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Diversity assessment of macroinvertebrates in the dam progressed Subansiri river in the North –Eastern India

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Abstract
Different indices such as Shannon Index H, Pielou Index J, Simpson Index D, Simpson 1-D, Marglef Index Ma, Maclintos Evenness Index McE, Maclintos Index Mc of macroinvertebrates were analysed to know the health status of the downstream of river Subansiri (from the site of construction of the 2000MW Subansiri Lower Hydroelectric Project to its confluence with the Brahmaputra) prior to the construction of the dam. In the modality of operation of the dam, to generate power, the dam authority proposed to release only 06 $m^3 s^{-1}$ of water for 20 hours of the day and release some 2579 $m^3 s^{-1}$ of water for 4 hours during the 'peak load demand period' in the evening / night, without considering the adverse effect on aquatic life and environment.

Keywords: Subansari, macroinvertebrates indices, large dam

1. Introduction
River Subansiri, the largest tributary of the mighty Brahmaputra is a healthy river [1]. The Subansiri continues its journey through the Himalaya for 200 km and enters into the plains of Assam with an approximate length of 130 km in its downstream and joining with the Brahmaputra. At the junction of hills and plains in the Gerukamukh area, construction of 2000 MW Subansiri Lower Hydroelectric Project is going on.
River ecosystems are adapted to the natural hydrological regime and many components of these systems rely on floods for the exchange, not just of water, but also energy, nutrients, sediments and living organisms [2]. Dam interrupts stream-flow and generates hydrological changes along the integrated continuum of river ecosystem [3, 4]. The impact of dam upon natural ecosystem and biodiversity has been one of the principal concerns raised by large dam [5]. Flow regulation by dams has disrupted the natural pulse flow regime of most rivers and has altered the processes that sustain biodiversity [6].
Many genera or families of benthic animals have been associated with the main habitat types [7]. Besides substrate, many freshwater invertebrates have precise requirements for particular current velocities or flow ranges [8]. Certain taxa may be ideal indicators of prevailing flow conditions, qualitative responses to flow changes, site specific studies show that most taxa associated with slow flow tend to increase in abundance as flows decline [9] whereas most species associated with faster flows exhibit the opposite response [10].
Diversity index is a statistical method which is planned to evaluate the variety of a data group consisting of different types of components. Features of a population such as number of existing species (richness), distribution of individuals equally (evenness) and total number of existing individuals underlie the basis of diversity indices [11]. Thus, any changes in any of these three features will affect the whole population, so that the diversity indices depending upon these features are used effectively to determine the changes in a population.
Keeping all these views in mind, a comprehensive study was done to portray a vivid picture of the river ecosystem by considering an important biotic community (macro invertebrate) as a tool. Our assessments provide a measure of the degree of diversity, dominance and similarity between the aquatic macroinvertebrates found at each site before being regulation of the river.

2. Methodology

2.1 Demarcation of the study area

The entire stretch in the downstream, from the dam site (Gerukamukh) to the Dhunaguri (confluence of river Subansiri with the Brahmaputra) is lies between latitude 26^0 50^0 - 27^0 35 $^/$ N and longitude 93^0 $41^/$-94^0 $23^/$ E). The entire down stream was demarcated in the following four sectors: **Sector I,** Dam site or Gerukamukh (N 27 ^{0} $33^/$and E 094^0 $15^/$) to Chauldhowa Ghat (27^0 $26^/$ $910^{//}$ N and 94^0 15 $^/$ $005^{//}$ E, Altitude 75 m), **Sector II**, Chauldhowa Ghat to Khaboli Ghat (27^0 $03^/$ $852^{//}$ N and 94^0 $07^/$ $312^{//}$ E, Altitude 64 m), **Sector III**, Khaboli Ghat to Dhunagurighat (27^0 $00^/$ $465^{//}$ N and 94^0 $01^/$ $414^{//}$ E, Altitude 64 m) and **Sector IV**, Dhunagurighat to Jamugurighat (26^0 $50^/$ $978^{//}$ N and 93^0 $48^/$ $365^{//}$ E, Altitude 59 m.) Fig.1

