Chapter- 4

RESULTS

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RESULTS

4.1 Seasonal Variation in Water Quality of Kalpani Beel

Seasonal variations affect the physical and chemical parameters of any water body which directly influence the flora and fauna living in it. Therefore the present study focused on recording the fluctuations in the physical and chemical properties of water in Kalpani Beel. A report on the monthly variations of physical and chemical parameters of water in Kalpani Beel was prepared and is presented in Table 6

Table 6: Mean seasonal variation in Physical and chemical parameters of H_2O in Kalpani Beel from April, 2016 to March, 2017.

Seasons	AT (°C)	WT (°C)	pH	FCO_2 (mg/l)	TH (mg/l)	TA (mg/l)	P (mg/l)	Cl^- (mg/l)	NO_3^- (mg/l)	NO_2^- (mg/l)	NH_3 (mg/l)	Fe (mg/l)
Pre-monsoon												
March	26.00	24.00	9.00	17.60	180.00	155.00	0.00	20.00	0.50	0.50	0.50	0.30
April	29.00	27.00	9.00	19.80	154.00	150.00	0.50	10.00	5.00	0.50	0.50	0.00
May	29.00	27.00	8.00	17.60	194.00	150.00	0.50	10.00	5.00	0.50	0.00	0.00
Mean ± SD	28.00 ± 1.41	26.00 ± 1.41	8.66 ± 0.47	18.33 ± 1.03	176± 16.57	151.66 ± 2.35	0.33 ± 0.23	13.33 ± 4.71	3.5 ± 2.59	0.5 ± 0.00	0.33 ± 0.31	0.1 ± 0.14
Monsoon												
June	33.00	31.00	9.0	8.80	110.00	140.00	0.50	20.00	10.00	2.00	0.50	0.30
July	36.00	34.00	9.00	10.12	82.00	150.00	0.50	10.00	0.00	0.00	0.00	0.00
August	34.00	32.00	8.0	39.60	182.00	200.00	0.50	20.00	10.00	1.00	0.00	0.00
Mean ± SD	34.33 ± 1.24	32.33 ± 1.24	8.66 ± 0.47	19.50 ± 14.17	124.66 ± 42.12	163.33 ± 97.58	0.5 ± 0.00	16.66 ± 4.71	6.66 ± 4.71	1.00 ± 0.81	0.16 ± 0.23	0.1 ± 0.14
Post- monsoon												
September	30.00	28.00	9.00	13.20	200.00	250.00	0.00	10.00	0.00	0.00	0.00	0.30
October	28.00	27.00	9.00	14.30	210.00	260.00	1.00	10.00	0.00	0.00	0.00	0.30
November	24.00	23.00	9.00	22.00	186.00	210.00	0.5	20.00	0.00	0.00	0.00	0.00
Mean ± SD	27.33 ± 2.49	26 ± 2.16	9.00 ± 0.00	16.5 ± 13.23	198.66 ± 9.84	240 ± 21.60	0.5 ± 0.40	13.33 ± 4.70	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.2 ± 0.14
Winter												
December	21.00	19.00	10.00	11.70	130.00	175.00	0.5	20.00	0.00	0.00	0.00	0.00
January	20.00	18.00	9.00	16.50	170.00	125.00	0.5	20.00	0.00	0.00	0.00	0.00
February	23.00	21.00	9.00	17.20	162.00	150.00	0.5	20.00	0.00	0.00	0.00	0.00
Mean ± SD	21.33 ± 1.24	19.33 ± 1.24	9.33 ± 0.47	15.13 ± 2.44	154 ± 17.28	150 ± 20.41	0.50 ± 0.00	20 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

Note: AT =Air temperature; WT= Water temperature; FCO_2 =Free carbon dioxide; p^H = Hydrogen ion concentration; TH= Total hardness; TA= Total alkalinity; P= Phosphate; Cl^- = Chloride; NO_3^- = Nitrate; NO_2^- = Nitrite; NH_3 = Ammonia; Fe = Iron

Water samples collected every month from April, 2016 to March, 2017 for a period of one year showed great fluctuations their physical and chemical properties. Air temperature (AT) around the Beel fluctuated between 19°C to 37°C around the year, Water temperature (WT) fell to a minimum temperature of 17°C during winter and raised up to a maximum of 35°C in summer, A higher P^H range of 11 was recorded during the winter in comparison to pH of 7.8 in summer. Enormous fluctuations in the level of Free CO_2, Total hardness (TH) and Total alkalinity (TA) were observed all throughout the year. The physical and chemical characteristics of water of Kalpani Beel are depicted in Table 7

Table 7: Physical and chemical characteristics of water collected from four different spots of Kalpani Beel from April, 2016 to March, 2017.

Parameters	Minimum	Maximum	Mean	SD	SE	WHO limits / standards
AT (°C)	19.00	37.00	27.75	4.90	1.41	*N/A
WT (°C)	17.00	35.00	25.91	5.89	1.70	30°-35°c
p^H	7.80	16.00	8.91	0.49	0.14	6.50-8.50
FCO_2 (mg/l)	8.00	40.00	17.36	7.67	2.21	22 mg/l
TH (mg/l)	80.00	212.00	163.33	36.86	10.64	100 mg/l
TA (mg/l)	123.00	262.00	176.25	42.13	12.16	120 mg/l
P (mg/l)	0.00	1.50	0.45	0.24	0.07	1.0-1.5 mg/l
Cl^- (mg/l)	9.00	21.00	15.83	4.93	1.42	250-600
NO_3^- (mg/l)	0.00	10.00	2.54	3.44	0.99	10 mg/l
NO_2^-(mg/l)	0.00	2.00	0.37	0.58	0.16	1 mg/l
NH_3 (mg/l)	0.00	0.50	0.12	0.21	0.06	0.25-5.0 mg/l
Fe (mg/l)	0.00	0.30	0.10	0.14	0.04	0.3 mg/l

Note: SD =Standard deviation; SE=Standard error; WHO= World health organization; *N/A= Not available

Correlations show the strength of a relationship between two variables and it is expressed numerically by the correlation coefficient, value range between -1.0 and 1.0. Positive correlation means correlation coefficient is exactly 1 and negative correlation means two assets move in opposite directions. Findings from correlation study used to determine occurrence and relationships among variables, and to forecast events from present data and knowledge.

A Correlation coefficient (r) analysis performed to investigate the relationship between different physical and chemical parameters in water samples is represented in Table 8. Analysis revealed both positive correlation and negative correlation. Among the parameters analyzed 56.52% showed positive correlation and 43.47%.negative correlation.

