are natural ecosystems which exhibit both fluviatile (riverine) and lacustrine (lentic) characteristics depending on their geographic and hydrographic characteristics, Beels are managed more or less on capture fisheries norms though stocking is resorted to, to correct the imbalances in fish species spectrum. In a lake ecosystem, the three major biotic communities of trophic significance are the plankton, benthos and the nekton. The harvestable biological products from fisheries waters often belong to the nekton which in turn depends on the plankton and benthos for their food, directly or indirectly. In beels, macrovegetation also plays a vital role in the energy transfer process which ultimately determines the fish output.

PLANKTON:

Plankton, by definition consists of "free floating organisms whose instrinsic power of locomotion, if present, is so feeble that they remain almost at the mercy of water movements". Plankton is a kaleidoscopic spectrum of organisms with representatives from almost all phyla of animals and thousands of species of non-flowering plants. Unicellular protozoams to vertebrates and bacteria to diatoms all drift around rubbing shoulders as the plankton community. Phyto-and zooplankton together constitute the base of the food pyramind. The quantitative and qualitative abundance of plankton give sufficient clues to the fish production potential of the lake to a considerable extent. Rate of production of plankton is determined by a host of environmental parameters like physico-chemical properties of water and soil, meteorological characteristics of the region and morphometric and hydrographic features of the beel.

The yearly average phytoplankton density in Media beel was reported to be 891 u l^{-1} with a peak each winter and summer, the main constituent of the water peak being Ceratium hirudinella and the summer peak maxima consisted of diatoms like Synedra ulna and Melosira granulata. The zooplankton density in this beel was 240 units l^{-1}. Total plankton recorded in Brahmapura oxbow lake in Gandak basin was reported as 1200 to 1,78,000 u l^{-1} which comprised thick blooms of Ceratium and Microcystis. Manika maun (oxbow lake) in the same river system recorded peak plankton production of 2400 to 4600 units l^{-1} in 1982 (11,390 units l^{-1} in 1983 and 5450 units l^{-1} in 1984). Kanti oxbow lake in Gandak basin recorded 6450 l^{-1} (Oscillatoria, Spirogyra, Phormidium. Navicula, Arcella, Cyclops, and Brachioms) in 1984 and 1209 units l^{-1} in 1985 with the breakup of 968 units of phytoplankton and 241 units of zooplankton the corresponding figure from 1986-87 was 1450 units l^{-1}.

In Garapota, a 122 ha open beel in West Bengal recorded 85 to 12,025 units l^{-1} during 1987 with the dominant species as Ceratium, Anabaena, Pediastrum, Botryoccocus, Amphora, Synedra, Nitzschia, Keratella, Brachionus, Filinia, Trichocerca, Ceriodaphnia and Chydorus.

Mogra beel in Nadia district of West Bengal is a closed beel choked with macrovegetation producing plankton to the time of 2 to 20 units l^{-1}.

BENTHOS:

Benthos community consists of animals, and plants living on the bottom, which are crawling on, burrowing into on attached to the bottom or a substratum. This includes the assemblage of organisms found attached to the submerged substrata commonly referred to as 'periphyton'.

Study of benthic communities in beels reveals the level energy being transferred through this phase and indicates trophic status of the lake. Organically rich bottom coupled with a conducive physico-chemical environment (soil) encourages fast colonization by the benthic community. Benthos, being nor or less sedentary organisms, are suitable condidates for assessing the pollution status of the beels through species diversity indices.

Benthos of beels are generally dominated by molluscs, insect larval, nymphs, and oligochaetes. Bellamya bengalensis and B. variatus are the most common among the gastropods, followed by Lymnaca accuminata Indoplanorbis exustus, Diogoniostoma cerameopoma, Brotia costula and Gyraulus convexiculus. Lammellidens marginalis, Parreysia corrugata and piscidium sp. are the common bivalves permit in beels.

It is often found that in beels, the bottom soil in blanketed by a thick mat of decayed macrovegelation which stinks and create anaerobic conditions and thereby restricting the growth of bottom fauna.

Periphyton:

The growth of periphyton is limited in beels in so far many of the beels do not have sufficient substrata for growth of this community. However, in weed chocked beels, the stems of plants provide sufficient substrate for periphytic growth. A variety of diatoms and ciliates which are not represented in the plankton and benthic province find their place among periphyton and they play a vital role in the trophic cycle of events in beels.

MACROVEGETATION:

This community is very important in the beel ecosystem as many of the beels, especially the closed ones, without sufficient water circulation are infested with a variety of floating submerged and emergent types of vegetation. The macrophytes often assumes the propotions of weeds and they lock away the nutrient resources of the lake. Therefore, weed management becomes necessary to effectively monitor the fisheries of the lake. A large number of animals like insects, mollucs, mites, annelids, and other animal groups thrive among the weeds and they are mostly of little consequence to the economic variety of fishes. Thus, the macrophytes and the weed associated fauna are to be suitably reckoned while assessing the biotic communities of the beels.

BIOTIC COMMUNITIES AND THEIR ROLE IN FISH PRODUCTION FROM BEELS.

Plants synthesise and store carbohydrates by the process of photosynthesis and are called primary producers. In the lakes and deep ponds, the sunlight which is essential for photosynthesis does not reach the bottom and therefore the bottom will be devoid of any vegetation. Thus, the whole production process is caused mainly by the phytoplankton excepting a limited littaral (belt of shallow areas all along the shores) vegetation and aquatic macrophytes. Phytoplankton is grazed upon by zooplankton which, in turn, sustains the higher animals. In a pyramidal relationship of aquatic organisms, the quantity of biomass of organisms rapidly gets reduced as they go up. About 10% of the biomass can be expected in a trophic level from the one just below it. Hundred tons of phytoplankton, thus, sustains 10 t of zooplankton and 1 t of nekton and benthos can be expected from it. when the nekton and benthos are predated upon by members of nekton, a similar reduction is effected. The actual food chain is, however, not as simple as this pyramid.

Phtoplankton froms the bulk of the food of zooplankton (some zooplankters are known to feed on detritus too). Many of the smaller members of nekton live on zooplankton. They include small weed fishes, insects etc. Carnivorous and predatory fishes feed on the smaller nekton and they contribute to commercial catches. When they die they contribute to detritus and are ultimately broken down to basic nutrients by the decomposing bacteria.

But, there are fishes directly feeding up.. on phytoplankton and zooplankton. Some fishes feed directly on detritus and thereby short circuit the protracted course of food chain. In e cosystem management, the studies of biotic communities becomes important, as the target fish species are selected in such a way that minimum energy is dissipated through the trophic chain. For instance, in a water body, where the zooplankton resource remain largely unutilized or underutilized, zooplanktophagous fishes are inducted to correct the imbalance.

Monitoring of fish populations in equally important. Since the beel fishery is basically extractive in nature, and the management is essentially on capture lines, the natural populations of fishes are to be encouraged to the maximum extent. However, stocking should be resorted to, for correcting any imbalances in the species specturm or to enable utilization of any specific food niches. Normally, the open beels retaining the connections with the river system offer scope for natural recuritment and the closed beels requires artificial recruitment (stoking).

Excessive growth of macrophytes often pose serious threat to the ecosystem. They blanket the water surface preventing penetration of sunlight and thus retards the growth of phytoplankton. The nutrients of water and soil phase are utilized for the unchecked growth of weeds. Weeds ultimately over-crowd and the dead planks sink to the bottom and toxic conditions are created. Thus, in weed choked beels, the solar energy is utilized mainly by the macrophytes and the fish population is limited to the air breathing species with a few detritophagous ones.

Through effective weed management the energy flow should be channelised through phytoplankton chain, rather than the macrophytes chain, which involves tremendous energy loss.

SPECIES DIVERSITY:

Stability of the ecosystem can be studied by comparing the species diversity of different communities. A number of species diversity indices are in vogue to study the variety, evenness, and dominance of different species. When a community is sampled, it is often found that a few species are represented by a lot of individuals and a large number of species by a few individuals. These relative abundance must be considered to represent the basic pattern of niche utilization in the community. Ratios between the number of species and importance values of individuals are called species diversity. There is an assortment of methods to calculate the indices to describe this diversity, all trying to establish relationship between total number of individuals (N) and the number of species (S) in a stand. The major components of species diversity indices are the 'variety indese' (d) which explains the species richness, 'equitability indese' (J) which indicates how evenly different species are packed among the total community and 'the concentration of dominance' (C) indicating how certain species outnumber others in their distribution. Shannon-weaver index is a general index universally used for comparing the ecosystems.

Species diversity indices give clue towards the stability of ecosystems, they indicate the impact of environmental modifications on the ecosystem and their general diviation from the natural community succession process.

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PRACTICAL

ANALYSIS OF PHYSICO-CHEMICAL PARAMETERS OF WATER AND SOIL

——— Babu Lal

INTRODUCTION

Chemical composition of water not only alter the physical properties of the medium but also have a significant influence on the life forms, which in turn, tend to change the chemical quality of water in due course of time. Therefore, to understand the behaviour of ecosystems from the holistic point of view, it is essential that due stress be given on physical and chemical features of the system. Some of the important parameters can be estimated as follows :-

Water analysis

Physical parameters	Chemical parameters
1 - Temperature 2 - Transparency	pH, Alkalinity, Free CO_2, D.O., Nitrate, NH_3, Phosphate, Organic matter, Calcium, Magnesium, Silicate, Specific conductivity and Iron etc.

Physical parameters

a) Temperature :- This can be recorded with an ordinary thermometer (accurate upto 0.1 °C).

b) Transparency :- (Secchi Disc method). The disc consists of a circular metal plate of 20 cm in diameter. The upper surface of which is divided into four equal quadrants each of them being painted black and white alternately while the lower side of the plate is painted black to eliminate reflection of light from that side. The disc is lowered with the help of a rope into the water and the depth (d_1) at which it disappears is noted. Now the disc is lifted slowly and the depth (d_2) at which the disc reappears is noted.

$$\text{Transparency} = \frac{d_1 + d_2}{2}$$

Chemical parameters

a) pH : Electrometric method :- Take the sample in a clean glass beaker, immerse the thoroughly cleaned wiped and dried electrode into the water and note the pH.

b) Colorimetric method :- (Lavibond comperator)- The principle of this method is to develop colour in the sample with one indicator dye and to compare this with colour of disc. Place 10 ml of sample in clear glass tube and add 0.5 ml of indicator. After the addition of indicator stirr the sample and match the colour developed against the colour disc in the comparator. To know which indicator is suitable make a preparatory test with universal indicator which gives an approximate pH. As the pH of the inland water generally varies between 6.0 to 9.0 the indicators bromothymol blue, phenol red and thymol blue may be used.

Alkalinity

In water analysis generally three types of alkalinity are noted. They are OH^- (hydroxides), CO_3^{-2} (Carbonate) and HCO_3^- (bicarbonates). They are determined by using seperately two different indicators phenolphthalein and methyl orange. The alkalinities so determined are called 'P' and 'M'. For all practical purposes however methyle orange alkalinity M.O.A. gives a measure of the acid combining capacity of water.

Regents

1. 0.02 N H_2SO_4 :- 30 ml of conc. H_2SO_4 (Sp. Gr. 1.84) is diluted to 1 litre. It gives 1N H_2SO_4. Take 20 ml of this solution and dilute to 1 litre. It is approx. 0.02 NH_2SO_4.

2. Standard 0.02N Na_2CO_3 :- Take 5.3 gms of anhydrous Na_2CO_3 in 1 litre of distilled water. It is 0.1 N Na_2CO_3 solution. Take 50 ml of this soln and dilute to 1 litre. It is 0.02N Na_2CO_3.

3. Phenolphthalein indicator :-

   Procedure

   i) Phenolphthalein alkalinity (P) :- Take 50 ml of the sample in a conical flask + 2 drops of phenolphthalein indicator. If the sample remains colourless (P) is absent. If it turns pink - Titrate with 0.02N H_2SO_4 until the pink colour disappears and note down the end point reading.

