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STATUS OF PATKAI LAKE NEAR TIKAK OPEN CAST MINE, ASSAM: A HYDRO-BIOLOGICAL APPROACH

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ABSTRACT

To see the impact of Acid mine drainage (AMD) in Patkai wetland near Tikak open cast mine of Margherita Sub-division , District Tinsukia, Assam, the hydro-biological characteristics were analysed for the year 2007-08. Physico-chemical characteristics revealed low D.O. (3.21 mg/l); high turbidity (25.19 NTU), hardness (83.15 mg/l); presence of heavy metals like Arsenic (0.038 mg/l) and Iron (0.18 mg/l) beyond permissible level in water and sediment soil. Aquatic diversity represents less diversity of plankton as well as low fish distribution with six species belonging to four genus indicating water pollution due to mining activities. The wetland needs immediate conservation to restore its value as potential water body.

Key words : Patkai wetland, Hydrology, AMD, metal pollution, conservation. .

INTRODUCTION

The coal mining industry has to dispose millions of litres of water every day. This water forms main source of various water supplies in the thickly populated coalfields (Singh, 1988). The Makum Coal field is located at the belt of Patkai Naga Range in Tinsukia district of Assam, India. The area lies between the latitudes 27°15′ and 27°25′N and longitudes 95°40′ and 96°5′E. Tikak open cast mine belongs to Makum Coalfields is located 8 km from Margherita in the North–East direction. It occupies a foot hill area of the Eastern Himalayan above 150 and 300 m sea level. The mine is situated at the hill top and the over burden (OB) removed had been initially dumped on the hill slopes. The slope dumping had caused land degradation which had attracted severe criticism. As the mining industry running from 1896, in its long history it creates huge excavations and other environmental problems including air, water, noise pollution, vibration of earth, deforestation and other socio-cultural problems (Dutta *et al*., 2004; Dkhar and Rai ,2005; Barpujari *et al.* , 2006) greatly affecting the human health, animal life, floral and faunal diversity nearby and far from settlement of mining industry (Bradshaw *et al* .,1986; Mariance *et al.*, 1989; Galpon,1997). Water pollution due to metals released from mining discharge was reported by variuos workers like Panda (2002) ; Dutta *et al.*, 2002. Some important works in the mining areas of Assam was done by Bhagabati (2002); Dutta *et al.* (2004); Khanderwal *et al.* (2005); Maiti and her co-worker (2005); Hasin and Islam (2005); Barpujari *et al.* (2002).

In the field of ichthyology there is valuable contribution by many workers (Lahon, 1979; Hamilton Buchanan, 1822; Day, 1878; Talwar and Jhingran, 1991; Jayaram, 1999; Sakhare and Joshi, 2002; and Brinda *et al.,* 2010) pertaining to water pollution and fish diversity.

In the recent years, the hydrological studies to see the toxic effect of different pesticides and other chemical pollutants in surface water has received the attention of a number of investigators but very little information is available about the hydrology of the wetlands near the mining region in Tinsukia district of Assam . About 15 numbers of beels of potential significance are surveyed in Margherita sub-division of District of Tinsukia (Bhagabati and Borkotoki, 2013).

Hence, attention has been mainly drawn to see the fish diversity in the potential water bodies of Margherita, a sub–division of Tinsukia district which is selected as our study area. Out of 15 numbers of beels of potential significance, Patkai lake situated near Tikak Open cast mine was selected as experimental water body for detailed study of hydro-chemistry, aquatic bio-diversity to see the impact of mining activities and was compared with the Mota beel (control water body) to see their future prospects for Aqua-culture .