Table 8: Correlation coefficients of Physical and chemical parameters of H_2O from four selected spots of Kalpani Beel (April, 2016 to March 2017)

Seasons	AT	WT	p^H	FCO_2	TH	TA	P	Cl^-	NH_3^-	NO_2^-	NH_3	Fe
AT	1	.997**	-.491**	.122	-0.298	.122	-.008	-.456**	.567**	.500**	.1865	.216
WT		1	-.490**	.127	-.269	.171	.0319	-.467**	.549**	.483**	.168	.070
p^H			1	-.619**	-.379*	.005	-.028	0.2	-.555**	-.326*	.097	.119
FCO_2				1	.424**	.155	.019	.260	.429**	.122	-.148	-.358**
TH					1	.574**	-.305	-.106	-.138	-.268	-.240	.223
TA						1	.125	-0.315**	-.207	-.291	-.382**	.602**
P							1	-.142	.090	-.036	-.292	-.239
Cl^-								1	.120	.254	.097	-.119
NH_3^-									1	.898**	.399**	.015
NH_2-										1	.620**	.303*
NH_3											1	.408**
Fe												1

4.2 Fish Biodiversity

Study on fish diversity conducted in Kalpani Beel belonged to 7 orders and 21 families, 38 generas, and 55 species. The fish diversity is a good indicator of health of aquatic ecosystem. Among the 55 species one was found listed as endangered in IUCN red list (IUCN, 2011). The scientific name, local name and conservation status (IUCN) of fishes inhabiting Kalpani Beel are depicted in the Table 9.

Table 9: Fish species from Kalpani Beel and their conservation status

Sl. No.	Scientific Name	Local Name	Order	Family	IUCN status
1	*Amblypharyngodon mola* Ham.	Moa	Cypriniformes	Cyprinidae	LC
2	*Catla catla* Ham.	Bahu	Cypriniformes	Cyprinidae	VU
3	*Chela labuca* Ham.	Laupeta	Cypriniformes	Cyprinidae	LC
4	*Chela atpar* Ham.	Silkani	Cypriniformes	Cyprinidae	NE
5	*Cirrhinus reba* Ham.	Lachim	Cypriniformes	Cyprinidae	LC
6	*Cirrhinus mrigala* Ham.	Mirika	Cypriniformes	Cyprinidae	LC
7	*Cyprinus carpio* Linn.	Common carp	Cypriniformes	Cyprinidae	VU
8	*Chagunius chagunio* Ham.	Pitkata	Cypriniformes	Cyprinidae	LC
9	*Ctenopharyngodon idella* Vale.	Grass carp	Cypriniformes	Cyprinidae	NE
10	*Garra annandalei* Hora.	Ghor poia	Cypriniformes	Cyprinidae	LC
11	*Gonorhynchus latius* Ham.	Lahari	Cypriniformes	Cyprinidae	LC
12	*Hypophthalmichthys molitrix* Vale.	Silver carp	Cypriniformes	Cyprinidae	NT
13	*Labeo bata* Ham.	Bata	Cypriniformes	Cyprinidae	LC
14	*Labeo boga* Ham.	Bhangon	Cypriniformes	Cyprinidae	LC
15	*Labeo rohita* Ham.	Rou	Cypriniformes	Cyprinidae	LC
16	*Labeo gonius* Ham.	Kurhi	Cypriniformes	Cyprinidae	LC
17	*Labeo calbasu* Ham.	Baus	Cypriniformes	Cyprinidae	LC
18	*Osteobrama cotio* Ham.	Baralia	Cypriniformes	Cyprinidae	LC
19	*Puntius chola* Ham.	Puthi	Cypriniformes	Cyprinidae	LC
20	*Puntius terio* Ham.	Puthi	Cypriniformes	Cyprinidae	LC
21	*Puntius sophore* Ham.	Puthi	Cypriniformes	Cyprinidae	LC
22	*Puntius sarana* Ham.	Cheniputhi	Cypriniformes	Cyprinidae	LC
23	*Esomus danrica* Ham.	Dorikona	Cypriniformes	Cyprinidae	LC
24	*Acantopsis choirorhynchos* Blee.	Botia	Cypriniformes	Cobitidae	LC
25	*Lepidocephalichthys guntea* Ham.	Botia	Cypriniformes	Cobitidae	LC

26	*Acanthocobitis botia* Ham.	Kukurbotia	Cypriniformes	Nemacheilidae	LC
27	*Parambassis baculis* Ham.	Chanda	Cypriniformes	Ambassisdae	LC
28	*Parambassis lala* Ham.	Chanda	Cypriniformes	Ambassisdae	NT
29	*Anabas testudineus* Bloc.	Koi	Cypriniformes	Anabantidae	DD
30	*Badis badis* Ham.	Vacheli	Cypriniformes	Badidae	LC
31	*Colisa sota* Ham.	Besa	Cypriniformes	Belontidae	NT
32	*Colisa fasciatus* Bloc.	Kholihona	Cypriniformes	Belontidae	NT
33	*Channa striata* Bloc.	Sol	Cypriniformes	Channidae	LC
34	*Channa punctata* Bloc.	Goroi	Cypriniformes	Channidae	LC
35	*Channa marulius* Ham.	Sal	Cypriniformes	Channidae	LC
36	*Channa gachua* Ham.	Chengeli	Cypriniformes	Channidae	LC
37	*Channa stewartii* Play.	Garka chang	Cypriniformes	Channidae	LC
38	*Glossogobius giuris* Ham.	Patimutura	Cypriniformes	Gobiidae	NE
39	*Nandus nandus* Ham.	Ghaghsi	Cypriniformes	Nandidae	LC
40	*Trichogaster fasciata* Bloc. &Sch.	Khalihona	Cypriniformes	Osphronemidae	LC
41	*Trichogaster lalius* Ham.	Lal kholihona	Cypriniformes	Osphronemidae	LC
42	*Notopterus notopterus* Pall.	Kanduli/ Pholi	Osteoglossiformes	Notopteridae	LC
43	*Sperata seenghala* Syke.	Ari	Siluriformes	Bagridae	LC
44	*Mystus cavasius* Ham.	Tangana	Siluriformes	Bagridae	LC
45	*Mystus carcio* Ham.	Tangana	Siluriformes	Bagridae	LC
46	*Clarias batrachus* Linn.	Magur	Siluriformes	Claridas	EN
47	*Heteropneustes fossilis* Bloch.	Singhi	Siluriformes	Hetaropneustidae	LC
48	*Pachypterus atherinoides* Bloc.	Bardia	Siluriformes	Shilbeidae	LC