   P (as ppm of $CaCO_3$) = No. of ml of 0.02NH_2SO_4 X 20

   ii) Methyl orange alkalinity (M) :- Proceed is the same way as before using methyl orange as indicator at the end point the colour changes from yellow to faint orange.

Free Carbon-di-oxide

As this gas is liable to escape easily from the sample, analysis should be done immediately after collection.

Regents: $\frac{N}{44}$ NaOH; 4 gm of A.R. quality NaOH id dissolved in 1 litre of water, which gives 0.1 N NaOH. Standardise this solution with 0.1 NH_2SO_4 using phenolphthalein indicator. 100 ml of this solution diluted to 440 ml gives $\frac{N}{44}$ NaOH.

Procedure :- Take 50 ml of water sample in a conical flask. Add 2 drops of phenolphthalein indicator. If the colour of water turns pink, there is no CO_2 present. If the water is colourless, add drop by drop with the help of a graduated 10 ml pipette with gentle stirring till the colour turns pink.

Calculations :- No. of ml of $\frac{N}{44}$ NaOH required X 20 = ppm of free CO_2

(D) Dissolved oxygen (Winkler's method)

Principle :- The principle of this method is based on the oxidation of manganous sulphate in alkaline medium by the oxygen present in the sample into mangnese oxyhydroxides /[$MnO(OH)_2$]/ This on acidification with concentrated sulphuric acid liberates oxygen which in turn liberates equivalent amount of iodine from KI. This iodine can be titrate with sodium thiosulphates using starch indicator. From the amount of iodine liberated the amount of oxygen originally present in the sample can be calculated.

Reagents

i) Manganous Sulphate:- 480 g of $MnSO_4$, $4H_2O$ or 400 g of $MnSO_4$, $2H_2O$ dissolved in distilled water and made upto 1 litre.

ii) Alkaline iodine :- 700 g of KOH or 500 g of NaOH and 135 g of Nal or 150 KI in distilled water and diluted to 1 litre.

iii) Sulphuric acid concentrated

iv) Starch Soln :- Make an emulsion of 2 g of starch in distilled water. Add this emulsion with 350 ml of boiling water in conical flask.

v) Standard Sodium Thiosulphate :- 24.82 g of Sodium thiosulphate dissolved in distilled water and diluted to 1 litre of distilled water, it gives 0.1 N $Na_2S_2O_3$. Standardise this solution with 0.1 N$K_2G_2O_7$ solution. 64.904 g dissolved in 1 litre. 125 of this solution diluted to 1 litre gives N/80 $Na_2S_2O_3$.

Procedure :- To the sample collected in 250 ml bottle add 2 ml of Manganous sulphate followed by 2 ml of alkaline iodide reagent well below the surface of the liquid, stopper with care to completely exclude air bubbles and misc. by inverting the bottle several times. Allow the precipitate to settle for some time leaving or lear supernatant above the precipitate. Carefully remove the stopper and add 2 ml of concentrated sulphuric acid and mix until the precipitate is dissolved. Take 50 ml of the soln andtitrate with standard thiosulphate (N/80) to pale yellow colour. Add 1 to 2 drop of freshly prepared starch soln and continue the titration to the first disappearance of blue colour.

Calculations: Dissolved oxygen (ppm) = 4 X No. of ml of $Na_2S_2O_3$ soln
(1 ml of $Na_2S_2O_3$ = 0.1 mg O_2)

Dissolved organic matter

Reagents

i) Standard $KMnO_4$ solution (1 ml = 0.1 mg O_2)

Dissolve 0.4 gm of $KMnO_4$ in distilled water and make upto 1 litre. Standardise this solution with standard ammonium oxalate solution in acid medium (1 ml of $KMnO_4$ = 1 ml of oxalate = 0.1 mg of O_2.

ii) Standard Amm-oxalate solution :- Dissolve 0.888 g of amm. oxalate in distilled water and make up to one litre.

iii) Dilute Sulphuric Acid (1:3) add 100 ml of conc. sulphuric acid slowly into 300 ml of distilled water.

Procedure

50 ml of sample in a 250 ml conical flask and acidify with 5 ml dilute sulphuric acid. Add 10 ml of standard $KMnO_4$ solution and keep it in a bath of boiling water for 30 minutes. Remove it and add 10 ml of ammo-oxalate. The pink colour of permanganate will disappear. Now add standard permanagaganate drop by drop from a graduated 10 ml pipette until the pink colour reappears.

No. of ml of $KMnO_4$ sol^n required X 0.1 X 20 X 0.375 = ppm of organic matter

Dissolved phosphates

Reagents

i) Sulphuric acid (50%)
ii) Ammonium molybdate (10%)
iii) Acid ammonium molybdate 15 ml of 50% H_2SO_4 + 5 ml of 10% Amm.molybdate
iv) Stannous chloride
v) Standard phosphate (1 ml = 0.01_p); 4.338 g of monobaric phosphate (KH_2PO_4) in 1 litre distilled water.

Procedure:- Place 50 ml of the sample in Nessler's tube add 2 ml of acid molybdate and 2 drops of stannous chloride mix gently, a blue colour develops. Prepare a number of standard solutions of phosphate in the Nessler's tube and add 2 ml of acid molybdate and 2 drops of stannous chloride. Match the blue colour of the solution with the standards.

No. of ml of standard phosphate X 0.01 X 20 = ppm of of P. (The method is based on the principle that phosphorus develops blue colour of phospho-molybdic acid in presence of acid molybdate and stannous chloride).

Nitrogen (Ammonia & Nitratenitrogen)

Reagents:

a) Nessler's solution
b) Standard NH_4Cl solution : Dissolve 3.819 g of anhydrous ammonium chloride in ammonia free distilled water and dilute it to 1 litre (1 ml = 1 mg N), 10 ml of this solution to 1 litre with ammonia free distilled water (1 ml = 0.01 mg N).
c) Ammonia free distilled water
d) Magnesium oxide
e) Devard's alloy

Procedure

Distillation method :- Place 50 ml of water sample in a Kjeldahl distillation flask. Add approximately 0.5 g magnesium oxide followed by 50 ml of ammonia free distilled water and distil in a Kjeldahl distillation unit. Collect 40 ml of the distillate. After making it 50 ml place it in a Nessler's tube. This gives the ammonia present in the sample (A). To know the amount of nitrate cool the distillation flask after ammonia distillation. Add small amount of devard's alloy to the contents of the flask followed by 50 ml of ammonia free distilled water. Distill the mixture in the similar way. Nitrate is reduced to ammonia by the Devard's alloy. Collect 40 ml of the distillate make up to 50 ml and keep it in the Nessler's tube. This gives the nitrate present (B).

Prepare a number of solutions of different nitrogen content from the standard solution. Add 1 ml of Nessler's reagent to each and also to the two distillates (NH_3 and NO_3^-). Match the colour of both Ammonia distillate (A) and nitrate distillate (B) with the colour of the standards.

No. of ml of standard far (A) X 0.01 X 20 = ppm of NH_3-N
No. of ml of standard far (B) X 0.01 X 20 = ppm of NO_3-N

i) Silicate : Silicate can be determined easily by colorimetric methods using artificial standards.

Reagents

a) Standard Picric acid soln - 108.8 mg/litre or standard Potassium chrom solution 284 mg/litre. Both are equivalent to 0.1 mg Si/ml.
b) 10% Ammonium molybdate solution
c) 25% sulphuric acid (by volume)

Procedure: Prepare a series of standard soln of different concentrations of either chromate or peric acid in 10 ml of water in Nessler's tubes. To 10 ml of sample add 0.5 ml of ammo-molybdate and 4 drops of 25% sulphuric acid. Match the yellow colour developed with the standard solutions.

No. of ml standard X 01 X 100 = ppm of Si

(J) - Iron

Iron is present in water in the soluble ferrous form. This is acidised to ferric form and when treated with ammonium thio-cyanate develops red colour of ferric-thio-cyanate.

Reagents:

i) $6N HNO_3$

ii) Standard Iron solution (1 ml = 0.01 mg iron)

iii) Ammonium-thio-cyanate in distilled water and make upto 1 litre.

Procedure:- To 50 ml of sample add 5 ml of 6 $NHNO_3$ and boil the mixture for some time evaporating half of the solution. Cool the solution, make to 50 ml and place in Nessler's tube. Prepare a number of iron solution of different concentration from the standard iron solution. Add 1 ml of ammonium-thio-cyanate to the sample and the standard solutions. Match the red colour developed in the sample with standard solutions.

ml of sample X 20 X 0.01 = ppm of iron

(Standard iron solution - 0.702 gm of Ferrous Ammonium sulphate in 50 ml of water. To it add 20 ml of conc. H_2SO_4 and dilute to 1 litre. 1 ml of this sol^n contains 0.1 mg Fe. 100 ml of this sol^n diluted to 1 litre gives

(1 ml = 0.01 mg Fe)

Calcium, Magnesium and Hardness

CEDTA or Versenate methods Divalent metals lkke Ca and Mg form chelate complexes with disodium dihydrogen ethylene diamine tetracetate dihydrate (E. D. T. A.).

Reagents

i) Standard Sodium Versenate: Dissolve 2.5 g of Sodium versenate in two (2) litres of distilled water. Add 13.5 ml N NaOH. Dilute to 2.5 litres amd adjust by titrating against standard calcium solution so that (1 ml of versenate = 0.01 E of Mg^{++}).

ii) Indicator for Ca (solid) : 0.2 gm ammonium purpurate and 100 g of NaCl are ground together in a mortar and kept dry.

iii) N NaOH solution

iv) Indicator for Ca + Mg : 1 g of Erichrome Black and 1 ml of Na_2CO_3 in 30 ml distilled water, mix together and make upto 100 with isopropyl alcohal.

v) Buffer solution : 67.5 g NH_4Cl in 570 ml conc. NH_4OH and diluted with distilled water

Procedure :- For Calcium alone: Take 5 ml of sample in a parcelein dish. Add 5 drops of NaOH solution and small amount of ammonium purpurate and dilute roughly 25 ml. Ammonium purpurate has purple colour but in presence of Ca, the colour of purpurate is restored again. Add drop by drop versenate solution with the help of a graduated pipette with frequent stirring till the purple colour is restored. Magnesium does not change the colour at this pH.

ml of versenate X 200 X 0.01 X 20 = ppm of Ca

For Ca & Mg

Take 5 ml of sample in a porcelein dish 0.5 ml of buffer solution and 2 - 3 drops of erichrome black T indicator. The sol^n becomes red. Add versenate solution drop by drop with the help of a graduated pipette until the blue colour of the dye is restored.

(ml of Versenate - ml of versenate for Ca) X 0.01 X 200 X 12 = ppm of Magnesium

Total hardness as $CaCO_3$ = (ml of versenate used for Ca + M) X 0.01 X 200 X 50 = ppm $CaCO_3$

ANALYSIS OF SOIL

Mechanical analysis	Chemical analysis
Sand, Silt, Clay	pH, Organic carbon, available-N, Available-P, Free $CaCO_3$, Sp. Conductivity

Mechanical analysis

Gravimetric Method

Reagents

i) Hydrogen peroxide (6.0%)

ii) N Hydrochloric acid

iii) N Sodium hydroxide

iv) Silver nitrate solution (5%)

v) Ammonium hydroxide solution

Procedure :- Take 20 g of soil in 400 ml beaker, add 35 ml H_2O_2 to it keeping the beaker in a water bath, when the reaction is over add more H_2O_2 till no more frothing takes place, Coat, add 50 ml NHCl and 200 ml distilled water to make the soil free of carbonates. Allow the content to stand for an hour with occasional stirring. Filter the soil and wash free of acid with hot water tested by $AgNO_3$ solution. Transfer the soil to one litre beaker add 8 ml N NaOH sol^n and shake for 20 minutes in a mechanical shaker. Transfer the content to a 1000 ml tall measuring cylinder, make up the volume and shake vigorously for one minute and allow to stand for 4 minutes. Lower a 20 ml pipette, 10 cm deep and suck out 20 ml of the content, dry it in a porcelein dish to a constant weight to get the weight of clay + silt. Repeat the operation after six (6) hours to get the weight of clay alone. Now percentage of sand can be calculated by deducting the percentage of clay + silt from 100, similarly the percentage of clay is subtracted from that of clay + silt to get the percentage of silt.