MATERIALS AND METHOD

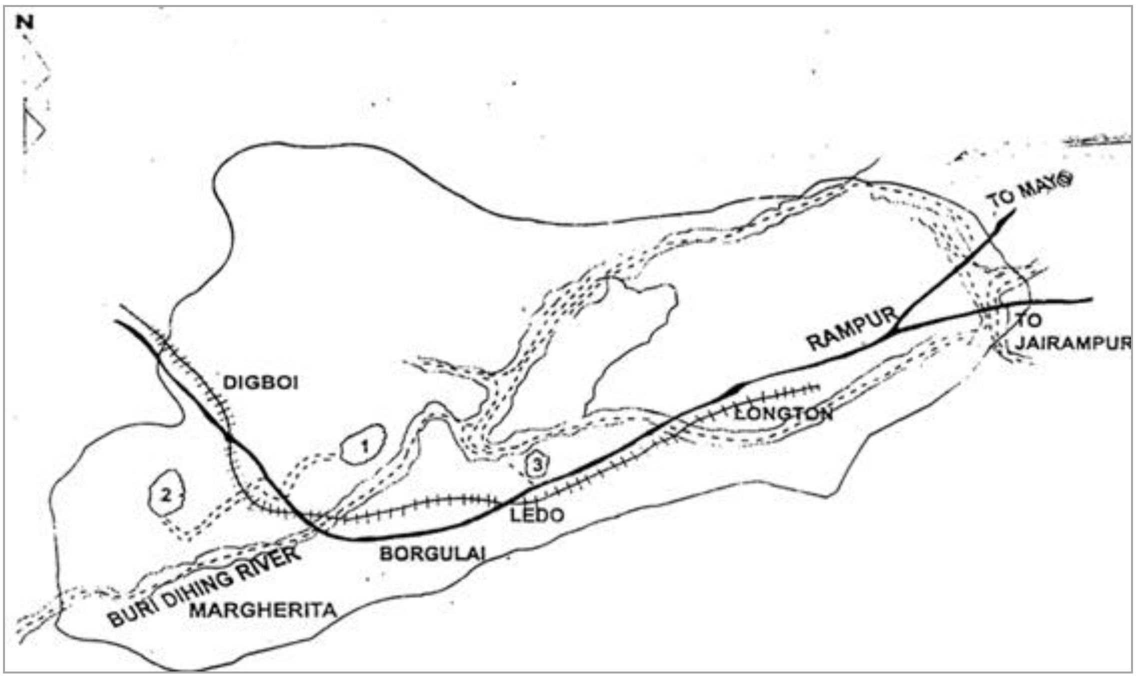
Site Selection:

The Patkai pond is a mine water affected wetland situated at the eastern range of Patkai hill near Tikak Open Cast Mine of Margherita Sub division. The pond is an example of reclaimed water body as it is a conversion of a quarry resulted from open cast mining process which was generated about 50 years ago. The area of the pond is about 2.9 hectare with an average depth 10 ft. Now the pond is utilized by the local community for various purposes like fishing, bathing, washing, drinking etc. On the other hand Mota beel is a fiood-plain affected water body and fishery situated about 10 km away from Margherita town (Figure:1).

Experimental Parameters

The physico-chemical characteristic of water and sediment soil of both the wetlands was analyzed following the standard methology of APHA (1995), heavy metal was analysed with the help of Atomic Absorptive Spectrometry (AAS) followed after Ramteke and Moghe, 1988. Plankton diversity was recorded followed by Sharma (2001).

Fig: 1. Study Area showing the selected water bodies (2) Mota beel (Control) & (3) Patkai lake (Experimental Water body) (*Source: Collected from Block Office, Margherita*)



To study fish diversity fishes were collected with the help of local fishermen using different type of nets and photographs were taken with help of digital camera. Fishes were brought to laboratory and preserved in 10% formalin solution and identified with the help of standard key and books (Day, 1878; Jayaram, 1999 and Talwar and Jhingran, 1991).