49	*Wallago attu* Bloc. & Sch.	Barali	Siluriformes	Siluridae	NT
50	*Mastacembelus armatus* Lace.	Bami	Synbranchiformes	Mastacembelidae	LC
51	*Macrognathus aral* Bloc. &Sch.	Gorsi / Turi	Synbranchiformes	Mastacembelidae	LC
52	*Macrognathus pancalus* Ham.	Turi	Synbranchiformes	Mastacembelidae	LC
53	*Monopterus cuchia* Ham.	Cuchia	Synbranchiformes	Synbranchidae	LC
54	*Xenentodon cancila* Ham.	Kokila	Syprinodoniformes	Belonidae	LC
55	*Tetraodon cutcutia* Linn.	Gangatop /Tepa	Tetradontiformes	Tetradontidae	LC

Note : EN=Endangered, VU= Vulnerable, NT=Near threatened, LC= Least concern, LR= Lower risk, DD= Data deficient and NE= Not Evaluated.

The number, percentage composition of fish families, genera and species in Kalpani Beel under various orders is presented in Table 10. The 55 species of fishes recorded in the studied Beel belonged to 21 families and 38 genera indicating rich diversity of fishes in the Beel.

Table 10: Number, percentage composition of fish families, genera and species under different orders

Sl. No.	Order	Families	Genera	Species	% of families in an order	% of genera in an order	% of Species in an order
1.	Cypriniformes	3	18	26	14.28	47.36	47.27
2.	Perciformes	8	08	15	38.09	21.05	27.27
3.	Osteoglossiformes	1	01	01	04.76	02.63	01.81
4.	Siluriformes	5	06	07	23.80	15.78	12.72
5.	Synbranchiformes	2	03	04	09.52	07.89	07.27
6.	Syprinodoniformes	1	01	01	04.76	02.63	01.81
7.	Tetradontiformes	1	01	01	04.76	02.63	01.81
	Total	21	38	55	_	_	_

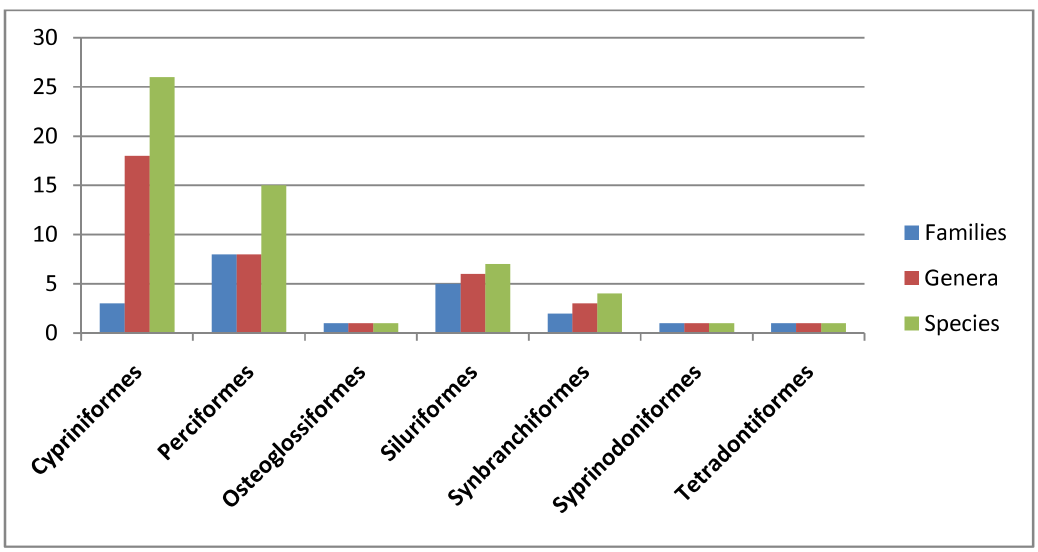
Study recorded the presence of 1 endangered species and 5 near threatened species. Presence of 1 endangered species is significant for this Beel. Conservation status of fish species under IUCN (2011) and percentage of occurrence are tabulated in the Table 11.

Table 11: Percent occurrence of fish species in Kalpani Beel in IUCN (2011) conservation status.

	EN	**VU**	**NT**	**LC**	**LR**	**DD**	**NE**
Number of species	1	2	5	43	0	1	3
Percent Contribution	01.81%	03.63%	9.09%	78.18%	0%	1.81%	5.45%

Note: EN= Endangered, VU= Vulnerable, NT= Near threatened, LC= Least concern, LR= Lower risk, DD= Data deficient and NE= Not Evaluated

Finding from bar graph exposed that cypriniformes was the dominant order (families 3, genera 18 and species 26) followed by perciformes (families 8, genera 8 and species 15) and Siluriformes (families 5, genera 06 and species 07) in the Beel. Number of families, genera and species under various orders is presented in bar graph Figure 6.



Order

Figure 4: Number of families, genera and species under various orders.

Percentage of fish species in the Beel under various threat categories were 01.81% endangered, 03.63% vulnerable, 9.09% near threatened, 78.18% least concern, 01.81% data deficient and 5.45% not evaluated. Pi- diagram showing the percentage of species under various threat categories as per IUCN status is shown in the Figure 7.