Chemical analysis

pH (a) Electrometric method :- Take 10 g of soil in 50 ml beaker and add 25 ml of distilled water (soil;water 1:2.5). Stirr the suspension at regular interval for 20 minutes. Immerse the electrode of the pH meter into the sample and note the pH.

(b) Colorimetric method

Reagents

1) Neutral Barium sulphate
2) Indicator solution (Bromophenol blue 3.0 = 4.6) (Bromocresol green 3.8 to 5.4), Bromocresol (purple 5.2 - 6.8), (Bromothymol blue 6.0 - 7.6), Phenol red 6.8 - 8.4), (Thymol blue 8.0 - 9.6)

Procedure: Place a layer of neutral $BaSO_4$ one cm thick in a 50 ml dry test tube, add 10g of air dry powdered soil and 25 ml of distilled water, shake well for 10 minutes and keep it for setling. Take 10 ml of clear aliquot in a clear glass tube add 0.5 ml of indicator and match the colour against colour discs and note the pH.

Organic Carbon

Reagents

a) Normal Potassium Dichromate solution : Dissolve 49.04g of reagent grade $K_2Ca_2O_7$ in distilled water and make upto 1 litre
b) Normal Ferrous sol^n: Dissolve 278.0g of Ferrous sulphate or 392.13g of ferrous ammonium sulphate in distilled water, to it add 15 ml of conc. H_2SO_4 and make up to 1 litre

c) Diphenyl anime indicator : 0.5 g dipheyl amine in 10 ml conc. H_2SO_4 and 20 ml distilled water.

d) Phosphoric acid (85%)

e) Conc. H_2SO_4

Procedure : Place 1 g of soil sample in a 500 ml conical flask. Add 10 ml of $NK_2Cr_2O_7$ and mix the tw. Then add 20 ml of conc. H_2SO_4 and mix by gentle rotation for 1 minute. Allow the mixture to stand for 30 minutes. Dilute it with distilled water to 200 ml and add 10 ml of phosphoric acid (85%). Titrate the excess of dichromate with $NFeSO_4$ solution using 1 ml diphenyl amine as indicator.

% Organic carbon = (10- No. of ml of $FeSO_4$ required) X 0.003 X 100

Available Nitrogen (Alkaline - Permangnate method)

Reagents

a) 0.02 NH_2SO_4: 30 ml of conc. H_2SO_4 diluted to 1 litre with distilled water to give 1 NH_2SO_4 sol^m 20 ml of this sol^n diluted to 1 litre (0.02 NH_2SO_4)

b) 0.(2 N NaOH - 4g of so ium hydroxide isolved in water and diluted to 1 litre to give 0.01 N NaOH standardise against 0.1 NH_2SO_4. 100 ml of 0.1 N NaOH diluted to 500 ml to give 0.02 N NaOH.

c) Methyl red indicator

d) 0.38% $KMnO_4$ sol^n - Dissolve 3.8g of $KMnO_4$ crystals in distilled water and make upto one litre.

e) 2.5% NaOH soln. Dissolve 25g of NaOH in distilled water and make upto one litre

Procedure : Place 10g of air dried powdered soil in 500 ml Kjeldahl distillation flask. Add 100 ml of 0.38% $KMnO_4$ sol^n and 100 ml of 2.5% NaOH, 2 ml of liquid paraffin and 10-20 glass beads and distil the mixture, collecting the distillate in conical flask containing 20 ml of 0.02 NH_2SO_4 and few drops of methyl red inuicator. Collect 75 ml of the distillate. Titrate the excess of 0.02 NH_2SO_4 with 0.02 N NaOH to a colourless end point.

Available Nitrogen (mg/100g soil)
= (20 - No. of ml of 0.02 N NaOH) X 2.8

Available phosphorus (Troughs methods)

Reagents

a) 0.002 NH_2SO_4 - Dilute 100 ml of 0.02 NH_2SO_4 (standardised) to 1 litre. Adjust the pH to 3.0 with 4m - sulphate
b) 50% of H_2SO_4
c) 10% Ammonium molybdate
d) Stannous chloride - 2.15g of A.R. quality stannous chloride in 20 ml conc. HCl. After the soln in complete add sufficient distilled water to make upto 100 ml and place a small piece of metallic tin in the bottle.
e) Acid - Ammon-Molybdate - 15 ml of 50% H_2SO_4 to 5 ml of 10% amn-molybdate. This should be prepared fresh at the time of analysis.
f) Standard phosphate soln (1 ml = 0.01 mg P) - 4.388 g of Potassium dihydrogen phosphate (KH_2PO_4) dissolved in phosphate free distilled water and made upto 1 litre. This soln contains 1 mg P per ml. 10 ml of this soln diluted to 1 litre (0.01 mgP/ml)

Procedure : Place 1 g of air dried powdered soil in 250 ml bottle. Add 200 ml of 0.002 NH_2SO_4 (pH adjusted to 3.0 with Am-sulphate). Shake the mixture for 30 minutes in a mechanical shaker. Keep it for 10 minutes and filter. Take 50 ml of the soln in a Nessler's tube, add 2 ml of acid amn-molybdate reagent and 2 drops of stannous chloride, mix gently, wait for five minutes; and match the blue colour developed with stannous phosphate solutio..s of different concentration in phosphate free distt. water.

Free $CaCO_3$

Reagents

a) 0.5 NHCl solm

b) 0.5 N NaOh solm

c) Bromothymol blue indicator

Procedure : Place 5 g of air dried powdered soil in 250 ml bottle and add 100 ml of 0.5 NHCl and shake for one hour. Allow to settle the suspension and pipette out 20 ml of supernatant liquid. Transfer to a small conical flask and add six drops of bromothymol blue indicator when yellow colour develops. Titrate it with 0.5 N NaOH till it is just blue, carry out blank experiments taking 20 ml of 0.5 NHCl in a flask and titrating it in the same way

$$\% \ CaCO_3 = (\text{Titre for blank} - \text{Titre for soil soln}) \times 2.5$$

Specific conductivity

Take 10g of soil in 50 ml beaker and add 25 ml of dis - tilled water (soil: water, 1:2.5). Stirr the suspension on regular intervals for 20 minutes, Immerse the conductivity bridge into the sample and note the conductivity (micro mhos). Portable water analyser kit is highly recommended for the estimation of electrical conductivity and total dissolved solids in the soil water extracts of 1:2.5 ratio

ESTIMATION OF PRIMARY PRODUCTIVITY

——— Babu Lal

The concept of "Production" is the total amount of organic matter produced in a given space during a given period (Thienemann, 1931). However, sometimes it has often been confused with the concept of standing crop. Odum(1971) defined basic or primary productivity of an ecological system, community, or any part thereof, as the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producer organisms, chiefly green plants, in the form of organic substances which can be used as food. The difference between the successive steps in the production process are as below:-

1. Grass Primary Production/Total Photosynthesis/Total Assimilation

It is the total product of photosynthesis, including the organic matter used up in respiration during the measurement period.

2. Net Primary Production/Apparent Photosynthesis/Net Assimilation of Photosynthesis

It is the storage product which is available for the next trophic level, or organic matter in plant tissues in excess of the respiratory utilization by the plants during the period of measurement.

Measurement of primary productivity

Earlier studies on primary production were restricted to the indirect estimation of production by long term changes of the standing crop and the concentration of inorganic nutrients or dissolved gases. Recently, primary production has been determined by the direct measurement of photosynthesis, since the basis of the organic matter production in the water is the photosynthesis of plants, especially by phytoplanktons. For this purpose, the so called "Light and Dark bottle Oxygen method" has usually been employed, but the sensitiveness of this method is unfortunately insufficient in low productive areas (Saij & Ichipura, 1961). The drawback has been overcome by the Radio-isotope Carbon-Tracer Technique introduced by Steemann Nielsen (1952). On other hand, the pigment analysis method was introduced by Ryther & Yentech (1957) for the determination of standing crop of phytoplankton. Some of the methods used to determine the primary productivity in aquatic media are summarized here.

A. MEASUREMENT FROM THE STANDING CROP OR OF DISSOLVED SUBSTANCES IN WATER

1. Change in standing crop of phytoplankton and its grazing by zooplankton.
2. Cell-size decrease method.
3. Changes in CO_2 and phosphate values
4. Changes in O_2 and NO_3^- ions

B. DIRECT MEASUREMENT BASED ON THE DETERMINATION OF PHOTOSYNTHESIS

i) pH method : Moore (1924) calculated the production on the basis of pH change which is caused in water by the uptake and release of CO_2 through photosynthesis and respiration.

ii) <u>Oxygen method</u> : Gaarder & Gran (1927) calculated the photosynthesis from amount of oxygen produced by phytoplankton during a given time.

<u>Sampling</u> : Water samples should be collected from regular depths or at percentage of surface illumination (100%,75%, 50%, 25%, 1%) with Vandron bottle of 2 litre capacity,are filled in the four bottles i.e. Initial (one), Light (two) and dark. Dark bottles are prepared by polishing or painting the clear corning, ground stoppered bottles with black enamel paint. To ensure the absence of light a black cloth or resin bag may be used, as a cover of the bottles. The depths can be calculated by Sechi disc readings.

<u>Procedure</u> : Add Winkler-A and Winkler-B (0.5 ml in 125 ml sample) in the Initial bottle. Sets of'light and dark' bottles are suspended <u>in situ</u> at the original depths where from the water sample is taken. They can be suspended from sunrise to noon or noon to sun set on a float or from a simple bamboo stand which is triangular in shape. After a given period, 6 or 12 or 24 hrs, the oxygen content of each bottles is determine by the Winklers method.

From the difference between the initial and the final concentration of oxygen, net production is obtained in the transparent bottles (L - I) and respiration in the dark bottle (I - D). However, it should be noted that the decrease of the oxygen in the dark bottle resulted from the consumption of oxygen not only through respiration of phytoplanktons and other organisms, but also through the decomposition of organic debris in the water. It should also be noted that the condition inside the dark bottles favours the bacterial growth. These bacteria also liberate dissolved oxygen and the total oxygen in the bottle increased. If this increase is accounted for calculations it leads to the over estimation of gross production.

Calculations

Oxygen estimated by Winkler's method is used for the calculating primary production.

$$\text{P. production (mgC/l)} = \frac{O_2 \text{ (ml)} \times 0.375}{PQ}$$

PQ = Photosynthetic Quotient = 1.25 (Strickland, 1960)

0.375 = factor (Qasim et al., 1968)

O_2 (ml) = 1 - D Respiration (In respiration, instead of PQ, RQ is used, which is generally equivalent to 1)

L - D Gross production

L - 1 Net production

These data are convenient to gm of oxygen per cubic meter by multiphying the numerator and denominator by 1000.

$$\text{mgC/m}^3 = \text{mgC/l} \times 1000$$

$$\text{Primary productivity (mgC/m}^3\text{/hr)} = \frac{O\text{(ml)} \times 0.375 \times 1000}{PQ \times \text{No.of incubation hrs}}$$

Plankton community respiration (mg oxygen consumed per hr)

$$= \frac{I - D}{24}$$

ESTIMATION OF PRIMARY PRODUCTIVITY BY RADIOISOTOPE CARBON-14 METHOD

A more sensitive method of measuring phytoplankton production was introduced by Steemann-Nielsen (1952). In this procedure, after the addition of a definite amount of ^{14}C in the form of carbonate ($NaH^{14}CO_3$), the water sample is exposed to light for a given period of time (No. of hours). After exposure, the water sample is filtered and the amount of ^{14}C fixed in the plankton cell is determined and the amount of assimilated carbon is calculated.