RESULTS AND DISCUSSION

Physico-chemical & elemental analysis:
According to Table 1, 2 & 3 physico-chemical characteristics of Patkai lake revealed high pH and low Dissolved oxygen, poor alkalinity, high turbidity, high TDS, high FCO_2 which might be due to the entry of acid drainage from the mine areas. Patkai lake is influenced by Acid mine drainage (AMD) which was the cause of the increase in pH and decreased dissolved oxygen levels and found to be least productive whereas Mota beel having normal pH, D.O. and alkalinity having favourable physico-chemical conditions was highly productive. This is also supported by Zitko and Carson (1976); Pascoe *et al.* (1986). According to them the toxicity of pollutant may be increased or decreased by various water quality factors including pH, temperature, hardness and Dissolved Oxygen content of water (Graph:1 & 2).

Table 1: Comparative physico-chemical characteristics of water of Mota Beel and Patkai Lake during 2007-08.

Sl No	Parameters	Mota beel		Patkai lake	
		Mean ± SD	δ (Variance)	Mean ± SD	δ (Variance)
1	pH	7.1 ± 0.5	0.078	6.3 ± 0.17	0.03
2	Water Temperature ^{0}C	18.3 ±4.5	16.88	19 ± 4.04	13.6
3	Turbidity (NTU)	24.3 ± 1.6	2.26	24.56 ± 1.9	3.33
4	Total Hardness (mg/l)	56.6 ± 1.8	2.88	80.6 ± 4.0	13.7
5	D.O.(mg/l)	6.9 ± 0.23	0.04	2.9 ± 0.4	0.16
6	Free CO_2 (mg/l)	8.91 ± 0.64	0.32	21.34 ± 0.6	0.3
7	TDS (mg/l)	89.25 ± 1.4	1.64	95.4 ± 2.1	3.7
8	Alkalinity (mg/l)	71.92 ± 7.5	47.2	59.25 ± 5.9	29.4
9	Residual Chlorine (mg/l)	Nd	--	Nd	--
10	Sulphate (mg/l)	1.14 ± 0.04	0.001	1.58 ± 0.1	0.01
11	Chloride as Cl^- (mg/l)	2.93 ± 0.27	0.064	2.935 ± 0.1	0.01

** = Significant findings*

Table -2: Comparative Elemental characteristics of water of Mota Beel and Patkai Lake during 2007-08.

Sl No	Parameters	Mota beel		Patkai lake	
		Mean ± SD	δ (Variance	Mean ± SD	δ (Variance
12	Magnesium (mg/l)	33.4 ± 1.06	0.95	40.3 ± 1.8	2.8
13	Calcium (mg/l)	21.94 ± 1.5	1.93	32.86 ± 2.7	6.3
14	Iron (mg/l)	0.18 ± 0.01	0.0001	0.79 ± 0.02	0.0005
15	Manganese (mg/l)	0.019 ± 0.004	0.0001	0.56 ± 0.05	0.002
16	Nickel (mg/l)	0.15 ± 0.01	0.00009	1.06 ± 0.02	0.0001
17	Arsenic (mg/l)	Nd	Nd	0.002±0.001	0
18	Zinc (mg/l)	0.345 ± 0.05	0.003	0.84 ± 0.06	0.002
19	Lead (mg/l)	Nd		0.074 ±0.004	0.0001
20	Mercury (mg/l)	Nd	---------	Nd	
21	Copper (mg/l)	Nd		Nd	--------
22	Cobalt (mg/l)	Nd	------------	Nd	---------

** = Significant findings*

Table-3. Mean values of sediment soil characteristics of mota beel and patkai lake during 2007-08.

Sl. No.	Parameters	Mo*ta* beel MEAN ± SD	Patkai lake MEAN ± SD
1	pH	6.5 ± 0.18	5.4 ±0.2*
2	Organic Matter (%)	0.94 ± 0.04	0.9 ± 0.02
3	Available phosphorous (%)	0.003± 0	0.0028± 0
4	Available Nitrogen (%)	0.008 ± 0.0005	0.0081 ± 0
5	Fe (mg/L)	82.6 ± 1.7	97.3 ± 2.5*
Elements (mg/ml)			
6	Mn	369.5 ± 55.3	646.4 ± 33.5*
7	Co	0.15 ± 0.0007	0.21 ± 0.01*
8	Cu	0.0058 ± 0	0.61 ± 0.007*
9	Cr	1.1 ± 0.06	1.45 ± 0.02
10	As	BDL	0.061 ± 0.05*
11	Hg	BDL	BDL
12	Ni	0.43 ±0.06	2.68 ± 0.4*
13	Zn	24.07 ± 2.09	41.33 ± 1.9*
14	Pb	17.14 ± 0.79	50.56 ± 2.05*