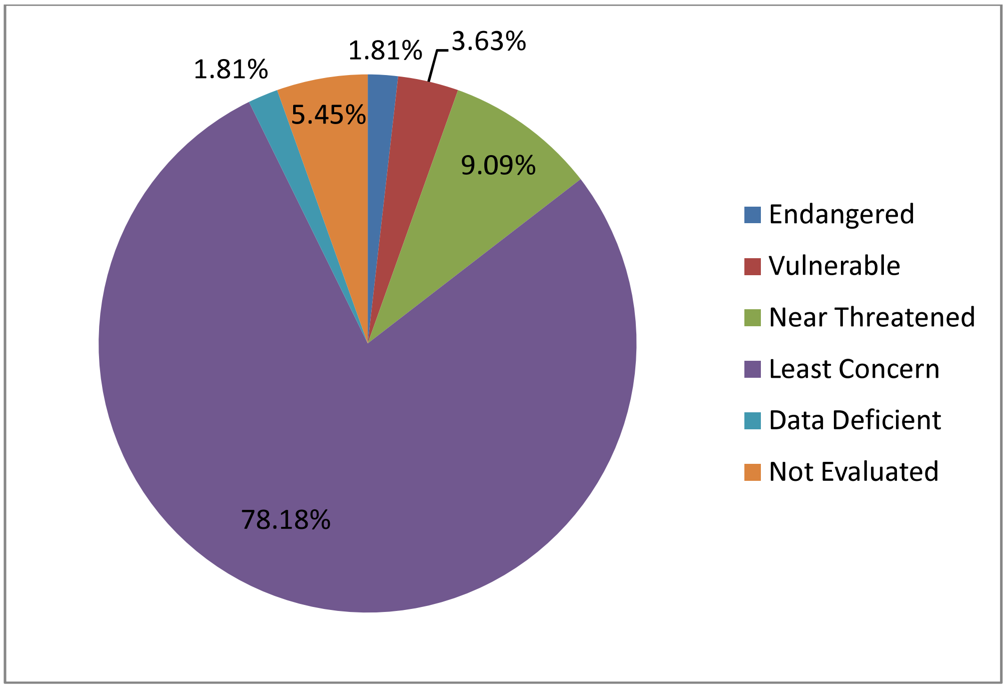


Figure 5: Pi diagram presenting percentage of fish species in Kalpani Beel under various conservation status categories as per IUCN status.

4.3 Aquatic Macrophytes

Aquatic macrophyte diversity study was conducted in Kalpani Beel from February, 2017 to January, 2018. 67 species of aquatic macrophyte were identified during the study period and is presented in Table 12.The studies on aquatic macrophytes are important to limnologist in order to understand the fluctuations in the aquatic ecosystem.

Table 12: List of aquatic macrophyte species of the study site recorded during the study period.

Sl. No.	Name of the macrophytes	Family	Local name	Habit	Life span	Life form
1	*Acorus calamus* L.	Araceae	Boch	H	P	SM
2	*Alocasia indica* (Lour) Koch	Araceae	Mankochu	H	P	SM
3	*Amaranthus spinosus* L.	Amaranthaceae	Kata- Khutra	H	A	SM
4	*Aponogeton appendiculatus* H. Brug	Aponogetonaceae	--	H	A	SA
5	*Argemone mexicana* L.	Aponogetonaceae	Sial-kata	H	P	SM
6	*Azolla pinnata* R. Br	Azollaceae	Xaru-puni	H	A	FF
7	*Bacopa monnieri* (L.) Penn	Scrophulariaceae	Brahmi sak	H	P	SM
8	*Brassica juncea* (L.) Czern	Brassicaceae	Li sak	H	A	SM
9	*Bryophyllum pinnatum* Roxb.	Crassulaceae	Pategaza	H	P	SM
10	*Ceratophyllum demersum* L.	Ceratophyllaceae	Sail bhobra	H	A	SS
11	*Ceratopteris thalictroides* Brogn.	Perkariaceae	--	H	A	SM
12	*Centella asiatica* (L.) Vrban.	Apiaceae	Bor Manimuni	H	A	SM
13	*Chara sp.*	Characeae	Chara	H	P	SA
14	*Colocasia esculenta* (L.) Schott.	Araceae	Kala kashu	H	P	SM
15	*Commelina beghalensis* L.	Commelinaceae	Kona simolu	H	A	SM
16	*Cyperus compresses* L.	Cyperaceae	Mutha bon	H	A	EA
17	*C. rotundus* L.	Cyperaceae	Keya bon	H	A	EA
18	*Cynodon dactylon* (L.) Pers.	Poaceae	Dubari bon	H	P	SM
19	*Eclipta prostrata* L.	Asteraceae	Kehraji	H	P	SM
20	*Eichhornia*	Pontederiaceae	Pani-metaka	H	P	FF

	crassipes (Mart. Solms.					
21	*Enhydra fluctuans* Lour	Asteraceae	Helachisak	H	A	SM
22	*Euphorbia hirta* L.	Euphorbiaceae	Gakhiratiban	H	A	SM
23	*Euryale ferox* Salisb	Nymphaeaceae	Kni-Kori	H	P	RFL
24	*Hydrilla verticillata* (L.f.) Royle	Hydrocharitauace	Hydrilla	H	A	SA
25	*Hydrocotyle rotundifolia* DC.	Apiaceae	Soru manimuni	H	A	SM
26	*Hymenachme acutigluma* (Steud) Gill	Poaceae	Dolgha	H	P	EA
27	*Ipomoea fistuosa* (Mart. Ex choisy)	Convolvulaceae	Amorlata	H	P	EA
28	*I. aquatic* Forssk	Convolvulaceae	Kolmou	H	A	RFL
29	*Jussieiva repens* L.	Onagraceae	Pani-khutura	H	A	SM
30	*Kyllinga brevifolia* Rottb	Cyperaceae	Kayabon	H	A	SM
31	*Lemna perpusilla* Torrey	Lemnaceae	Shoru-puni	H	A	FF
32	*Limnophila heterophylla* (Roxb) Benth	Scrophularaceae	Patal khar	H	A	SA
33	*L. indica* (L.) Druce	Scrophularaceae	Kharbon	H	A	SA
34	*Lasia spinosa* Thw	Araceae	Chang mora	H	P	SA
35	*Marsalia quadrifolia* L.	Marselliaceae	Pani tengechi	H	A	EA
36	*Mimosa pudica* L.	Mimsaceae	Lajukilota	H	A	SM
37	*Monochoria hastate* Presl	Pontederiaceae	Janakiphul	H	P	EA
38	*Myriophyllum tuberculatum* Roxb	Haloragaceae	--	H	A	RFL
39	*Najas indica* (Willd.) Cham	Hydrocharitaceae	--	H	A	SA
40	*Nymphaea alba* L.	Nymphaeaceae	Boga vet phul	H	P	RFL
41	*N. nouchali* Burm f	Nymphaeaceae	Boga vet	H	P	RFL
42	*N. pubescence* Wild	Nymphaeaceae	Mokua/Bhetp hul	H	A	RFL
43	*N. rubra* Roxb. Ex. Salisb	Nymphaceae	Rongabhet	H	P	RFL

