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Icthyodiversity in the Coal Mining and Adjacent Non-Coal Mining Drainages of Jaintia Hills, India

B. K. MYLLIEMNGAP and S. N. RAMANUJAM*

Fish Biology Laboratory, Department of Zoology
School of Life Sciences, North-Eastern Hill University
Shillong – 793022, India

Abstract

The study deals with an assessment of the fish diversity in the water bodies of coal mining and adjacent non-coal mining areas of Jaintia Hills district of Meghalaya. The water bodies in mining areas have been adversely affected by contamination of acid mine drainage (AMD) originating from coal mining operations by private coal miners. Certain parameters such as low pH, high conductivity, high metal content and low dissolved oxygen are some of the implications brought about by coal mining activity which has resulted in the decline or total loss of fish fauna in the coal mining areas of the region. In the water bodies of the coal mining areas where pH is approximately 4.0, only one species, *Brachydanio rerio* was found. However, survey of fish diversity in water bodies not impacted from the mining area revealed a total of 38 fish species belonging to 28 genera under 14 families and 6 orders. Diversity was higher in water bodies of lower altitude with a recorded Ħ of 2.2201 as compared to water bodies in higher altitude with Ħ of 1.5396. Cyprinidae represents the majority of fishes surveyed in all rivers irrespective of the altitude.

Introduction

Commercial exploitation of coal in Meghalaya started in the 19th century as a cottage industry in the Khasi Hills and eventually proliferated to other parts of the state, viz., Jaintia Hills and Garo Hills in the beginning of the 1970s. Jaintia Hills, one of the seven districts of Meghalaya, lies between latitude $25^{o}5$’N to $25^{o}4$’N and longitude $91^{o}51$’E to $92^{o}45$’E. The ecology of the area has been threatened by large scale environmental degradation caused by extensive deforestation, overexploitation of natural resources and other anthropogenic activities coupled with unprecedented rise in human population. As a result, soil erosion, scarcity of water, pollution of air, water and soil, reduced soil fertility and loss of biodiversity are some of the serious problems of the area (Das Gupta et al. 2002). Common impacts due to coal mining activities include, but are not limited to; low DO, higher sulphate content and turbidity. These conditions are affecting the aquatic life and decreasing fish diversity to a great extent.

The primary cause of degradation of water quality and the declining trend of biodiversity in the water bodies of the coal mining areas is attributed mainly to the acid mine drainage (AMD),

*Corresponding author. E-mail address: ramanujam_sunkam@yahoo.com

which makes water highly acidic and rich in heavy metal concentration (Pentreath, 1994). Fish generally do not inhabit waters severely polluted by coal-mine drainage (Lloyd and Jordan, 1964; Cooper and Wagner, 1973). AMD lowers the pH of the receiving streams, and below the tolerance range will effect growth and reproduction (Parsons, 1957). Acid water also increases the permeability of gills to water, adversely affecting the gill function. Rosemond et al. (1992) have shown that direct effects of low pH on aquatic life are more critical than indirect effects on food sources. Coal extraction in Jaintia Hills district is done by primitive sub-surface mining method commonly known as 'rat-hole' mining. Entire road sides in and around mining areas are used for piling of coal, which is a major source of air, water and soil pollution.

The focus of the current study is to establish a baseline and document the icythiodiversity in the coal mining region in Jaintia Hills of Meghalaya.

Materials and Methods

Description of Study Area

The collection of fish and water samples were made at seasonal intervals from the different coal mining sites as well as from areas where there is no mining activity between January, 2007 and December, 2008 for comparative study on the diversity of fish fauna in the region. Major water bodies both in the coal mining as well as those away from the coal mining areas were surveyed. Some of these rivers include Myntdu, Lukha and Lubha rivers which flow into the Bangladesh plain. In the eastern side of the district are tributaries of river Kopli namely, river Mynriang, river Umiurem and river Myntang. River Kopli is the biggest river in Jaintia Hill district. The river originates from the black mountains of Lum Bah-bo Bah-kong and flows northward into the Brahmaputra valley. This river demarcates Jaintia Hills and North Cachar Hills of Assam. Some other rivers in coal mining are Kmai-um and Rawaka of Rymbai, ThwaiKungor of Bapung, Brilakam of Myrsiang, and Mynsar of Loksi. Besides, there are a number of streams, which flow through narrow valleys (Fig. 1).