* = *Significant findings*

Elemental analysis in the selected beels shows that pertaining to metal pollution, the site most polluted with heavy metals was Patkai lake, i.e., waters and sediments had the highest concentration of metals namely As , Fe and Pb. Patkai Lake was beyond permissible level again may cause water pollution and makes it unsuitable for domestic usage. The relative limit of detection of Arsenic in the experimental water body, Patkai lake were in the range of 0.01–0.038 in water and 0.4–1.0 mg/ml soil (Bhagabati and Borkotoki, 2013). Concentration of metals in lakes viz., Copper, Zinc and Iron are all toxic to fish and amphibians (Freda, 1991; Lande and Guttman, 1973). On the other hand the Control site viz. Mota beel was characterized by the presence of low concentrations of metals in water and in sediment (Table-2). The analysis showed that Arsenic (As) could not be detected in the water and soil of control water body, Mota beel. The usual level of As in potable water is within 0.001 mg/l. Some coals have high Arsenic level (Dey, 1996) and the Arsenic is emitted when the coal is burnt. Arsenic occurs in water as a result of mineral dissolution, industrial (Singh, 1988), discharge or application of insecticide (Gerald *et al.*, 1971).

The Fe level in water amd sediment soil of control Mota beel was recorded 0.18 and 82.6 mg/l respectively. On the other hand due to acid surface drainage the **Fe** concentration in Patkai pond is 0.79mg/l in water and 97.3 mg/l in soil. Water containing >2 mg/l Fe cause staining of clothes and porcelain, and imparts a bitter astringent taste. The permissible limit for filterable Fe in drinking water is 0.3 mg/l.

Lead (Pb) content in the control water body (Mota beel) recoded Pb in sediment soil only (17.14mg/l) whereas in experimental Patkai lake Pb content was recorded in higher amount in both water (0.74mg/l) and sediments (50.56mg/l).

However, the presence of other elements in the water like Mn, Co, Cu, Cr, Hg, Ni and Zn showed no significant difference with the control (Table-3).

Acid mine drainage is a particularly severe by product of mining especially where coal seams have abundant quantities of pyrite. When pyrite is exposed to water and air, it forms sulfuric acid and iron (Singh, 1988). The acidity of the runoff is problematic by itself, but it also dissolves metals like manganese, zinc and nickel, which then become part of the runoff. The resulting acidity and presence of metals in the runoff are directly toxic to aquatic life and render the water unfit for use. Some metals like Arsenic bio-accumulate in the aquatic food chain.

Figure-2. Mining Area Of Tikak Open Cast Mine, Margherita

Figure-3. TIKAK OCM

Figure-4. Bathing In Patkai Lake

Figure-5. Washing of cloth by local people at the bank of Patkai lake

The runoff from surrounding OCM fields and concentration of chemical constituents in partially dried up aquatic environment of Patkai were the possible cause for the deterioration of water quality. Patkai lake was further disturbed by unplanned anthropogenic activities along the shorelines of the lake (Fig-3, 4 & 5), which had its influence on the water quality.

Plankton Diversity:

Table-4, shows Plankton diversity of the experimental water body namely Patkai lake was less. On the other hand, Mota beel (control) had higher diversity of zooplankton and phytoplankton when compared to Patkai lake because of the sufficient nutrient input resulting in mesotrophic condition and lesser disturbance to the water quality which resulted in the rich fish diversity (Sharma, 2001).