To determine production under field conditions, the ^{14}C method is employed in three ways.

1) '*In situ*' method
2) 'Tank' method
3) The 'Modified Tank' method

In the last two methods, incubation of bottles is done in the laboratories. The principal advantage of ^{14}C method is that it is a more sensitive method of measuring the production. The method is more useful in oligotrophic waters because even low production can be measured correctly.

The disadvantages of this method particularly for Indian workers who work in small places are high cost of instruments and difficulties in obtaining permission for Radio-isotopes studies.

Apparatus

1. Incubation bottles (125 ml, corning) clear as well as dark
2. Float
3. Polyvinyl Chloride (PVC) Vandorn samples
4. Bottles for Alkalinity and pH
5. Aluminium foil or absorbent paper
6. Inoculation syringe 1 ml

7. Rubber gloves
8. Container for radioactive waste (solids and liquids)
9. Sqeeze bottles with 5% HCl for decontamination of spills
10. Membrane filtration apparatus
11. Vacuum pump
12. Membrane filters (0.45 μm pore size of 47 mm diameter if counting is by liquid scintillation or 25 mm if counting is by G.M. or PGF counters
13. Small foreceps
14. Aluminium planchets and moderately fast drying house hold cement (DUCO) if planchet counting/or liquid scintillation vials if using liquid scintillation for counting;
15. Wax pencil or felt tipped pen
16. pH meter
17. Titration equipments for alkalinity

Chemicals : ^{14}C tagged ampoule (sp. activity = 2 microcuries/ml). For extensive work purchase concentrated solution and dilute, then fill and seal ampoules as follows; Purchase $Na_2{}^{14}CO_3$ stock solution with a radioactive concentration of 2.0 millicuries/ml. Dilute 1 ml of stock solution to one litre with a dilution solution (50 gm NaCl + 0.3 gm Na_2CO_3 and one pellet of NaOH in one litre of distilled water). Fill ampoule with quantity desired and seal. Autoclave them in inverted position in a metal pan filled with a diluted Methylene blue solution. Remove from autoclave and cool to room temp. in a pan of dese solution. Any ampoules that have an imperfect seal will suck the dye solution inside should be discarded (Wolf & Schelske, 1967).

Procedure for 'In situ' method

Select the stations and depths as for oxygen method, collect water samples from desired depth fill 2 light bottles, one dark bottle and one bottle for pH and alkalinity measurement. The stations and different depths are selected in the same way as discussed earlier for oxygen method. Open an ampoule and fill syringe without air bubble. Inoculate the ^{14}C soln at bottom of the bottle, using the long cannula. Remove cannula quickly and restopper it and cap with a black fail.

Suspend the bottles at desired depths. After incubation, retrive bottles and place in blackened ice box and cover them with ice. Care should be taken that the period of storage in ice should not exceed three hours. Filter the samples wash the filtration unit with distilled water and 2% HCl, Choose any of the following method for counting.

1) Planchet counting

Smear a thin films of cement on planchet and place filter on cement. A few seconds delay will allow a surface film to dry. Write appropriate label on bottom of planchet count a known standard, not minimum of 2,000 cells.

2) Liquid scintillation counting

This is more efficient method over previous one (Lind & Champbell, 1969). Remove the filter and coil to place vertically in scintillation vial, with algal layer to the inside. Two scintillation cocktails are used. One regime for desiccation of filters and second does not require desiccation and permits rapid completion of the procedure, when dry, add 20 ml of cocktail 4 gm PPO (2,5 diphenyl oxazol) + 100 mg dimethyl POPOP [T4-bis-2 (4 methyl-5 phenyl-oxazoly) - benzene are dissolved in toulene (AR) and make the valume one litre] cap vial immediately and label the cap. The dry filter will become transparent in the cocktail. Wipe finger prints from vial before placing it in counter.

Calculations

Rate of photosynthesis P = Pl -Pd and Pl or Pd = $\frac{r}{R}$ X C X f

P = photosynthesis rate (mgC/m^3)

Pl = Carbon uptake/m^3 in light bottles

Pd = Carbon uptake/m^3 in dark bottles

r = uptake of radioactive carbon/minute = counts per minute for filtered)

$$\frac{\text{Volume of bottles}}{\text{Volume X Volume filtered}}$$

R = ^{14}C inoculated in counts/minute = 2.22 X 10^6 X micrococcus added X efficiency of counter

C = Inorganic carbon (^{12}C) available in mg/m^3 = total alkalinity X conversion factor from table 1 X 1000

f = correction of slower uptake of ^{14}C as compared with ^{12}C = 1.06 e.g. suppose 125 ml light bottle is inoculated with 2 microcuries ^{14}C. 50 ml is filtered and count was 4500/minute at an efficiency of 85%, pH = 7.5 and total alkalinity is 100 mg/litre at 20°C.

$$Pl = \frac{4500 \times \frac{125}{50} \times (100 \times 0.26 \times 100) \times 1.06}{2.22 \times 10^6 (2)\ 10.85}$$

= 82.90

So, 82.90 mg uptake in light/m^3/incubation/time. Same calculation is for dark bottle. The difference of light (Pl) and dark (Pd) will give net photosynthesis.

MEASUREMENT OF PRIMARY PRODUCTION BY PHYTOPLANKTON PIGMENTS

INTRODUCTION

Green pigments found in phytoplankton, absorbs energy from sunlight, enabling them to buildup carbohydrate from carbon-di-oxide and water during the process of photosynthesis.

$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{\text{Solar energy}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

The chlorophyll is the general name of green pigments and is used as production index. These are tetrapyrolic malecules with a central magnesium atom and two ester groups and absorb red light (650 to 680 mμ) and blue light (400 to 450 mμ). Five types of chlorophyll (a,b,c,d, & e) are groups of the Algae. The distribution of these pigments in three main groups of the Algae are as follows (Round,1975).

Chlorophylls	Formulae	Chloro-phyceae	Cyano-phyceae	Bacilla-riophyceae
Chlorophyll a	$C_{55}H_{72}O_5N_4Mg$	Present	Present	Present
Chlorophyll b	$C_{55}H_{70}O_6N_4Mg$	Present	Absent	Absent
Chlorophyll c	Unknown	Absent	Absent	Present
Chlorophyll d	$C_{54}H_{70}O_6N_4Mg$	Absent	Absent	Absent
Chlorophyll e	unknown	Absent	Absent	Absent

The another fat soluble group of pigments comprising the yellow or red coloured carotenoids consisting of carotenes, xanthophylls and carotenoid acid. They obsorbs blue-green light (430 - 510 m) and present in all groups of the algae. As these phytoplankton pigments having different ranges of light absorption, helps the phytoplankton to remain actively fixing light energy into organic food over a great depth. As a measures of standing crop of phytoplanktons, chlorophyll and carotenoid were first used by Harvey (1934) in the ocean and by Koxminski (1938) in lakes. The spectrophotometric determination of chlorophyll of Richards and Thampson (1952) facilitated the seperate determination of chlorophyll a, b, c and carotenoids in oceanic waters. The so called chlorophyll method has been used as a basis of calculating the amount of organic matter produced in a given space during a definite period and also as a characterization of community age and structure. (Odum, McConnell and Abboott, 1958), quantification of phytoplankton standing crop (Small, 1961) and photosynthetic rates (Ryther and Yestsch, 1958). The physiological state of the phytoplankton and nature of the water (Productive/unproductive) can also be known from the ratios of chl.a/chl.c and chl.a/carotenoid (Becacos-Kenton, 1973, Bhagava and Dwivedi, 1974).

ESTIMATION OF PIGMENTS

The plant pigments are assayed by using the following method proposed by Richards & Thompson (1952) and slightly modified by NAS - (NRC committee Nat.Acad.Sci-Nat.Res.Council) on Oceanography (1964)

Equipment & Apparatus

1. Spectrophotometer or spekol (= spectro colourimeter)
2. Millipore or sartoris filtration unit
3. Stoppered graduated centrifuge tubes of 15 ml capacity
4. Millipore or sartoris membrane filter papers (47mm diameter with 0.45 (pore size) or Whatmans glass fibre filters (GF/C; 4.25 cms dia.)
5. Centrifuge
6. Wash bottles
7. Vacuum pump etc.

Chemicals

1. 90% Acetone - Chemicals should be of AR grade for better results

   90 ml of Acetone + 10 ml of redistilled water, Transfer into a plastic wash bottle. It is recommended that for better results, use fresh 90% Acetone

2. 1% Magnesium Carbonate suspension

   This is prepared by dissolving 1 gm of $MgCO_3$ in 100 ml of dist. water, use immediately.

Sampling

Collect 500 to 5 litres of water sample from any part or zone with Vandorn water sampler and to prevent the entry of the zooplanktons water samples should be filtered through a small piece of 0.3 mm. mesh size nylon netting. Then it is transfered into a polythene screw capped bottle.

Procedure

Shake the sample and invert the polythene bottle into the funnel of the filtrations unit fitted with cellulose type membrane filters (Millipore or Sartoring) or fibre glass filters (Whatman GF/C) for filtration under the vacuum pressure below 50 cm of Hg. As the last part of the sample is being filtered add few drops of $MgCO_3$ suspension, to prevent the formation of pheophytin; (Chlorophyll exposed to acidic solution (Vernonl, 1960) or acidic resins (Wilson & Nuthing, 1963) soon liberates their Magnesium atom and yield grey brown pheophytins) although none has proved that phaeophytin is formed without it (Humphrey, 1961). This addition of $MgCO_3$ may increase the speed of filteration; it may help in pigment extraction if the acetone suspension is ground (with a glass rod in the centrifuge tube; it may give clear centrifugation; and it may diminish loss of plankton by acting as a filter when transferring the filter from a storage, to an extraction tube. Drain the filter and take the filtrate. If the filtrate are to be stored, fold them so that the disc containing plankton come innermost and keep them in dark in a desiccator not less than a temperature of 20°C. They may be stored frozen in the dark for not more than few weeks. When possible, analysis should be completed within one or two days.

Pigment Extraction

Procedure

Pigments are extracted by placing the filter in a 5 to 10 ml of 90% Acetone in 15 ml stoppered graduated centrifuge tubes. Dissolved the filter by shaking the tube vigorously. Keep the tube in a refregerator in complete darkness for 20 - 24 hrs. Frequent shaking ensures rapid extractions. Following extraction, allow the tubes in dark to come at room temperature and add 90% Acetone to make up the extract to 10 ml (if membrane filter is used) or 12 ml (if glass fibre filter is used), replace the glass stoppers of the centrifuge tubes by plastic stoppers to prevent the breakage during centrifugation. Centrifuge for 20 minutes at 4000 rpm. Measure the extraction (optical density O.D.) of the solutions against a cell containing 90% acetone at 7500 Å, 6650, 6450, 6300, 5100 and 4800 Å. The O.D. of values obtained at 7500 Å serve as a measure of scattering and absorption by particulate matter and should be subtracted from the O.D. readings at the rest of the wave lengths.

Calculations

Chlorophylls (mg/m^3) or Chl. mg/l = $\left(\frac{V}{V.I}\right)$

or

Carotenoid ($m.SPU/m^3$) = $\frac{C}{V}$

where C = value of chlorophyll obtained from the formula given below

V = volume of water filtered in litres

Formulae - (After Strickland & Parsons, 1972),

$$\text{Chl. a} = 11.6E_{6655} - 1.31\,E_{6450} - 0.14\,E_{6300}$$

$$\text{Chl. b} = 20.7E_{6450} - 4.34E_{6650} - 4.42\,E_{6300}$$

$$\text{Chl. c} = 55E_{6300} - 4.64E_{6650} - 16.3E_{6450}$$

(after Richardes & Thompson, 1952)

$$\text{Carotenoid} = 7.6\,E_{4800} - 1.49\,E_{5100}$$

E = Extinction values at wave lengths indicated, measured in 10 cm cells after correction for a blank

Blank correction

1) Cell to cell blank : Fill both the spectrophotometer cells with 90% acetone and measure the cell to cell of the sample cell against the reference cell at all wave lengths.