Biodiversity studies

Collection and analysis of fish and water samples

Fishes were collected using nets (cast nets and gill nets) and local bamboo traps used by the local fishermen. A few of them were obtained from the nearest fish landing centers. They are then

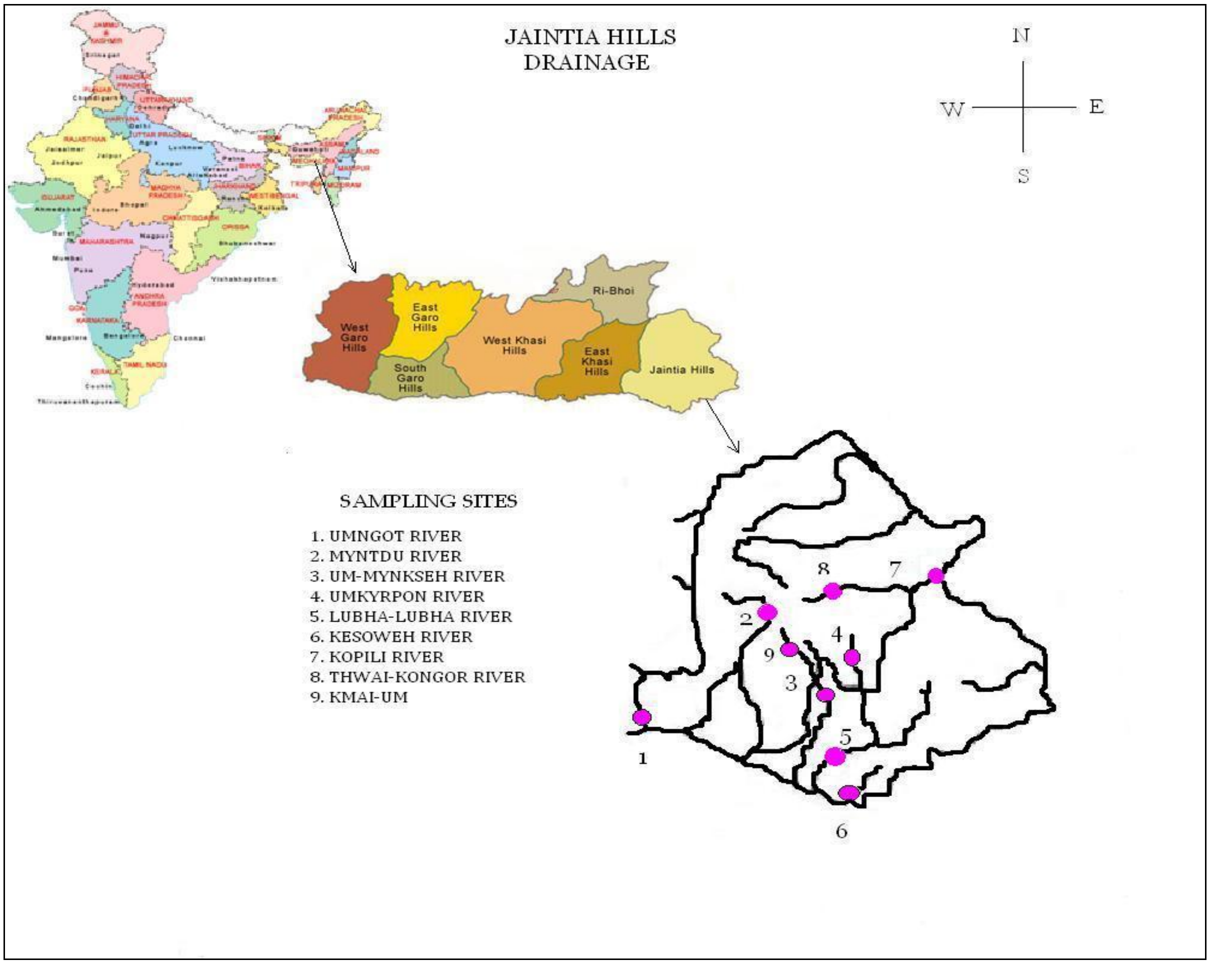

Fig. 1. Location showing sampling sites

preserved in 5% formaldehyde and brought to the laboratory for identification using Standard field guides of Zoological survey of India (Jayaram, 1999; Vishwanath, 2002). The diversity of fish in the different rivers was then compared using Shannon-Wiener's diversity index (Ħ) and Simpson's Index of Dominance (D).

Water samples were collected along with fish collections from water bodies of both the coal mining as well as the non-coal mining sites seasonally. The samples from the water bodies of non-coal mining area were considered as control for comparison. They were analyzed for the physico-chemical parameters i.e., pH (using pH meter by Lutron Co.), conductivity (using conductivity meter by Lutron Co.), dissolved oxygen (using DO meter by Lutron Co.) and metals using Atomic Absorption Spectroscopy (Perkin Elmer Spectrophotometer, Model 460).