The zooplankton analysis confirmed the poor water quality of Patkai lake. The lake had poor representation of the zooplankton community (Table-4, 4.1 & 4.2) which is vital for the survival of the higher trophic levels. This had possibly let to various disorders in fishes eventually leading to the death of fishes in Patkai lake. In Tikak OCM region AMD and other anthropogenic activities i.e., bathing, washing of clothets etc. had altered the zooplankton community structure, which would influence the entire trophic structure of the lake (Figure-2, 3, 4, 5).

Table 4. Comparative Analysis Of Numeric Abundance (μl^{-1}) and Percentage Composition Of Plankton In Mota Beel And Patkai Wetland During 2007-08

Group	Range				%	
Phyto-plankton	**Mota beel**	**Avg**	**Patkai Lake**	**Avg**	**Mota beel**	**Patkai lake**
Bacillariophyceae	122-300	217	37-226	123	34.4	26.4
Desmids	93-260	122	18-42	38	19.4	08.2
Myxophyceae	85-160	113	65-73	89	17.9	19
Chlorophyceae	135-241	216	90-297	216	28.3	46.35
Total Phyto-plankton	450-922	630	262-626	466	100	100
Zoo-plankton						
Rotifers	93-144	91	30-48	53	30.4	18.3
Copepods	64-116	78	52-140	125	22.6	43.2
Protozoans	146-256	141	34-115	88	42.33	30.44
Cladocerans	20-32	34	24-29	23	06.0	07
Total Zoo-plankton	373-472	344	155-286	235	100	100
Total plankton (Mean)	809-1433	974	460-892	632		

It showed the less diversity of plankton in the lake. The phyto-plankton diversity of Patkai wetland (Table-4.2) reveals the less growth of algae. Similarly, presence of zoo-plankton like *Keratela*, *Daphnia*, *rotifers and cladoceran* in less amount indicates metal pollution in Patkai wetland. It is also supported by Chakrapani *et al.* (1996).

On the other hand, rich diversityof phytoplankton in the Mota beel indicated suitability of the water body of the beel for aquaculture. Sukumaran *et al.* (2008) also reported that phytoplankton is the major primary producers in many aquatic systems and is important food source for other organisms.

Fish diversity:

The present study reveals that Fish community structure in the experimental water body, Patkai lake revealed low fish diversity in comparison to the control, Mota beel during the study period (Table-5.1, 5.2 & 5.3). Characteristics of fish community structure can be considered as highly relevant end-point since they reflect the health of whole aquatic habital including water quality. A gradual decline in fish population in different water bodies throughout the globe had become a great concern in the recent years which is also reported by Myashita *et al.* (1990), Natarajan (1984) and Devi (2010).

Table-5. 1: Fish diversity recorded in patkai lake and mota beel during study period

Family	No. of individuals	
	Mota beel (Control)	**Patkai lake (Experimental)**
Notopteridae	13	--
Cyprinidae	76	8
Balitoridae	4	--
Bagridae	41	--
Siluridae	9	--
Channidae	49	12
Claridae	72	19
Gobidae	23	4
Heteropneustidae	18	--
Belonidae	7	---
Anabantidae	21	---
Mastacembellidae	11	----
Total	334	43

Table-4.1: Diversity of zooplankton groups recorded in patkai lake and mota beel during study period