2) Turbidity blank : The extinction from colloidal material present in the extract caused by filter paper is known as turbidity blank. The extinction at 7500 Å is corrected for any cell to cell blank at this wave length and the resulting extinction (Eb) is multiplied by a factor 'f' to give the total turbidity blank extinction.

The 'f' values are given below for each wave length

Wave length (Å)	f
6650	1
6450	1
6300	1
5100	2

Total blank correction = Cell to cell blank + (f X Eb)

Estimation of Carbon Production from Chlorophyll concentration

Primary production can be estimated from radiation, transparency and chlorophyll using the equation (cited from Nair, 1970).

$$P = \frac{R}{K} \times C \times 3.7$$

C = g. chlorophyll/m^3

P = Photosynthesis in gm Carbon/m^2/day

R = Relative photosynthesis

K = Extinction

The value 3.7 gm is the quantity of carbon assimilated per hour at light saturation for each gm of chlorophyll (Ryther & Yentsch, 1957). Production in gC/m^3 at a particular depth can be calculated from the expression.

$Pd = Rd \times Cd \times 3.7$

Rd = Relative photosynthesis at depth (d)

Pd = Photosynthesis in gC/m^3/day at depth (d)

Cd = gm chlorophyll/m^3 at depth (d)

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STUDIES OF MACROVEGETATION IN BEELS

------ Kumudranjan Naskar

Introduction

The geometric progression in the growth and development of several aquatic weeds reach menacing proportions both in aquaculture and agriculture fields. This diversionary waste of nutrients is a world wide phenomenon but in tropical countries this problem is felt more acutely. As revealed by past experience, methods of eradication of this peril have not proved very effective. For this, it becomes inescapable to explore greater possibilities of their wider use by intensifying research on its end-use. Many of these obnoxious aquatic weeds have been tested very efficient as manure for agriculture field and feed for fishes, as well.

Water is an important resource for the well beings of human societies. The aquatic weeds affect a lot by chocking the beels, ponds, jheels, irrigation canals, water-ways, water-pumps, reservoirs and the aquaculture and agriculture farms. This weed infestation results unhygienic conditions for the economic and culturable fishes and agricultural crops. However, partial benefits are also derived from several aquatic flora, which are sometimes beneficial as physical stabilizers of banks and bottom water; these are promising for production of oxygen via photosynthesis and assimilations of pollutants via growth and development.

Most of these aquatic flora start their lives in or under the water. For the need of solar energy these auto-trophic organisms mostly conglomerated to the shallow water and start growing towards the surface by producing the floating foliages. Some of these weeds grow completely under *the water, while the inflorescence axis and the flowers come out above the water surface during pollination. Several forms of the aquatic angiosperms were also recorded as amphibious, macro-phytoplankton or free floating and swampy nature.*

Most of these aquatic flora on completing their life-cycle and on the adverse eco-climatic condition form the resting propagules like turions and tubers. After decay these green bio-mass, different kinds of nutrients are released to the water bodies and on the next season these resting propagules start regrowth and development for the new bio-mass. Any water body that produce more aquatic weeds are usually considered rich for many forms of lives, because it furnishes shelter and food for them. But aquatic weed infestation cause deficiency of plankton and algal flora. The growth and distribution of these aquatic weeds are subject to variations in water with a slight variation of the physico-chemical level of water or with the slight differences in temperature. Certain aquatic flora need exact nutrient or eco-climatic requirement and also restricted within such limit, Depending upon the degree of diverse tolerency, aggressiveness and also upon their mobility, their habitats are very clearly demarcated. This must be accomplished by habit of rapid multiplication.

In the beels, larger water bodies of the eastern parts of India, these aquatic weeds are surveyed as following types ; i) the free-floating, ii) rooted hydrophytes with floating leaves, iii) submerged forms and iv) rooted immersed form.

Different forms of aquatic flora

Warming (1909) classified the flowering plants into eight groups based on the availability of water in the substrata. These are - i) Hydrophytes, ii) Helophytes, iii) Mesophytes, iv) Halophytes, v) Oxylophytes, vi) Psycrophytes *vii) Lithophytes and viii) Psammophytes. These first and second groups are the subject of study in the present treaties. The aquatic weeds, belongs to these two groups are the predominant species throughout the aquatic environment in the Tropics. These groups of plants grow either in freshwater or on the soil fully or partially impregnated with water. In these categories we may mention the names of beels, ponds, lakes, jheels, streams, reservoirs, roadside ditches and canals, rice fields and several other marshy places.*

Arber (1928) classified the hydrophytes under (a) rooted and (b) non-rooted; while, Luther (1949) groups as (a) helophytes, which are attached to the substrate, (b) rhizophytes, whose basal parts can penetrate the substrate and (c) planophyton, free-floating with submerged or surface floating organs. Tansley (1948) and Sculthorpe (1967) classified the vascular hydrophytes into two major groups (a) rooted hydrophytes and (b) free-floating hydrophytes. The rooted hydrophytes are again classified as (i) emergent hydrophytes, (ii) floating leaved hydrophytes and (iii) submerged hydrophytes. Mitra (1977) grouped the hydrophytes based on Sculthorpe with regard to their relation to aquatic environment into (i) free-floating hydrophytes, (ii) rooted hydrophytes, (iii) rooted-submerged hydrophytes and (iv) rooted and immersed hydrophytes, occuring in shallow water or marshy places, also known as amphibious plants.

1. *Free floating hydrophytes : This group of plants can float freely in the water surface and are common in the beels, jheels, lakes, ponds. These are also known as macrovegetation, e.g. Eichhornia crassipes, Pistia stratiotes, Salvinia natans, Spirodella polyrrhiza,*

Trapa bispinosa, *Lemna perpusilla*, *Wolffia arrhiza*, *Azolla* sp.

2. Rooted hydrophytes with floating leaves : This group of plants are rooted in the bottom, but their leaves float or come out from the water surface. *Aponogeton natans*, *Neptunia oleracea*, *Nelumbium* sp., *Nymphaea* spp., *Nymphoides* spp., *Sagittaria* sp., *Potamogeton* sp.

3. Rooted submerged hydrophytes : This group of plants are rooted at the bottom and are also submerged in the water phase. The common examples are *Ceratophyllum demersum*, *Hydrilla verticillata*, *Myriophyllum indicum*, *Najas graminea*, *Nechamandra alternifolia*, *Ottelia alismodes*, *Potamogeton* sp., *Vallisneria spiralis* and *Urticularia inflexa*.

4. Rooted and Immersed hydrophytes or helophytes or amphibious plants : This group of plants can grow in shallow water or marshy places as well as on the moist waste lands; these are amphibious in habitat; these are *Aeschynomene indica*, *A. aspera*, *Alternanthera* spp., *Ammannia* spp., *Alisma plantago*, *Amischophacelus axillaris*, and many other aquatic and semi-aquatic plants.

These last three groups are called 'Benthos' or fixed hydrophytes by Warming (1909), while the first group of plants is called 'Plankton' by Henson (1887).

The water bodies with the infestation of aquatic weeds are noted by low Chloride and a little higher Phosphate. Calcium carbonate and higher organic Carbon and Nitrogen are dominated in such weed infested water, while pH ranges between 6-8. The presence of all such organic compounds are due to the decomposition effects of the macrovegetation. These organic compounds play a direct role as manure to the aquaculture or the agriculture though sometimes it has the *pollution effect to such water. All these weed flora can be utilize for compost making and bio-gas generation and recycling these waste materials in aquaculture and agriculture are very economic.*

These weeds are obnoxious if anyone think so, but these should be economic and valuable articles of commerce if we can utilize them with a definite purposes. If we think them difficult to eradicate it should be remain as problem - but if we determine to utilize them we can do so in many purposes. If there are fallow lands or water or neglected fields these weeds setteled firmly but with regular tillage these weeds can be avoided for ever.

Now, the identifing key will help to identify these weeds :

IDENTIFICATION KEYS TO THE COMMON MACROVEGETATION IN THE BEELS OF WEST BENGAL

1a Plants without any flower, sporophytes reproduce spores only - PTERIDOPHYTA (2)

1b Plants with flowers; reproduce by seed and the most common vegetation in beel - SPERMATOPHYTA (4)

2a(1a). Plants rooted and attached on the marshy places; leaflets quadrifoliate, glabrous

Family-1. Marsileaceae

Aquatic herbs, rhizomes creeping, slender; having the sporangia, produced within a specialised sporocarp. The sporocarp wall is produced by the modification of the leaf-blade; sori borne within the sporocarp which are of gradate ty e and the spores are heterospores.

* Marsilea quadrifolia L.
* Marsilea minuta L.

- Both these plants are aquatic, grow on the margins of the beels and water areas (3)

2b(1a). Plants with free floating fronds

3a(2b). Leaves opposite, upper leaf surface hairy; free floating and completely covered the water surface; especially in South India

Family-2. Salviniaceae

Free-floating hydrophytes and in the marshy places; grow gregariously. Stem branched, rhizomatous attaining a length upto 12 cm and the body is densely clothed with short stalked or sessile leaves, arranged in three whorls. Rootless but the lower submerged leaves are highly dissected and resembles the roots.

* Salvinia cucullata Roxb.
* Salvinia natans Hoffm.

- Both of these aquatic weeds cause serious problems in fish culture by chocking the surface water in beels, ponds and canals.

3b(2b). Leaves alternate; upper leaf surface glabrous; free floating on the water surface, greenish to brownish

Family-3. Azollaceae

Leav.s small, deeply lobed, each lobe 1-nerved;
microsporangia aggregated within the conceptacle.

* Azolla pinnata R. Br.

\- Fugacious, small free floating herbs in beels.

4a(1b). Plants very small to minute, a few milimeter; not clearly differentiated into stem with leaves; flat or globose; free floating and flowers not visible in the naked eyes

Family-4. Lemnaceae (Duck weeds)

Small to minute, gregarious aquatic free floating herbs; scale like or globose. These group of plants are the smallest among the flowering plants.

A. Fronds root-less, occasionally with a solitary basal reproductive pauch; dark green carpet like and chock the water surface rapidly

* Wolffia arrhiza (L.) Horkel ex Wimmer

\- Smallest among the angiosperms and very obnoxious weed in fish pond; but major carps relish the fresh vegetative fronds.

AA. Fronds rooted, each one with 2 lateral reproductive pouch

B. Fronds with one root, nerve-less or faintly 1-3 nerved

* Lemna perpusilla Torrey

\- Fronds asymmetric, obovate or overte-oblong; seed erect; flowers in *marginal clefts. Commonly grow on the surface and hampared fish culture, though it is relish by the chinese grass carp.*

BB. Frends more than one root, 4-5; conspicously 5-8 nerved

** Spirodela polyrrhiza (L.) Sch. Frends herbaceous, broadly ovate or orbicular, 7-nerved. Very common free floating weeds in freshwater ponds, beels and sewage water.*

4b(1b). Plants clearly differentiated into stem and leaves; flowers generally visible in the nacked eyes. (5)

5a(4b). Petals present (6)

5b(4b). Petals absent (apetalous) (28)

6a(5a). Flowers large, 10-16 cm diam., carpels embedded in the flat top of the fleshy receptacle; rooted rhizomatous herbs with very elongated spiny or armed petioles and floating peltate leaves

Family-5. Nelumbonaceae (Lotus family)

Large aquatic herb with rhizomatous roots; petioles and peduncles very long; flowers acyclic.

** Nelumbo nucifera Gaertn.*

- This rhizomatous giant herb grow in the freshwater ponds, beels and canals hamper a lot the common fish culture. Its armed petioles check the free movement of the fish and it is very difficult to eradicate from the vast water bodies.