44	*Nymphoides hydrophyllum* (Lovr. Kuntze)	Menyanthaceae	Jetuke Khar	H	A	RFL
45	*N. indicum* (L.) O. Kuntze	Menyanthaceae	Panikala	H	A	RFL
46	*Ottelia alismoides* (L.) Pers	Hydrocharitaceae	Pani kola	H	A	SA
47	*Oxalis corniculata* L.	Oxalidaceae	Xoru tengechi	H	A	SM
48	*O. acetosella* L.	Oxalidaceae	Tengachisak	H	A	SM
49	*O. corymbosa* (DC) Lour	Oxalidaceae	Bortenghachi	H	A	RFL
50	*Pistia stratiotes* L.	Araceae	Borpuni	H	A	FF
51	*Polygonum barbatun* L	Polygonaceae	Bon ghah	H	A	EA
52	*Potamogeton crispus* L.	Potamogetonaceae	Maju puni	H	P	SA
53	*Rumex dentatus* L.	Polygonaceae	Bon suka	H	A	SM
54	*R. nepalensis* Spreng	Polygonaceae	Bon suka sak	H	A	SM
55	*Sagittaria sagittifolia* L.	Alismataceae	Pani kochu	H	P	EA
56	*Salvinia molesta*	Salviniaceae	---	H	A	FF
57	*Saccharum spontaneum* L.	Poaceae	Kanhibon	H	P	EA
58	*Spirodela polyrrhiza* (L.) Schl.	Lemanaceae	Maju puni	H	A	FF
59	*Trapa natans* L.	Trapaceae	Pani singri	H	P	RFL
60	*T. bispinosa* (Roxb) Makino	Trapaceae	Shoru singri	H	P	RFL
61	*Typha elephantina* Roxb	Typhaceae	Hatibon	H	P	EA
62	*Utricularia aurea* Lour	Lentibulariaceae	Jagibon	H	A	SS
63	*U. bifida* L.	Lentibulariaceae	Patal khar	H	A	SS
64	*Vallisnaria spiralis* L.	Hydrocharitaceae	Fita ghah	H	P	SA
65	*Vetiveria zizanioides* (L.) Nass	Poaceae	Berenia bon	H	P	SM
66	*Wolfia arrhiza* Wimm	Lemnaceae	Khud puni	H	A	FF
67	*Xanthium strumarium* L.	Asteraceae	Agora	H	P	SM

Note: Abbreviation used in the table are, H= Herb, A= Annual, P= Perennial, SM= Swamp and marshy, EA= Emergent anchored, FF = Free floating, RFL= Rooted with floating leaved, SA= Submerged anchored, SS= Submerged suspended

During the study period, total of 67 plant species that belonged to 56 genus and 35 families were identified from the study site. Among them the dominant family found was that of Araceae. List of families with number of genera and species of the study site is tabulated in Table 13. Macrophytes are important for helping in maintaining ecological balance.

Table 13: List of families with number of genera and species of the macrophyte of the study site

Sl. No.	Families	Genera	Species
1	Araceae	6	6
2	Nymphaeaceae	2	5
3	Hydrocharitaceae	4	4
4	Poaceae	4	4
5	Asteraceae	3	3
6	Cyperaceae	2	3
7	Oxalidaceae	1	3
8	Polygonaceae	2	3
9	Scrophulariaceae	2	3
10	Apiaceae	2	2
11	Convolvulaceae	2	2
12	Lemnaceae	2	2
13	Lentibulariaceae	1	2
14	Menyanthaceae	1	2
15	Pontederiaceae	2	2
16	Trapaceae	1	2
17	Alismaceae	1	1
18	Amaranthaceae	1	1
19	Aponogetonaceae	1	1
20	Azollaceae	1	1
21	Brassicaceae	1	1
22	Ceratophyllaceae	1	1
23	Characeae	1	1
24	Commelinaceae	1	1
25	Crassulaceae	1	1
26	Euphorbiaceae	1	1
27	Haloragaceae	1	1
28	Marselliaceae	1	1
29	Mimosaceae	1	1
30	Onagraceae	1	1
31	Papaveraceae	1	1
32	Perkariaceae	1	1
33	Potamogetonaceae	1	1
34	Salviniaceae	1	1
35	Typhaceae	1	1
Total : family 35, Genus 56, species 67			

The study reveals that, total 67 species of macrophytes were reported from the Beel and species were classified into 6 categories. Swamp and marshy species were dominant in the study site. Life form of macrophytes of the study area is presented in Table14. Macrophytes provide suitable breeding and sheltering place for fishes.

Table 14: Life form of macrophyte in the study area

Sl. No	Life form	Number of Species
1	Free Floating	8
2	Submerged suspended	3
3	Submerged Anchored	10
4	Rooted with Floating Leaves	11
5	Emergent Anchored	10
6	Swamp and Marshy	25

The composition study of the studied aquatic macrophytes showed that 37% of swamp and marshy species were dominant followed by16% of rooted with floating leaves. Pie- diagram showing percent composition of aquatic macrophyte life forms in the study area is shown in the Figure 8. Aquatic macrophytes respond to the changes in water quality and have been used as indicator of pollution.

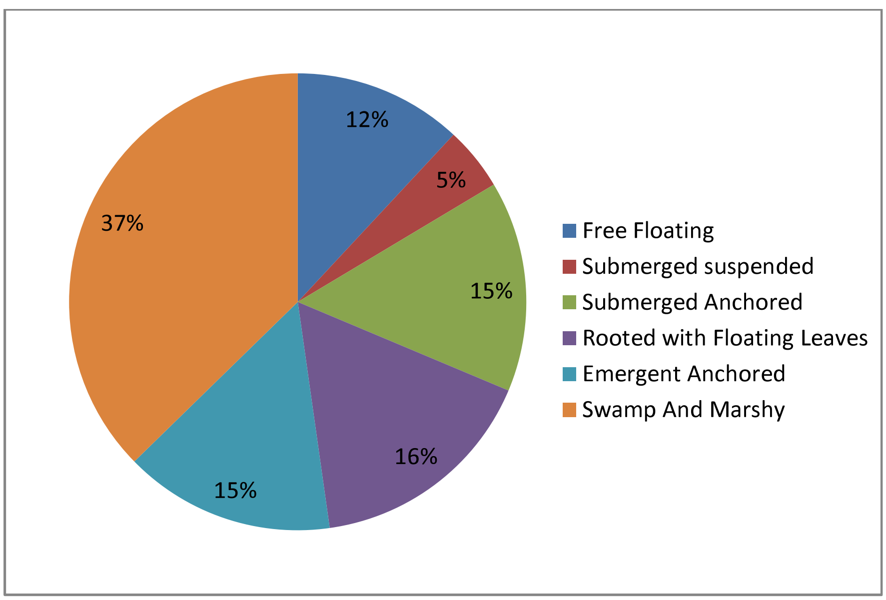


Figure 6: Pie diagram showing the percentage composition of life forms of aquatic macrophytes in the study area.