Groups	Species	Patkai Lake (experimental)	Mota beel (Control)
Rotifera	*Brachionus angularis*	+++	+
	Brachionus calyciflorus	+	++
	Brachionus caudatus aculeatus	+	+
	Brachionus diersicornis	+	++
	Brachionus quadridentata	--	+
	Keratella cochlearis	+++	--
	Keratella tropica	+++	+
	Lecane lunaris	+	+
	Lacane monostyla	+	++
	Gastropus minor	--	+
	Ascomorpha ovalis	+	++
	Asplanchna sp	++	+
	Synchaeta sp	+	+
	Polyarthra vulgaris	--	+
	Philodina citrine	+	+++
Cladocera	*Daphnia pulex*	+	+++
	Daphnia carinata	+	++
	Monia micrua	--	+
	Monia brachiata	+	+
	Bosmina. Sp	+++	+
	Alonella. Sp	+	+
Copepoda	*Cyclopoid copepodite*	+	++
	Diaptomus pallidus	+	++
	Neodiaptomus sp	+	+
	Cyclops sp	+++++++	++
	Mesocyclops sp	+	+
	Nauplius larva	+	+
Protozoa	*Paramecium caudatum*	++	+++
	Vorticella campanula	+	+++
	Pandorina	+	++
	Centropixis	+	+
	Eudorina	--	+
	Difflugia	++	--

NB: + indicates presence and – indicates absence

Table-4.2. Phytoplankton groups recorded in Patkai Lake and Mota beel during study period

Family	Species
Chlorophyceae	***Ankistrodesmus***
	Botryococcus
	Ceratium
	Chlamydomonas
	Chodatella
	Crucigenia
	Dictyosphaerium
	Dinobryon
	Euglena
	Hormidium
	Oedogonium
	Pediastrum
	Protococcus

	Scenedesmum *Spirogyra* *Synura* *Ulotrix* *Volvox* *Zygnema*
Desmidiaceae	*Arthrodesmus* *Closterium* *Cosmarium* *Desmidium* *Euastrum* *Gennicularia* *Micrasterius* *Penium*
Bacillariophyceae	*Amphora* *Cocconeis* *Cyclotella* *Cymbella* *Diatoma* *Diatomella* *Epithemia* *Eunotia* *Fragillaria* *Gomphonema* *Melosira* *Meridion* *Navicula* *Pinnularia* *Surirella* *Synedra* *Tabellaria*
Myxophyceae	*Anabaena* *Aphanocaspa* *Coeiospherium* *Merismopodia* *Nostoc* *Oscillatoria* *Rivularia* *Spirulina* *Netrium* *Xanthidium* *Tetradesmum* *Microcystis*

In the present study As, Cu, Ni, Zn were obtained as trace metal pose a serious threat to the aquatic ecosystem and might result in selective elimination of the most sensitive life stages of vulnerable fish species in Patkai lake which is supported by the low fish diversity of the lake. Heavy metal pollution in water and soil surface of Patkai wetland lower the fish diversity. Similar finding was also reported by Chen *et al.* (1997); Deka *et al.* (2005) and by Zhou (2000) in soil and fish.

The interrelationship between the physico-chemical parameters and plankton production of pond water and its relation with fluctuation of plankton are of great importance and basically essential in fish culture. Fishes are dependent on physico-chemical parameters. Any change of these parameters may affect the growth, development and maturity of fish (Jhingran, 1985).

Table-5. 1: Fish diversity recorded in patkai lake and mota beel during study period

Family	No. of individuals	
	Mota beel (Control)	Patkai lake (Experimental)
Notopteridae	13	--
Cyprinidae	76	8
Balitoridae	4	--
Bagridae	41	--
Siluridae	9	--
Channidae	49	12
Claridae	72	19
Gobidae	23	4
Heteropneustidae	18	--
Belonidae	7	---
Anabantidae	21	---
Mastacembellidae	11	----
Total	334	43

Table 5.2: Fish diversity indices

Diversity Indices	Patkai lake	Mota beel
Total number of Families	4	12
Number of individuals	43	334
Dominance_D	0.44	0.22
Shannon_H	1.805	3.114
Simpson_1-D	0.3998	0.7215
Evenness_e^1H/S	0.9023	0.8685

Table 5.3: Comparative account of Fish diversity of Patkai lake and Mota beel during 2007-08.