6b(5a). Flowers smaller than the above; carpels not embedded in the flat top of the fleshy receptacle (7)

7a(6b). Sepals sepaloid and petals petaloid; perianth clearly differentiated into sepals and petals (8)

7b(6b). Sepals and petals both petaloid; perianth not clearly differentiated into sepals and petals (24)

8a(7a). Petals free (9)

8b(7a). Petals united (16)

9a(8a). Ovary superior (10)

9b(8a). Ovary inferior or semi-inferior (14)

10a(9a). Ovaries and styles 2 or more, free or united only at base of the ovary; sepals 3; leaves alternate or divided or lobed; plant with milky latex

Family-6. Alismataceae

A. Flowers unisexual; receptacle globose; stamens 6 - many; leaves floating, broadly ovate, deep cordate or rising above the surface of water, hastate or sagittate base

* Sagittaria sagittifolia L.

* Sagittaria guayanensis H.B.K.

AA. Flowers bisexual; receptacle flat; stamens 6; robust aquatic herbs; leaves whorl, sagittate

* Limnophyton obtusifolum (L.) Miq.

\- Both Sagittaria spp. and Limnophyton sp. grow gregariously on the margin of the beels, canals and sewage ponds.

10b(9a). Ovaries and styles united, or carpels solitary (11)

11a(10b). Petals 3, or inner perianth 3, petal like (12)

11b(10b). Petal more than 3 (13)

12a(11a). Pedicels subtended by a lanceolate bract; leaves lanceolate to ovate; entire at apices, enclosing the stem at base; flowers not in spikes; cotyledons one, grow on the moist waste places, on the margin of the beels

Family-7. Commelinaceae

Jointed stem, leaves alternate, entire, sheathing; perianth segments 6, in 2 series. Flowers irregular commonly blue; fruits capsule.

A. Fertile stamens 3; staminodes present

B. Cyme 1 or 2, arising from a spathaceous bracts

* Commelina benghalensis L.
* Commelina diffusa Burm.f.
* Commelina paludosa Blume
* Commelina suffruticosa Blume
* Commelina erecta L.

BB. Cymes panicled; not arising from a spathaceous bract

* Murdannta vaginatum Bruec.
* Murdannia spirata Bruec.
* Murdannia nudiflora (L.) Brenan

AA. Fertile stamens 6; staminodes absent

B. Bracteoles conspicous

* Cyanotis cristata (L.)

BB. Bracteoles inconspicous

* Amischophacelus axillaris (L.) Bao & Kammathy

- All these members of the family commelinaceae grow on the margins of the beels, canals and ponds and after decomposition add the nutrients to the water bodies.

12b(11a). Pedicels not subtended by a lanceolate bract; flowers in spikes; fruits a nut, seeds with two cotyledons; grow profusely on the margin of the beels and also on shallow water and most moist waste places

Family-8. Polygonaceae

Herbs with swollen nodes; leaves with ochreate stipules; ovary triangular, superior, unicellular, ovule solitary, erect orthotropous

* Polygonum orientale L.
* Polygonum glabrum Willd.
* Polygonum barbatum L.
* Polygonum hydropiper L.
* Polygonum pubescens Blume

- All these aquatic and semi-aquatic plants very commonly grow on the side of the beels and also in the shallow water.

13a(11b). Stamens more than 2 times as many as petals; petals numerous, usually more than 8; leaves with long petiole; stigmas radiate; rhizomatous stem rooted on the bottom soil and foliage leaves

Family-9. Nymphaeaceae

Plants comparatively smaller; lamina margin entire or toothed; flowers 5-8 cm diam., white, anther without appendages; stigma rays with clubbed appendages

* Nymphaea nouchali Burm.f.
* Nymphaea stellata Willd.

- Both these flora commonly grow on the beels and ditches; rhizomatous root anchor on the soil but the foliar parts and flowers floats on the surface water with the help of slender petiole and inflorescence axis.

N. nouchali and N. stellata differ

from each other by entire lamina margin, 5-12 cm flower diameter, appendaged anther and stigma rays with clubbed appendages for N.nouchali

13b(11b). Stamens two times as many as petals or fewer; flowers bisexual; leaves with traps and terminal bristles; plants free floating in shallow water

Family-10. Droseraceae

Copiously covered with long glandular hairs with secreting fluids by means of which they catch and digest small insects and worms.

* Aldrovanda vesiculosa L.

- Succulent, glabrous, delicate submerged weed with articulated stem; occasionally on shallow water ditch and beels.

14a(9b). Petals 3

Family-11. Hydrocharitaceae

Aquatic herbs; epigynous; ovary inferior, unilocular, placentation parietal

A. Perianth 3 in single whorl

* Vallisnaria spiralis L.

AA. Perianth 3 + 3 in double whorls

B. Stem branching, leafy

C. Leaves usually opposite below but whorled above; ovules anatropous

* Hydrilla verticillata (L.f.) Royle

CC. Leaves scattered, lower opposite; ovules orthotropous

* Nechamandra alternifolia (Roxb.) Thw.

BB. Stem none with stolons only or a creeping rootstock

C. Leaves sessile; male flowers several within the spathe

* Blyxa octandra (Roxb.) Planch. ex Thw.

CC. Leaves petioled; flower 1 or 2-3 within the spathe

* Ottelia alismoides (L.) Pers.

- All these members are the true aquatic plants; these Hydrocharitaceae flora mostly grow in submerged conditions in the beels and jheels and check the water bodies very adversely. This weed infestation cause serious problem in fish culture and also for fishing in the beels and jheels. But most of the species of the Hydrocharitaceae are good food for the herbivorous chinese grass carp.

14b(9b). Petals usually 4 or 6 . (15)

15a(14b). Fruits capsule

Family-12. Onagraceae

Flowers epigynous, tetramerous, sepals valvate; corolla convolute; stamens in 2 whrols of 4; outer whrol larger than inner; ovary 4 locular, ovules many.

* Ludwigia adscendens (L.) Hara

* Ludwigia octovalvis sub.sp.sessiliflora (Mich.) Raven

* Ludwigia perennis L.

* Ludwigia prostrata Roxb.

- All these aquatic plants grow on the margins of the beels and other areas;

floats with the help of white air-roots.

15b(14b). Fruit indehiscent, nut likewith 2 or 4 thorn like process; leaves with swollen floating petioles

Family-13. Trapaceae

Branches assimilatory; uniseriate, multicellular hairs on petioles/pedicels and lower surface of leaves; top-shaped drupes.

* Trapa bispinosa Roxb.

\- Mostly cultivated, free floating aquatic herbs in beels, jheels and the waste waters. Fruits are edible either raw or cooked.

16a(8b). Ovary superior (17)

16b(8b). Ovary interior or semi-interior (21)

17a(16a). Flowers actinomorphic (radially symmetrical) (18)

17b(16a). Flowers zygomorphic (bilaterally symmetrical)

Family-14. Lentibulariaceae

Leaves bearing utricles, flowers irregular, steamens 2, epipetalous anther 1-celled.

Plants bearing bladder like insect traps.

* Urticularia inflexa Forssk. var. stellaris Tayler

* Urticularia gibbosa L. sub-sp. exoleta (R.Br.) Tayler

* Utricularia aurea Lour.

\- Common submerged and occasionally floating weeds in the beels, paddy fields and shallow water ditches.

18a(17a). Placentation parietal; petals usually with hairs or lamellae on the surface

Family-15. Menyanthaceae

Leaves exstipulate, cymose, stamens as many as corolla lobes; ovary unilocular with glandular disc.

* *Nymphoides cristatum (Rexb.) Kuntze*

* *Nymphoides indicum (L.) Kuntze*

- *Gregariously grow on the margins of the beels and on the shallow water. Rooted rhizomatous base on the bottom of the water bodies and leaves are floating on surface water.*

18b(17a). Placentation axile, petals usually glabrous or smooth, fruit capsule; style terminal (19)

19a(18b). Ovules 1 or 2 in each loculus; petal tube funnel shaped

Family-16. Convolvulaceae

Leaves alternate, exstipulate, corolla twisted; intrastaminal disc annular or cupular, ovary superior, 2-locular with 2 ovule.

* *Ipomoea aquatica Forssk.*

- *Herbaceous aquatic floating traillers; leaves mostly hastate; occasionally amphibious on marshy grounds; attached on the margins and prostrate/trailling branches floats in beels, ponds and jheels.*

* *Impomoea fistulosa* Mart. ex. Choisy

- Large straggling shrub; stem fistular; leaves ovate cordate; flowers large; grow profusely on the dampy and moist waste places and on the shallow water margins of the beels and jheels. It was introduced in India from South America a Century ago.

19b(18b). Ovules many; petal tubes lobed (20)

20a(19b). Style-2, united only at base

Family-17. *Hydrophyllaceae*

Helicoid cymes; imbricate aestivation, stamens without scales, between filament.

* *Hydrolea zeylanica* (L.) Vahl

- Procumbent aquatic herb; grow profusely on the margins and edges of the beels, jheels and paddy fields.

20b(19b). Style 1, sometimes 2-lobed at apex

Family-18. *Scrophulariaceae*

Leaves exstipulate; flowers irregular, petals often spread, stamens 4, didynamous.

- *Bacopa monnieri* (L.) Wettstein
- *Limnophila heterophylla* (Roxb.) Benth.
- *Limnophila indica* (L.) Druce
- *Limnophila pulcherrima* (Griff.)Hook.f.
- *Limnophila repens* Benth.
- *Lindenbergia indica* (L.) Vatke
- *Lindernia anagallis* (Burm.) Pennell
- *Lindernia ciliata* (Colsm.) Pennell
- Lindernia cordifolia (Colsm.) Merr.

All these weed flora grow mostly on the moist waste places and on the margins of the beels, jheels and paddy fields.

21a(16b). Inflorescence a head subtended by an involucre of bracts

Family-19. Asteraceae

Capitulum inflorescence; flowers epigynous, corolla united.

- Enhydra fluctuans Lour.
- Caesulis axillaris Roxb.
- Eclipta alba (L.) Hasak.
- Gnaphalium indicum L.
- Xanthium indicam Koen. ex Roxb.
- All these weed flora grow profusely on the margins of the beels, jheels and other moist waste places.

21b(16b). Inflorescence a spike or panicle or flower solitary solitary (22)

22a(21b). Leaves opposite or apprently whroled; flowers in branched cymes, lower leaves whroled

Family-20. Rubiaceae

Leaves opposite, stipulate; flowers epigynous, petals 4 or 5; stamens 4 or 5, epipetalous; ovules 1 - many in each loculus.

* Oldenlandia biflora L.

* Oldenlandia corymbosa L.

* Oldenlandia diffusa (Willd.) Roxb.

* Oldenlandia herbacea Roxb.

- All these weed flora grow profusely on the margins of the beels and on the moist waste lands.

22b(21b). Leaves alternate or all basal (23)
23a(22b). Inflorescence densely spicate, terminal

Family-21. Sphenocleaceae

Aquatic fleshy herb; leaves alternate; bracteate spike and white flowers.

* Sphenoclea zeylanica Gaertn.
  - Common weed on the marshy lands and margins of beels and jheels.

23b(22b). Infloresence lax of flowers axillary; anthers free

Family-22. Primulaceae

Petals 5, united; stamens as many as corolla lobes and opposite to them, placentation free central; fruit capsule

* Anagallis arvensis L.
* Anagallis pumila Sw.
* Primula umbellatta (Lour.) Bentv.
  - All these plants grow on the damp places in the margins of beels and jheels.

24a(7bb). Perianth segments free; ovary always superior (25)
24b(7b)). Perianth segments united; ovary inferior or superior (27)
25a(24a). Flowers in simple or forked spikes; attached rhizomatous stem but floating leaves; common on the beels.