Results and Discussion

The geographical position of different water bodies surveyed is given in Table 1. The areas surveyed includes both high altitude (above 1000 m.) and low altitude (below 1000 m) sites. Diversity of fish species was less in the places of higher altitude like Khleihriat, Jowai, Ladrymbai as compared to Dawki and Sonapur. Apart from the diverse distribution of fish species in relation to geographical position, diversity of fish species in Jaintia Hills seems to have been greatly affected by AMD, as studies showed complete absence of fish fauna in the coal mining areas while abundance in the non coal mining areas. Studies on benthic macroinvertebrates have revealed presence of only a few tolerant species namely *Chironomus* larvae (Diptera), dragonfly larvae (Odonata) and water bugs (Hemiptera) in rivers and streams of the coal mining areas. The presence of only a few tolerant species of benthic macro-invertebrates and the absence of most of the aquatic organisms particularly the sensitive species are attributed to water contaminated with AMD (Swer and Singh, 2004).

Studies on water bodies surveyed shows complete absence of fish fauna in the coal mining areas with little exception to Thwai-Kungor, Bapung where only *Brachydanio rerio* was found even with the pH ranging from 4.0 to 5.0. However, rivers Myntdu (Jowai) and Umngot (Dawki) which are not affected by coal mining reveals the regions rich fish diversity. Various fish species of the order Cypriniformes, Siluriformes, Perciformes, Synbranchi-formes, Beloniformes and Tetraodontiformes were found in these two rivers. Lubha and Lukha rivers in Sonapur which drains southwards into Bangladesh was known for its rich ichthyofauna. Collections made till early 2007 are included in Table 2. However, in April 2007 these water bodies were polluted by nearby coalfields and cement factories leaving them totally devoid of fish fauna. Recent survey (in 2009) showed recovery of some fish fauna in these rivers with the presence of a few smaller fish species like *Brachydanio* sp., *Lepidocephalus* sp., *Macrobrachium* sp., etc.

Table 1. Details of surveyed rivers in Jaintia Hills

River and province	Collection site	Geographical position	Altitude (m)
River Kopili,	Iooski	N 25°30’35”-E 92°34’30”	860
River Myntdu,	Jowai	N 25°26’59.5”-E 92°12’06.2”	1402
River Umkyrpon,	Khliehriat	N 25°21’31.2”-E 92°22’11.5”	1172
Kmai-um, Rymbai,	Rymbai	N 25°19’50”-E 92°19’45”	1160
River Lubha,	Sonapur	N 25°06’36.7”-E 92º21’54.2”	28

The physico-chemical studies on water quality (Table 3) has shown low pH, low DO and high conductivity in the water bodies of the coal mining areas. It was observed that the water bodies are adversely affected by contamination of AMD originating from mines and spoils, leaching of heavy metals, organic enrichment and silting by coal and sand particles. The color of the water in most of the rivers and streams in the mining area varies from brownish to reddish orange which may be due to high concentration of iron and other heavy metals. Atomic Absorption Spectrophotometer analysis of water samples collected from the coal mining sites reveals more concentration of heavy metals as compared to water samples from the non-coal mining sites (Table 4). The metal concentration observed, though few of them are within the permissible limits for human consumption, may be affecting the fish fauna individually or in the form of complexes.

Table 2. Studies on the distribution of fish species in the water bodies of Jaintia Hills, Meghalaya carried out between Jan., 2007 and Dec., 2008.

Order	Family	Species	Total No collected	Rivers/Streams		
				Myntdu	Dawki	Lubha&Lukha
Cypriniformes	Cyprinidae	*Danio dangila*	120	+	+	-
		D.rerio	231	+	+	+
		D. aequipinnatus	92	+	+	+
		Puntius chola	36	+	+	-
		P. sophore	35	+	-	+
		P. sarana	54	-	+	+
		Cirrrhinus reba	26	-	+	-
		Chela laubuca	18	+	+	-
		Labeo gonius	31	-	+	+
		L.boga	12	-	+	+
		L. pangusia	17	-	+	+
		Cyprinus carpio	60	+	+	-
		Amblypharyngodon mola	07	-	+	-
		Barilius bendelisis	65	+	-	-
		Salmostoma bacaila	53	-	-	+
		Garra gotyla	39	-	+	-
		G. lamta	47	-	+	-
	Balitoridae	*Balitora brucei*	12	-	+	+
		Acanthocobitis botia	85	-	+	+
	Cobitidae	*Botia dario*	73	-	+	+
		Lepidocephalus guntea	76	-	-	+
Siluriformes	Siluridae	*Ompok pabo*	19	-	+	+
	Bagridae	*Mystus cavasius*	38	+	+	+
		M. vittalus	27	-	-	+
		Olyralongi caudata	43	+	-	-
	Sisoridae	*Bagarius bagarius*	09	+	+	+
		Clarias batrachus	104	+	-	-
	Heteropneustidae	*Heteropneustes fossilis*	06	+	-	+
Perciformes	Nandidae	*Badis badis*	25	+	-	-
	Gobiidae	*Glossogobius giuris*	23	-	-	+
	Belontidae	*Colisa fasciatus*	47	-	+	+
	Channidae	*Channa gachua*	22	-	-	+
		Channa punctatus	88	+	+	+
Synbranchiformes						
	Mastacembelidae	*Macrognathus aral*	15	-	+	-
		M. pancalus	11	-	-	+
		Mastacembelus armatus	17	-	-	+
Beloniformes	Belonidae	*Xenentodon cancila*	18	-	+	-
Tetradontiformes	Tetraodontidae	*Tetraodon cutcutia*	33	-	+	+