Sl No	Name of the fish and family	Patkai lake (experimental)	Motabeel (control)
1	*N. chitala* (Ham.-Buch) *Notopteridae*	---	+
2	*N. notopterus* (Pallas)	---	+
3	*Salmostoma bacaila* (Ham.-Buch) *Cyprinidae*	---	+
4	*Rasabora rasbora* (Ham.-Buch)	---	+
5	*B. elanga (*Ham.-Buch)	---	+
6	*Amblypharyngodon mola* (Ham.-Buch)	+	+
7	*Cyprinus carpio (*Linn)	++	---
8	*Puntius chola (*Ham.-Buch)	---	+
9	*P. conchonius* (Ham.-Buch)	---	+
10	*P. sophore* (Ham.-Buch.*)*	---	+
11	*Labeo bata* (Ham.-Buch)	----	+
12	*L. calbasu* (Ham.-Buch	---	++
13	*L. gonius* (Ham.-Buch .)	---	+
14	*L. rohita* (Ham.-Buch.)	----	++
15	*Cirrhina mrigala* (Ham.-Buch.)	++	+++
16	*C. reba* (Ham.-Buch)	---	+
17	*Catla catla* (Ham.-Buch.)	---	+
18	*Nemachelius botia* (Ham.-Buch.) *Balitoridae*	---	+
19	*Mystus cavasius* (Ham.-Buch.) *Bagridae*	---	+
20	*M . seenghala* (Sykes)	---	++
21	*M . tengra* (Ham.-Buch*)*	---	+
22	*M. vittatus* (Bloch)	---	+
23	*Wallago attu* (Schneider) *Siluridae*	---	+
24	*Channa punctatus* (Bloch) *Channidae*	++	+++
25	*Clarias batrahcus* (Linn.) *Claridae*	+++	+++
26	*Glossogobius guris* (Ham.-Buch.) *Gobidae*	++	+++
27	*Heteropneustes fossilis* (Bloch*) Heteropneustidae*	--	++
28	*Xenentodon cancila* (Ham.-Buch.) *Belonidae*	--	++
29	*Colisa fasciatus* (Schneider)	--	+
30	*Channa punctatus* (Bloch) Channidae	--	+++
31	*C. striatus* (Bloch)	--	+
32	*Anabus testudineus* (Bloch) Anabantidae	--	+
33	*Chanda nama* (Ham.-Buch.) Chandidae	--	+
34	*C. ranga* (Ham.-Buch.)		+
35	*Macrognathaus aral* (Bloch- Schneider) Mastacembellidae	--	+
36	*M. armatus* (Lacepede)	--	+

The interrelationship between the physico-chemical parameters and plankton production of pond water and its relation with fluctuation of plankton are of great importance and basically essential in fish culture. Fishes are dependent on physico-chemical parameters. Any change of these parameters may affect the growth, development and maturity of fish (Chanda Mallaiah, 2013 and Jhingran, 1985).

CONCLUSION

Quality of an ecosystem depends on the physico-chemical characteristics and biological diversity of the system (Tiwari and Chauhan, 2006). The study clearly showed that the productivity of the wetlands varied significantly depending upon the hydro-biological and soil qualities. Among the two selected water bodies, Patkai lake (Experimental) was found to be the most affected by mining activities cannot be used as an alternative source for drinking water supply and also not suitable for pisciculture and other activities. On the other hand Mota beel (control) was found to be an ideal water body suitable for pisciculture.

The results for the present study on Patkai lake near Tikak OCM indicates the need for comprehensive monitoring of the lake for proper management decisions to be taken for the restoration the lake, which had been threatened ecologically due to AMD and various anthropogenic activities. Control measures should be taken to restore the natural bio-diversity of the wetland by restricted fishing, bathing, washing of clothes in the water. The mining wastes should be treated with standard means before disposal to the water body. Concerned authorities of the NECF Ltd have to take appropriate action by controlling the AMD and industrial effluent let into the Patkai Lake. The Patkai Lake needs immediate remedial actions against water quality degradation. Hence the Margherita Development Block (MDB) should stop NECF Ltd for dumping of coal and AMD, which has affected the water quality and aquatic biota in the lake as revealed in this study.

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