Family-23. Aponogetonaceae

Laticifarous, perennial aquatic herbs; leaves reticulately veined with a few veins.

* Aponogeton crispum Thunb.
* Aponogeton natans (L.) Engl. & Krause

25b(24a). Flowers solitary or in variously pedicellate inflorescence (26)

26a(25b). Inflorescence umbel like; leaves linear, arising in 2 rows from a rhizome

Family-24. Butomaceae

Placentation superficial.

* Tenagocharis latifolis (D.Don) Buchen.

\- Common in the wet places and on the margins of the beels.

26b(25b). Inflorescence not umbel like; leaves not linear, not in 2 rows; leaves sheathing at base, never peltate

Family-25. Ranunculaceae

Radical or alternate leaves with twisted, sheathing petioled; flowers regular; clayxppetaloid; stamens many, free; fruits achenes or folicles.

* Ranunculus sceleratus (L.) Sp.

\- Frequently found on margins of the beels and ponds on wet lands.

27a(24b). Ovary superior; inflorescence subtended by 2 spathe; style 1; leaves parallel nerved

Family-26. Pontederiaceae

Leaves with swollen petiole; inflorescence panicle or raceme, subtended by spathe like leaf sheath.

A. Tepals forming a distinct tube below; petioles swelling; spongy; anther equal

* Eichhornia crassipes (Mart.) Solms.

\- Most troublesome free floating aquatic weed; infest very quickly on the beels, jheels and all other water bodies, particularly when these are very fertile.

AA. *Tepals nearly free; petioles not swelling; anther unequal*

* *Monochoria hastata* (L.) Solms.

* *Monochoria vaginalis* (Burm.) Presl.

27b(24b). *Ovary inferior; perianth segments united for at least half their length; forming a tube below; style long*

Family-27. Amaryllidaceae

Ovary trilocular with many ovules arranged in 2 - series on the axile placentation.

* *Crinum defixum* Kar Gawl.

- *Gregariously grow on the margins of the beels and jheels in the marshy places.*

28a(5b). *Perianth sepaloid, membranous* (29)

28b(5b). *Perianth reduced to hairs, minute scales or glumes or absent* (36)

29a(28a). *Perianth scarious or membranous* (34)

29b(28a). *Perianth sepaloid* (30)

30a(29b). *Flowers crowded on to a fleshy spikes (spadix); subtended by a fleshy bract (spathe)*

Family-28. Araceae

Herbs with acrid watery latex; leaves broad, long petioled.

A. *Free floating aquatic herbs; leaves ovate cuneate, ovary single basal*

* *Pistia stratiotes* L.

- *Common weed on the surface water; gregariously floating on the stagnant water in village ponds, jheels, beels and ditches; completely cover the surface water.*

AA. Moist loving attached herb, usually tall, coarse; leaves and scapes arising from the rhizome; leaves peltate; spadix with a barren appendage, not adnate to the spathe, spathe yellow or orange

B. Ovule few, basal

* Alocasia fornicata (Roxb.) Schott.

\- Gregariously grow on the margins of the beels.

BB. Ovules many on a triparietal placentae

* Colocasia esculenta (L.) Schott.

* Colocasia nymphaeifolia Kunth.

\- Commonly grow on the margins of the beels, roadside ditches and canal sides in the wet places.

30b(29b). Flowers not crowded on to a spadix subtended by a fleshy spathe (31)

31a(30b). Ovary superior (32)

31b(30b). Ovary inferior; inflorescence without spathe like bracts; fruits nut like

Family-29. Haloragaceae

Plants monoecious; unisexual; stamens 4-8 and inferior ovary with a solitary ovule in each loculus.

* Myriophyllum indicum Willd.

* Myriophyllum tuberculatum Roxb.

\- These are submerged aquatic herbs in the beels, canals, ponds and ditches.

31a(31a). Fruits many seeded capsule or of many seeded berry; sepals united into a tube

Family-30. Lythraceae

Plants often with 4-angular bracts; calyx valvate; corolla crumpled; androecium inflexed in buds; ovary superior, 2-6 locular; ovules many.

* Ammannia baccifera L.
* Ammannia multiflora Roxb.
* Ammonnia salicifolia Monti
  - All these weed flora grow gregariously on the margins of the vast water bodies and on the marshy places.

31b(31a). Fruit 1-seeded capsule or indehiscent (33)

33a(32b). Flowers solitary, sessile in axile of whroled, forked capillary leaves

Family-31. Ceratophyllaceae

Branch single, arising from the nodes; flowers minute, monoecious, solitary; perianth of 6-12 narrow sub-valvate segmented.

* Ceratophyllum demersum L.
  - Common submerged aquatic weeds in the beels and jheels.

33b(32b). Flowers in spikes; leaves entire, sepal 2, 4 or 6; 1 leaves mostly cauline; fruit of 4, free nutlets; stamens 4

Family-32. Potamogetonaceae

Perennial, submerged herb; flowers floating; perianth variable; stamens 1 - 4; carpels 1-4, ovule solitary apical.

* Potamogeton crispus L.
* Potamogeton nodosus Poir.
  - Common submerged aquatic weed in the beels; on the freshwater ponds and canals.

34a(29a). Perianth 2-tipped, membranous sheath; whole plant including flowers submerged; leaf margin toothed

Family-33. Najadaceae

Flowers wholly submerged; ovary superior, unilocular, ovule solitary, erect.

* Najas graminea Del.

\- Rooted submerged herb in the beels; jheels and shallow marshy places.

34b(29a). Perianth of 3 to 6 segments; flowers emerged; leaf margin not toothed (35)

35a(34b). Leaves linear, basal and spirally arranged

Family-34. Plantaginaceae

Seemingly parallel veined, basal sheathing leaves. Inflorescence capitate or spicate on wiry or stout scapes.

* Littorella sp.

35b(34b). Leaves lanceolate or oblanceolate, cauline and in opposite pairs

Family-35. Amaranthaceae

Inflorescence congested with scarious bracts; perianth dry, membranous; filaments connate in a cup or tube.

A. Anther 1-celled; staminal tube short, stigma capitate

* Alternanthera paronychioides St.

* Alternanthera philoxeroides (Mart.) Griseb.

* Alternanthera pungens Kunth.

* Alternenthera sessilis (L.) R.Br.

\- All these are the marginal weeds in the beels and in the marshy places.

AA. Anther 2-celled; leaves alternate or fasciclec

* Aerva lanata (L.) Juss.

\- On the moist waste places; in the side of beels

36a(28b). Flowers unisexual, densely arranged in unisexual, superposed spikes or unisexual globose heads borne on the same axis; arranged in superposed, cylindrical spikes; ovary on a hairy stalk

Family-36. Typhaceae

Tall aquatic or marshy herbs with creeping rhizomes, leaves erect.

* Typha angustata Bory & Chaub.

* Typha elephantina Roxb.

\- Gregariously grow on the deltaic swamps and beels; a true aquatic plants.

36b(28b). Flowers bisexual or if unisexual then mixed in heads or borne on separate axes (37)

37a(36b). Flowers usually subtended by 2 glumes; stem usually hollow between nodes; leaves in 2-rows

Family-37. Poaceae (Grass family)

Perennial or annual herbs with cylindrical hollow/fistular stem; leaves linear; inflorescence spikelets.

* Apluda mutica L.

* Arundo donex L.

* Brachiaria mutica (Forssk.) Stapf.

* Coix lachryma jobi L.

* Desmostachya bipinnata (L.) Stapf.

* Echinochloa colonum (L.) Link.

* *Echinochloa crusgalli* (L.) Beauv.
* *Eragrostis cilianensis* (All.) Vignolo-Lutati

** *Eriochloa procera* (Retz.) Hub.

- These are some of the common grasses on the margins of the beels and on the marshy lands.

37b(36b). Flowers usually subtended by 1 glume; stem usually solid between nodes; leaves in 3 or rarely 2 rows

Family-38. Cyperaceae (Sedge family)

Solid triangular culm; leaves trichotomous with ligules; leafsheath closed.

* *Bulbostylis barbata* (Rottb.) Kunth.
* *Carex fedta* Nees
* *Cyperus alopecuroides* Rottb.
* *Cyperus brevifolius* (Rottb.) Hassk.
* *Cyperus cephalotes* Vahl
* *Cyperus exaltatus* Retz.
* *Cyperus iria* L.
* *Cyperus paniceum* (Rottb.) Boech.
* *Eleocharis atropurpurea* (Retz.)Kunth
* *Fimbristylis aestivalis* (Retz.) Vahl
* *Scirpus articulatus* L.
* *Scirpus corymbosus* Heyne ex Roth
* *Scirpus grossus* L.f.
* *Scirpus juncoides* Roxb.
* *Scirpus mucronatus* L.
* *Scirpus tuberosus* Desf.

- All these are some of the very common sedges on the margins and shallow water of the beels.

STUDY OF PLANKTON

---- P. K. Chakrabarti

INTRODUCTION

Existance of a life is possible so long as the food is available in an ecosystem. Fishes and shrimps too depend on food from various niches within the water bodies. But all such food items are not inert or non-living. A wide spectrum of aquatic flora and fauna which are cunsumed by the fishes and shrimps for their growth and maintenance are worth to be studied in details. According to location, distribution and size aquatic organisms are named differently as -l, plankton, periphyton, nekton or benthos. Always there is definite preference, selection or discarding of a specific organism as a food item for the fishes. Moreover, physico-chemical environment also influences the food organisms a lot by way of encouraging proliferation of a kind by suppressing others. Thus the variations and the distributional patterns of these fish food organisms make the aquatic system productive or unproductive from fisheries point of view, depending on the relative representation of beneficial and undesirable forms in the biotope. Therefore, the studies on fish food organisms also help in identifying compatible and competitive ones for the manipulation of the biotic environment in favour of better exploitation. A simple study, however, about the scattering and abundance of fish food organisms in an aquatic system is incomplete unless the same is compared to the findings of food and feeding habit studies alongwith the know-ledge about the index of preponderance for the fishes and shrimps.

Plankton community

The term 'Plankton' is from the Greek language and means, 'Wandering'. It includes those aquatic flora and fauna which readily drift alongwith the water current and move irregistantly by the wind action. If at all they show locomotic, it is merely passive. The size of a plankton can be microscopic to as large as jelly fishes. In general plankton are studied under two groups; One, ultra small called nanoplankton and the other, relatively large called net plankton. Nanoplankton comes under the perview of microbiological studies while limnologist usually concentrate on the studies of net plankton which in general term as designated as plankton only.

Plankton can be classified as phytoplankton and zooplankton. Phytoplankton are capable of photosynthetic activities and zooplanktons are to depend on the phytoplankton or other organisms for their nurishments.

In the study of plankton there are some confusion about classifying some of the organisms as phyto or zooplankton, because they occur at the boarder of the plant and animal kingdoms, showing overlapping characters as in Euglena sp. So a group of workers prefer to include primitive plants and animals under a separate kingdom called protista to avoid any confusion. This includes algae, fungi, protozoa and bacteria, since blue-green algae and bacteria do not possess true nucleus in their cell, they are considered as an isolated group and are called lower protista or monera. Naturally other algae, protozoans and fungi are grouped as higher protista.

Thus, the most primitive plankton exhibits photosynthesis unicellular state with flagella or motility. Towards the evaluation of the animal kingdom, protista lost photosynthetic power, retaining locomotion and unicellular state as in most protozoans and towards the evaluation of plant kingdom, protista retained photosynthesis, reduced motility and developed multicellular characters like higher algae.

Fungi confuse one about their origin being multicelluler like algae and possessing flagellate reproductive cells loosing chlorophyls like amoeboid flagellates.

Among lower protista, blue-green algae are capable of photosynthesis while most of the bacteria (excepting green and purple) cannot produce free oxygen. Filamentous sulphur bacteria (Beggiatora sp. or Thiothirix sp.) resemble blue-green algae (Oscillatoria sp.) and confuse identification. Pringsheim (1949) detected gliding movement without flagella in blue-green algae in contrast to sulpher bacteria which both are grown on hard surfaces.