*Presence (+) and absence (-)

Table 3. Physico-chemical properties of the water of some rivers of Jaintia Hills, Meghalaya

Rivers/Streams and location	Surrounding areas	pH	DO (mg/L)	Conductivity (mS/cm)	Remarks
Kopili, Iooski	Coal mining area	3.7-4.0	2.6-5.2	0.85-0.89	polluted by AMD
Umkyrpon, Khliehriat	Coal mining area	3.1-4.0	5.2-5.9	0.27-0.29	polluted by AMD
Kmai-um, Rymbai	Coal mining area	2.6-3.5	4.8-5.	0.23-0.25	polluted by AMD
Myntdu, Jowai	Away from coal mining area	6.7-7.1	10.1	0.10-0.12	not Polluted by AMD
Lubha, Sonapur	Adjacent to coal mining area	6.8-6.9	4.6-5.5	0.14-0.18	slightly polluted by AMD and cement factories

High metal concentration in the rivers of the coal mining areas is evident and may lead to bioaccumulation in fish tissue, thus bringing a shift in the fish population and the overall community in the region (Amoo et al. 2005). Pyrite in coal and overlying strata, when exposed to air and water, oxidizes, producing iron and sulfuric acid (Cravotta, 1996). Low pH (between 2-3), high conductivity, high concentration of sulphates, iron and toxic heavy metals, low dissolved oxygen (DO) characterize the degradation of water quality (Swer and Singh, 2004). The changes observed in water quality of coal mining area in the present study might be a cause for decline in diversity of fish fauna in the region. It has been reported that a total of 24 species of diatoms belonging to Bacillariophyceae were recorded from AMD impacted streams as compared to 56 species from unimpacted stream and a few from Chlorophyceae (Das and Ramanujam, 2010). This may be one of the causes for less food and oxygen availability for fish in AMD impacted water bodies. Dissolved heavy metals commonly found in waters polluted by mine drainage are toxic to the aquatic biota (Ali et al. 2002; Sprague, 1964). The toxic effects of heavy metals on fish are multidirectional and manifested by numerous changes in the physiological and biochemical processes of their body system (Dimitrova et al. 1994). In more recent studies, it was observed that some streams in the Boulder River watershed in Montana, impacted by nearly 300 abandoned metal mines are devoid of all fish near mine sources (Farag et al. 2003).

Table 4. Concentration (ppm) of selected elements of the water samples of the rivers surveyed.

Sampling site	lead	copper	cadmium	zinc	iron
Iooski Kopili	0.03	0.032	ND	1.426	0.088
Khliehriat Umkyrpon	0.08	0.020	ND	1.202	0.033
Rymbai Kmai-um	0.04	0.02	0.03	ND	7.13
Thamar Leshka	ND	0.013	0.005	0.942	0.124
Lukha & Lubha	0.03	0.042	0.03	2.41	0.371
Myntdu Jowai	ND	0.010	ND	4.412	0.129

ND- Not Detected

Iron is a common component of mine drainage, which can have a detrimental effect on aquatic life. Shannon-Wiener's diversity index (Shannon, 1948) was calculated only for the rivers in non-coal mining areas i.e., Myntdu, Umngot and Lukha-Lubha where there was greater diversity of fish species and not in the rivers of coal mining area where only one species of fish was found. As diversity decreases with increasing altitude (Lowe-McConnell, 1999), it was found that Myntdu which occupies the highest altitude has the least fish fauna diversity with Ħ of 1.5396 followed by Umngot with Ħ of 1.6849 and lastly by Lukha-Lubha which occupies the lowest altitude amongst the three river bodies with Ħ of 2.2201. Simpson's Index of Dominance (D) was found to be least in Lukha and Lubha river body which is due to the equal distribution of species belonging to different families while higher in Umngot and Myntdu where species of few families only are present.

Conclusion

The Jaintia Hills district is known for its high diversity of fish fauna. At the same time it is also a major coal producing area, with an estimated 40 million tonnes of coal reserve. Unscientific mining strategy poses a serious threat to the icthyofauna of the water bodies in the region. AMD along with other anthropogenic activities have greatly led to the decline of fish diversity in the district. Low pH, high metal content in the water bodies of the coal mining areas resulted in the decrease and total disappearance of fish and other aquatic organisms.

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