4.4 Mineral Content of Aquatic Plants in Kalpani Beel

The study of evaluating the minerals and its concentration in six aquatic plants collected from the Kalpani Beel of Assam, India were carried out using Atomic absorption spectrometry. In the last few decades, research relating to mineral content of aquatic plants and mineral requirement of fish has been carried out in India and elsewhere. People residing in the vicinity of Kalpani Beel consider aquatic plants as a good source of minerals for the fishes; however, no report on their mineral composition is available so far.Aquatic weeds, namely, *Pistia, Nymphaea*, *Ipomoea* and *Hydrilla* has been used by researchers in formulation of fish food. Utilization of water hyacinth (*Eichhornia*) as animal feed has been reported by many workers. *Trapa* are delicious to eat and contain carbohydrates, proteins and essential minerals. After reviewing the above referred studies; six aquatic plants from Kalpani Beel were selected for mineral analysis. The botanical name and part used is tabulated in Table 15

Table 15: Botanical name and parts used of some aquatic plants of Kalpani Beel of Assam, India

Botanical name	Used parts
Eichhornia crassipes (Mart) Solma	Lamina and petiole
Hydrilla verticillata (L.f.) Royle	Leaves and shoots
Ipomoea aquatic Forssk	Leaves and shoots
Nymphaea rubra Roxb. Ex. Salisb	Leaves
Pistia stratiotes L	Leaves and shoots
Trapa natanus (Roxb.) Makino	Leaves and shoots

A total of 11 elements, namely calcium (Ca), copper (Cu), cobalt (Co), chromium (Cr), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), molybdenum (Mo), sodium (Na), and zinc (Zn), were analyzed. Concentration of elements (in mg/100 g) content in the studied plants is shown in Table 16. The present study provides vital data on the availability of some essential elements, which can be useful to give nutritional information for designing value-added foods.

Table 16: Concentration of minerals (mg/100 g) in some selected aquatic plants of Kalpani Beel of Assam, India

Mineral mg/100g	**Plant code names**					
	EC	**HV**	**IA**	**NR**	**PS**	**TN**
Ca	0.067 ± 0.026	0.045 ± 0.009	0.093 ± 0.034	0.074 ± 0.013	0.121 ± 0.074	0.064 ± 0.025
Cu	0.004 ± 0.003	0.012 ± 0.002	0.004 ± 0.001	0.007 ± 0.008	0.001 ± 0.004	0.004 ± 0.002
Co	0.000 ± 0.000	0.026 ± 0.014	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
Cr	0.003 ± 0.004	0.007 ± 0.001	0.007 ± 0.001	0.011 ± 0.006	0.005 ± 0.002	0.008 ± 0.003
Fe	0.234 ± 0.124	0.016 ± 0.05	0.257 ± 0.312	2.711 ± 2.012	0.242 ± 0.433	1.036 ± 0.174
K	35.186 ± 2.752	0.335 ± 0.017	36.721 ± 1.625	18.723 ± 0.768	37.362 ± 3.014	30.501 ± 1.308
Mg	3.372 ± 1.143	0.004 ± 0.006	3.880 ± 1.025	6.759 ± 2.112	5.514 ± 1.378	2.561 ± 1.410
Mn	0.135 ± 0.041	0.004 ± 0.003	0.206 ± 0.042	0.428 ± 0.064	0.219 ± 0.011	0.376 ± 0.023
Mo	0.016 ± 0.006	0.014 ± 0.020	0.002 ± 0.001	0.003 ± 0.003	0.002 ± 0.004	0.001 ± 0.005
Na	0.053 ± 0.018	0.035 ± 0.004	0.626 ± 0.112	1.233 ± 0.241	3.444 ± 1.032	4.299 ± 2.065
Zn	0.026 ± 0.010	0.011 ± 0.05	0.041 ± 0.016	0.022 ± 0.021	0.017 ± 0.008	0.035 ± 0.004

Note: Mean ± SD (Standard deviation) EC = *Eichhornia crassipes*, HV = *Hydrilla verticillata*, IA = *Ipomoea aquatica*, NR = *Nymphaea rubra*, PS = *Pistia stratiotes*, and TN = *Trapa natans*

A correlation coefficient analysis performed to study the relationship between different element concentrations in aquatic plant samples showed more positive correlations than negative correlations. Co and Cu (r = 0.88576), Fe and Cr (r = 0.88351), and Mn and Fe (r = 0.83065) showed a significantly positive correlation.The correlation coefficient between major and minor-element concentration of selected aquatic plants are tabulated in the Table 17. Trace elements are essential chemical elements required in the normal metabolism of fish

Table 17: Correlation Coefficient between major and minor-element concentrations of selected aquatic plants from Kalpani Beel of Assam, India.

	Ca	Cu	Co	Cr	Fe	K	Mg	Mn	Mo	Na	Zn
Ca	1.00000										
Cu	-0.77192	1.00000									
Co	-0.60288	0.88576**	1.00000								
Cr	-0.15226	0.32695	-0.02661	1.00000							
Fe	-0.07829	0.07118	-0.33355	0.88351**	1.00000						
K	0.71011*	-0.97144	-0.8889	0.38604	0.13333	1.00000					
Mg	0.67843	-0.5635	-0.76143	0.39237	0.62617	0.50783	1.00000				
Mn	0.23951	-0.41244	-0.69359	0.68188	0.83065**	0.33435	0.69936	1.00000			
Mo	-0.57413	0.4763	0.51832	0.50936	0.39758	0.38566	0.5268	0.7284	1.00000		
Na	0.40172	-0.55973	-0.42441	0.13738	0.16558	0.38643	0.24536	0.58192	0.72177	1.00000	
Zn	0.16215	-0.52623	-0.64342	0.00626	0.05011	0.64948	0.15552	0.42659	0.44443	0.19407	1.00000

(*** P< 0.001; ** P< 0.01; * P< 0.05)

4.5 Photosynthetic Pigments of *Hydrilla verticillata*

Among the investigated six aquatic plants, *Hydrilla verticillata* is a submerged aquatic plant, whereas *Pistia stratiotes, Eichhornia crasspies, Ipomoea aquatica, Nymphaea rubra and Trapa natanus* were free floating aquatic plants. The chlorophyll content of a plant can be taken as an index of photosynthetic productivity of a plant. However no information was available regarding the chlorophyll content of *Hydrilla verticillata* plant. Therefore, photosynthetic pigments analysis of *Hydrilla verticillata* was undertake to know the productivity of this plant.