Method of collection

Plankton is collected generally by truncatedcone shaped net made of bolting silk or organdie cloth. Bolting silk is the best material for a plankton net and No. 25 standard grade may be used for it. This has a mesh size of 0.064 mm (200 meshes per 2.54 cm). The upper and broader circumference (30 cm) of the net is attached to a brass ring with a handle and the lower narrow circumference (9.2 cm) is fixed to the mouth of a collecting tube or bucket. Known volume of water (not less than 50 litres) usually filtered through it. Where plankton is required from a particular depth either ClarkeBumpus, Knudsen's reversing bottle or Kremer's samplers are used. ClarkeBumpus automatically filters and records the volume of water strained, but for other two samplers the know volume of water is strained by a a hand net for plankton as described earlier. For any shallow depth of water body, the surface plankton is collected by a mug of known volume and filtered through a plankton net of standard specification.

Preservation and estimation

Plankton sample is immediately preserved in 4% or 5% formalin after collection. Allowing the sample to settle for a day the volume of the plankton is measured in a measuring cylinder. If the plankters are numerous in the original sample then they can be counted with the help of a Sedgwick Rafter Cell which provides a known volume and area for microscopic examination and enumeration of organisms. Area of the counting cell is 50 X 20 mm with 1 mm depth to hold 1 ml of the sample under a cover slip. Before transferring the sample to the counting cell, it is well shaken for homogeneous mixture. Frequencies of different plankton species are noted at random from each of 10 squares out of 1000 squares at random and the average of these are used for estimation. When plankton density is poor a hand centrifuge of 300-500 rpm is used to have a concentrate. The sub-sample from the whole sample is drawn for examination and ratio between them is noted.

If n_i is the number of a species occuring in a square of the counting cell then the number 'N' for the species in the total water volume filtered (i.e. for the whole sample) is calculated by :-

$$N = \frac{n_1 + n_2 + n_3 + n_4 + n_5 + n_6 + \ldots . n_{10}}{10} \times 1000 \times \text{Volume in ml of the sample from which sub-sample was drawn for the analysis}$$

Now N is expressed in standard form i.e. u/l by the formula

$$u/l = \frac{N}{\text{Litres of water filtered}}$$

The second method for quick analysis is the drop method. In this process the concentrate of the centrifuged sample is made 5 ml or 10 ml in volume then a drop is drawn by a dropper of which 20 drops makes 1 ml. The drop is put in a glass slide and covered with a cover slip to count the organisms. A few drops are estimated and the average of them giving n as the number for a particular species is noted and then u/l is calculated as follows :-

$$u/l = \frac{n \times 20 \times (5 \text{ or } 10) \text{ as the concentrate was}}{\text{volume of water filtered (l)}}$$

Sometimes a part of the drop is also examined and by proportionately the entire drop is estimated.

Field identification

Often protista require staining for their identification especially bacteria which also require a pure culture to estimate their number and identification.

Besides protista, coelenterates, helminths, rotifers, annelids, fairy shrimps, tadepole shrimps, claw shrimps, water fleas, seed shrimp, copepods, fishlice malacostracans (show bugs, squids, decapods) aquatic insects etc. occur in the plankton.

Common filamentous algae are :-

Species	Field characters
Oscillatoria sp.	Filament solitary, anteriorly tapering with swollen epical cell
Lyngbya sp.	Sheath longer than trichome, cells wider than length
Anabaena sp.	Trichome of bead like cells with heterocyst
Ulothrix sp.	Squarish cell giving vertebral column like appearence
Spirogyra sp.	Cells with double spiral bands
Spirulina sp.	Trichome spiral spring like
Other common algae	
Chlorella sp.	Unicellular with cup shaped chloroplast
Closterium sp.	Cells alternated at 2 extremities also provided with sickle shaped chloroplast in each cell
Merismopedia sp.	Cells arranged in the form of a mat in a single plane
Anacystis sp.	Cell mats in 3 dimensional space
Phacus sp.	Beetle leaf shaped with flagella
Euglena sp.	Flagellates with eye spot at the base of the flagella. Pigments gives scaly apperance
Penium sp.	2 celled alga 'T' shaped
Coelestrum sp.	Cells like a bunch of grapes
Scenedesmus sp.	Cluster of 4 sickle shaped cells colony of 4-64 cells
Pediastrum sp.	Colony of 4-64 cells looks like a decorative table mat with peripheral cells having distinct notches

Cosmarium sp.	2 cells in the form of eight

Common diatoms (silicious algae with 2 valves held by a girdle)

Navicula sp.	Diamond shape, with transverse striations and central mark
Pinnularia sp.	Cells with costae and both ends blunt
Synedra sp.	Elongated cells with sharply pointed end elongated cells
Nitzschia sp.	Opposite sides ends sharply through bending of opposite sides
Gyrosigma sp.	'S' shaped diatom
Bacillario sp.	Elongated cells with beads of cell contents along the long axis
Cocconeis sp.	Oval shaped
Anomoeoneis sp.	Looks like two first brackets closing together with the blunt club-shaped ends.
Hydrosera sp.	Apperance triangular
Coscinodiscus sp.	Disc like diatom, valve convex, pheripheral and central marking similar. No marginal spine
Gomphonema sp.	Club-shaped
Amphora sp.	Looks like Navicula, but separated by the absence of a central marking and arched shape giving little triangular appearance

Common rotifers (animalcule with ciliated corona/whirl organ)

Asplanchna sp.	Pouch like appearence, without lorica, without cuticular appearance
Polyarthra sp.	With flat cuticular appendages
Filinia sp.	With setiform cuticular appendage
Keratella sp.	With dorsal plate having polygonal facets, lorica with anterior spine
Brachionus sp.	With dorsal plate without polygonal facets. Retractile foot & toes shorter than lorica
Monostyla sp.	Looks like a germinated gram. With 1 toe

<u>Lecane</u> sp. — Looks like a germinated gram with 2 separate toes

<u>Common Anostraca (fairy shrimp)</u>

<u>Branchipus</u> sp. — Looks like a small shrimp with 17 pairs of appendages

<u>Common Notostraca (Tadpole shrimp)</u>

<u>Apus</u> sp. — Looks like kingcrab, No supra-analplate shield like carapace and 60 pairs of thoracic appendages

<u>Lepidurus</u> sp. — Looks like kingcrab, with supra analplate shield like capace and 60 pairs of thoracic appendages

<u>Common Conchostraca (Claw shrimp)</u>

<u>Cyziens</u> sp. — With bivalve carapace having single compound eye, No frontal organ on head, Rostrum apex without a spine. With deep occipilal notch. 10-28 pairs of thoracic appendages

<u>Common Cladocera (Water fleas)</u>

<u>Daphnia</u> sp. — With bivalve carapace, 6 pairs of thoracic appendages, carapace with long anal spine and anterior head crest

<u>Bosmina</u> sp. — With bivalve cara-pace with a short anal spine. Antennules curving back-wards. No hepatic caeca

<u>Moina</u> sp. — Body thick and heavy, carapace rhomboidal and incompletely cover-ing the body. Instead any anal spine horseshoe shape process exists. 2 posterior setae present

<u>Common Ostracoda (Seed shrimp)</u>

<u>Cypris</u> sp. — Bivalve carapace, 3 pairs of thora-cic appendages backwardly and dor-sally directed. Clawed exopodite in 2nd Antenna

<u>Common Copepoda</u> (Body with metasome and urosome 5 or 6 pairs of thoracic appendage)

<u>Cyclops</u> sp. — Anterior part much broader and oval and posterior part narrow, caudal region narrow

Diaptomus sp.	Anterior part of the body broader then posterior caudal region narrow
Harpecticus sp.	Caudal region as broad as anterior part

Common Branchiura

Argulus sp.	Carapace sheild like with 2 ventral suckers on maxillae

Malacostraca have 5 head segments, thoracic segments and 7 abdominal segments

Common Isopoda (Rarely occur in the plankton as these are parasitic)

Bopyrus sp.	Carapace absent, head fused with 1st thoracic segment, dorsoventrally flattened, Uropond absent
Sphaeroma sp.	Carapace absent, head fused with 1st thoracic segment, dorso-ventrally flattenedm uropond present, abdomen with 2 segments

Common Amphipod (Mostly occurs in the benthos)

Gammerus sp.	Carapace absent, head fused with 1st thoracic segment, laterally compressed 1st Gnathopod smaller than the 2nd

Common Mysidacea

Mysis sp.	Shrimp like with carapace covering only 3 thoracic segments, 1 or 2 pairs of thoracic appendages in maxillipeds and none are chelated. Antenale scale 1/2 times of Antennular peduncle

Common aquatic insects can be identified by following CICFRI Bulletin No. 54.

Other books which can be referred for plankton studies are:-

1. Freshwater Biology by W.T. Edmonson (Editor)
2. The marine & freshwater plankton by Charles C. Devis
3. The freshwater algae by G.W. Prescott

A NOTE ON THE METHODS OF COLLECTION OF BOTTOM BIOTA

——— V. V. Sugunan

Bottom sampler

Ekman dredge is best suited as a sampler for bottom biota for soft bottoms. Two sizes of this sampler are available namely 15.2 X 15.2 cm and 22.9 X 22.9 cm. The former is more convenient from the point of view of sampling. Where, however, the bottom is hard, Peterson grab with an enclosure area of about 0.08 sq.m. may be used.

Collection procedure

1. Collect samples by Ekman dredge from randomly chosen stations.
2. Each sample may be transferred to suitable containers like enamel buckets or other larger sized containers.
3. Take sieve No. 40 which will retain only macro-organisms.
4. Take suitable quantity of dredged material from the bucket and place it in sieve. Wash it with liberal quantities of tap water or water from other source.
5. Transfer the residue (macro-organisms) into a wide-mouthed bottle. Repeat the same procedure for other parts of samples.

6. Prèserve the material in 10% formalin, if detailed analysis has to be done at a later date.

   (Note : Should studies cover micro-organisms as well, use sieve No. 100 or other finer grades)

Quantitative evaluations and computations

(a) Count method

1. Transfer small portions of screenings into petri dishes or shallow porcelain dishes.

2. Segretate the organisms into species, genera or groups according to the nature of the investigations.

3. Count them per qualitative identity under one or more of the above heads.

4. Compute for each individual group or for all groups the number of macro-organisms per square metre, which can be done as follows :-

$N = \frac{n}{ah}$ where,

N = number of macro-organisms in 1 sq. m.

n = number of macro-organisms per sampled area

a = area of Ekman dredge in sq. m.

h = number of hauls.

(b) Volumetric method

1. Place a group of organisms upon filter paper and retain them until the moist sheen is removed. Repeat for other groups.

2. They may then be transferred to a test tube of known volume calibrated for 1 and 2 ml. According to size of the sample, water is then added from a burette upto 1 ml or 2 ml marks.

3. Substract the amount of water dropped from the burette, from the test tube reading which gives the volume of bottom organisms in the test tube.

4. Compute the volume of animals per sq. m. either for individual groups or for all animals, by the formula :

   $V = \frac{v}{ah}$ where,

   V = volume in ml of macro-organisms above 1 sq.m. of bottom surface.

   v = volume of macro-organisms per sample (containing one or more hauls)

   a = transverse area of Ekman dredge to be expressed in sq. m.

   h = number of hauls constituting a sample

(c) Gravimetric method

1. Place a group of organisms upon filter paper and retain them until the moist sheen is removed. Repeat for other groups.

2. Weigh them in a balance of appropriate sensibility, The weight recorded represents the wet weight.

3 Dry the above to a constant weight to get dry weight.

   (Note : Exclude the sheel weight of molluscs).

(After Jhingran et al. 1988, Methodology on Reservoir Fisheries Investigations in India.

Bull. No. 12 Bull. Central Inland Capture Fisheries Research Institute).

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