Light visible to the human eye occupies only a small portion of the electromagnetic spectrum, namely from about 350 to750 nanometers, or from violet to red. The color of light is also related to the energy of the light (Bowen, W.R. and Baxter,W. D.1980). The spectrum of radiant energy, color of light and their wavelength, λ (nm) is presented in Figure 9 (https://eyelighting.com).

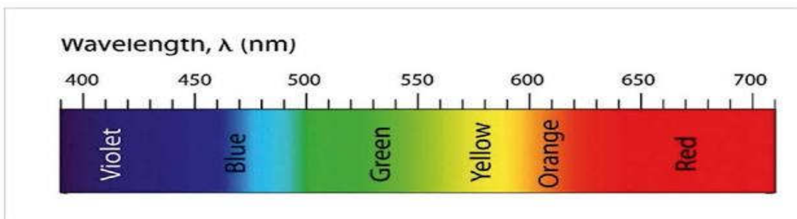


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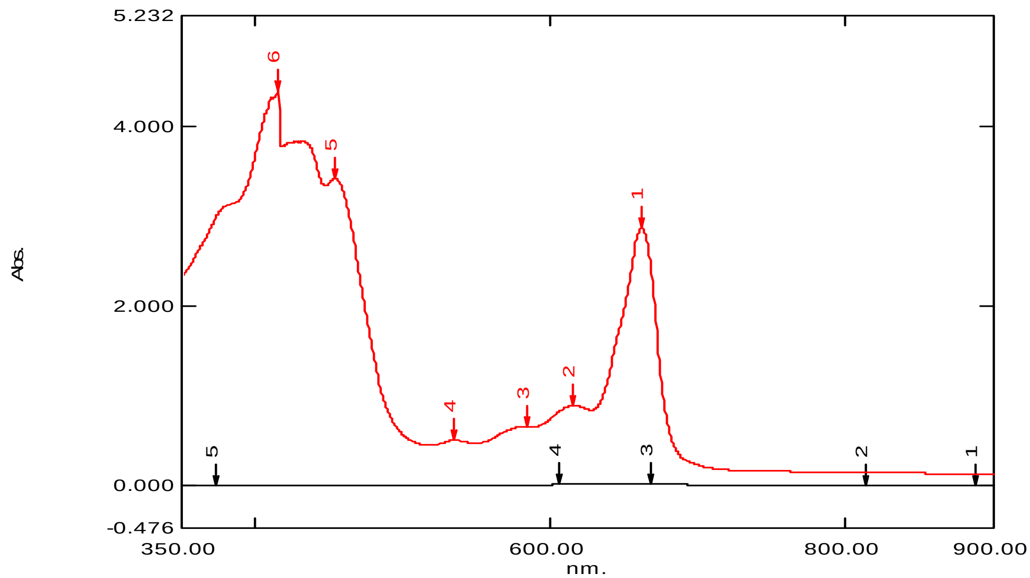
Figure 7: Spectrum of radiant energy (nm = nanometer)

Chlorophyll, the green pigments of plants is the most important pigments active in the photosynthetic process. *Chlorophyll-a* and *chlorophyll-b* are the best known and most abundant and found in all autotrophic plants. *Chlorophyll a* and *b* have absorption maxima in the 600- 675 nm and in the 400- 475 nm range. The present study provides us some important data on the availability of some photosynthetic pigments, which can be useful to give us productivity information of this plant. The absorption peak-1 in the wavelength 662 nm indicated the presence of *chlorophyll a*, peak-2 in the wavelength 642 nm indicated the presence of *chlorophyll b*, peak-6 in the wavelength 435 nm indicated the presence of *chlorophyll a* and peak- 5 in the wavelength 453 nm indicated the presence of *chlorophyll-b*. The absorption peaks and the wavelength (nm) of the photosynthetic pigments of *Hydrilla verticillata* plant in acetone solution is presented in the Figure 10. The graph exposed absorbance (Abs.) on the Y- axis and wavelength (nm) on the X- axis.



Wavelength (nm)

Figure 8: Absorption peaks of *chlorophyll a*, *chlorophyll b* and *carotenoids* in acetone solution

The absorbance peaks of photosynthetic pigments in their wavelength (nm); colour of light and their wavelength were tabulated in the Table 18. Aquatic plants play a vital role in healthy ecosystem. They serve as primary producers of oxygen through photosynthesis.

Table18: Absorbance peaks, their wavelength (nm) and photosynthetic pigments

Wavelength (nm)	Color of visible light	Absorbance		Photosynthetic pigments
		Peaks No.	Wavelength (nm)	
390-430	Violet	–	–	–
430 -470	Blue	6	435	*Chlorophyll - a*
470 -500	Blue green	5	453	*Chlorophyll- b*
500-560	Green	4	533	Carotene
560 -600	Yellow	3	570	Xanthophylls
600 -650	Orange	2	642	*Chlorophyll- b*
650 -760	Red	1	662	*Chlorophyll- a*

Note: nm = nanometer

4.6 Effect of *Hydrilla verticillata* Formulated Fish Feed on Growth and Muscle Composition in *Labeo rohita* Fingerlings

Commercial fish feeds are prepared by carefully evaluating the nutritional need of the fishes. Through investigations on the availability of commercial fish feed in the vicinity markets it was found that four types of commercial fish feeds from four different manufacturers are sold. The Nutritional composition of commercial fish feeds available in the nearby markets of Kalpani Beel is presented in the Table 19.

Table 19: Nutrition composition of commercial fish feeds (g/100g)

Sl.No	Name of fish feed	Manufacturer	Protein	Fat	Fiber	Moisture	Vitamins	Minerals
1	Tetrabitscomplete	Sea Star Aquarium, Delhi	47.5	6.5	2.0	6.0	A, D.	Mn, Zn, Fe.
2	Aini fish food	Sudesh art and crafts Pvt. Ltd. Delhi	32.0	4.0	3.0	9.0	A, C, E.	Premix
3	Nova	Nova Sea food, Gujarat	20.0	3.0	7.0	10.0	Premix	Ca,P.
4	Optimum	Royal Aquarium, Mumbai	28.0	3.0	4.0	10.0	C,E.	Premix

*Source: Data in the table were provided by manufacturers.

The proximate compositions of different formulated fish feeds (CD, H30, H40 and H50) are presented in the Table 20. Crude protein in experimental diets ranged from 26.50 g/100g to 34.65 g/100g while one of the commercial feed showed higher protein content (47.5g/100g). Among the three experimental diets H40 had the highest protein content.

Table 20: Proximate Composition of Experimental diets (g/100g)

Sl. No.	Parameter	Control diet (CD)	Experimental diets / Fish food		
			H30	H40	H50
1	Total solids	88.89	90.11	88.89	91.31
2	Moisture (%)	11.11	9.89	11.11	8.69
3	Crude protein (%)	29.50	30.60	34.35	26.50
4	Crude fat (%)	3.49	2.92	1.78	0.29
5	Crude fiber (%)	11.07	11.67	11.94	11.76
6	Ash (%)	0.11	0.17	0.22	0.16
7	NFE	44.72	44.75	40.6	52.6
8	Caloric value (K cal/ g.)	328.29	327.68	315.82	319.01

CD= Control diet, H30= 30% plant powder, H40= 40% Plant powder, H50= 50% plant powder and NFE =Nitrogen free extract.

Growth parameter studies in fishes are important for effective study of their nutritional requirements. Growth parameters of fingerlings fed experimental diets and control diets are presented in Table 21. Maximum weight gain, length gain and specific growth rate was observed in fingerlings fed with H40.

Table 21: Growth parameters of *Labeo rohita* fed experimental diets for 60 days

Parameters	Control diet(CD)	Experimental diets		
		H 30	H 40	H 50
Initial weight (g)	9.52±0.2	9.53±0.1	9.41±0.1	9.31±0.1
Final weight (g)	32.32±0.1	40.13±0.1	45.71±0.2	44.0±0.2
Weight gain (g)	22.8±0.3	30.6±0.2	36.3±0.2	34.7±0.3
Initial length (cm)	8.10±0.2	7.50±0.1	7.80±0.1	8.20±0.1
Final length (cm)	13.33±0.1	15.20±0.1	16.17±0.1	14.62±0.2
Length gain (cm)	5.23±0.3	7.70±0.2	8.37±0.2	6.42±0.3
PWG%	239.49	321.09	385.75	372.71
SGR	0.885	1.04	1.145	1.125
ACF	1.364	1.142	1.08	1.408
PSR	100.00	83.33	100.00	83.33

PWG= Percentage of weight gain; SGR=Specific growth rate; ACF=Average condition factor; PSR= Percentage survival rate.

4.6.1 Cost analysis of formulated feeds

Cost analysis of the formulated experimental feeds and commercial feeds indicated a significant cost reduction with decrease in other nutrient additives in the formulated experimental feeds. The results of the cost analysis are presented in Figure 11.

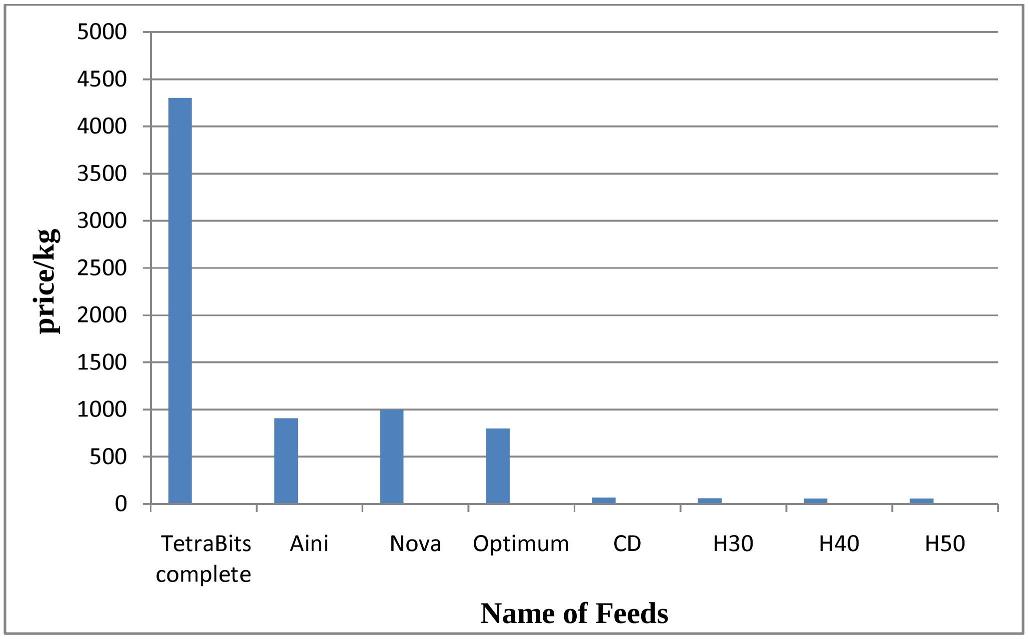


Figure 9: Cost analysis of commercial and *H. verticillata* integrated fish feeds.

4.6.2 Proximate composition analysis of fish muscle of *Labeo rohita* fed experiment diets

The proximate composition of fish muscle of *Labeo rohita* (Rohu) fed the experimental diets H30, H40, H50 and CD is presented in Table 22. Carcass quality is a matter of great importance from the perspective of consumer acceptance. Increase in muscle protein and lipid content of fish fed on experimental diets could be ascribed to the efficiency of the fishes to digest plant ingredients as an energy supplement for growth (Sivani *et al.* 2013).

Table 22: Proximate composition of *Labeo rohita* (Ham.) muscle fed experiment diets (g/100g) on dry weight basis

Parameters	CD	Experimental diets		
		H 30	**H 40**	**H 50**
Moisture	60.7 ±1.8	60.6 ± 1.7	60.6 ± 1.2	60.5 ± 1.6
Total Solid	39.30 ± 1.0	39.4 ± 1.2	39.4 ± 0.8	39.5 ± 1.1
Crude protein	18.00 ± 1.5	19.4 ± 1.4	20.5 ± 1.3	19.8 ± 1.9
Crude fat	3.83 ± 0.1	3.76 ± 0.3	3.68 ± 0.4	3.47 ± 0.1
Ash	2.09 ± .02	2.21 ± 0.3	2.64 ± 0.7	2.37 ± 0.5
NFE	15.38 ± 0.6	14.03 ± 0.2	12.58 ± 0.1	13.86 ± 0.3
Calorific value (Kcal/100g)	167.99± 0.1	167.56 ± 0.6	165.44 ± 0.7	165.87± 0.1

Note: CD= Control diet, H30= 30% plant powder, H40= 40% Plant powder, H50= 50% plant powder and NFE =Nitrogen free extract.