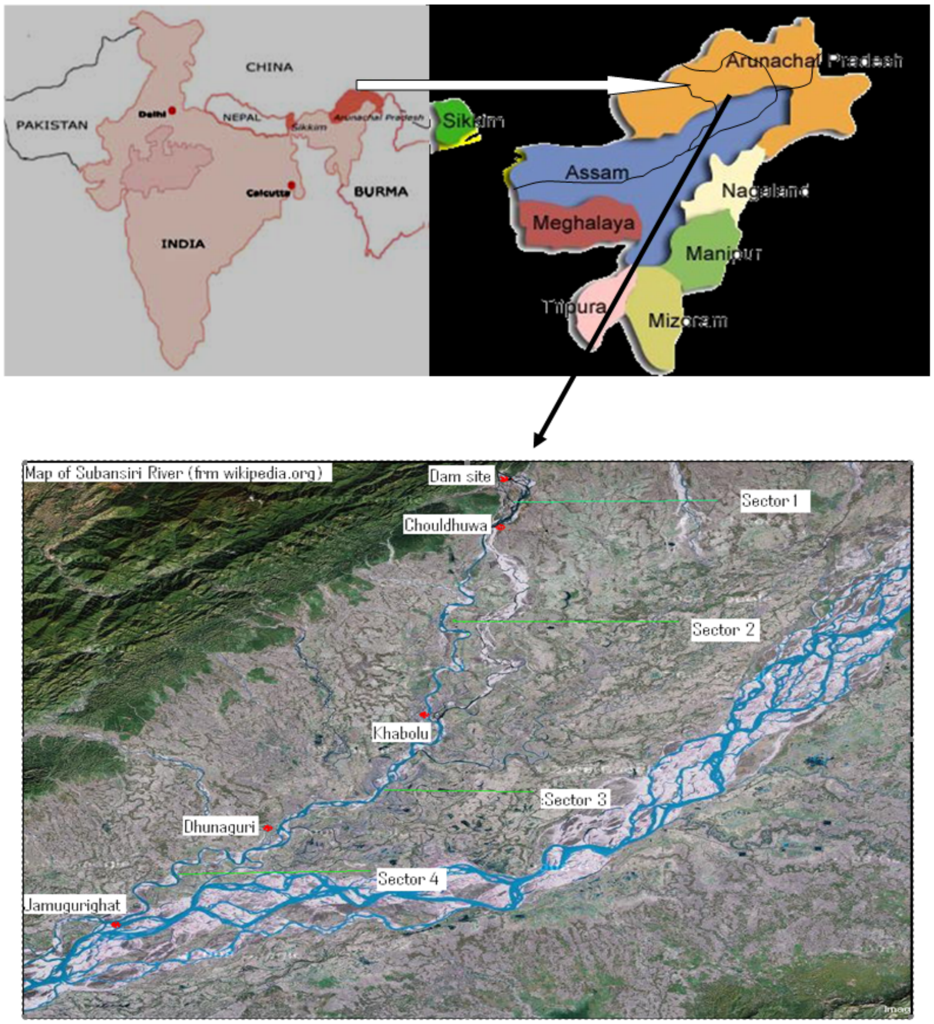

Fig 1: Locations of study area

Dam site of R. Subansiri before construction

Dam site of R. Subansiri during construction

2.2 Sample Survey
Collection and study of macroinvertebrates were done by following Welch and Norris [12, 13]. Prawns were sampled at the landing centre from the catch of fishermen. They had been caught by gillnetting (2-2.5 cm mesh size). Specimens were preserved in plastic jars containing 10 % formalin, packed in polythene bags and brought to the laboratory. They were identified according to the standard literature of Kurian and Sebastian [14].

2.3 Statistical Analysis
Macro invertebrate species diversity was subjected to diversity analysis using different indices like Shannon – Weiner index (H) [15]; Simpson Dominance index (D); Simpson index of diversity (1-D) [16]; Margalef's index [17]; Pielou Evenness Index [18] .McIntosh Diversity Index [19]; McIntosh Evenness Index and Sorensen index of similarity [20].

3. Result and Discussion
3.1 Macroinvertebrate Diversity
In the downstream of the Subansiri as many as 34 species of macroinvertebrate mostly of arthropods and molluscs were recorded. Among the arthropods, 6 species of Palaemonidae, 3 species each of Agrionidae and Nepidae and 1 species each from Siphlonuridae, Aeshnidae, Lestidae, Notonectidae, Gyrinidae, Hydrphilidae, Dytiscidae, Chironomidae, Culicidae, Limnephilidae and Gomphidae were encountered. 7 molluscan species belonging to four families of Thiaridae, Margaritiferidae, Pilidae and Bulimidae were also recorded mainly from lower stretches of the river (Table 1). Because a river ecosystem is dynamic, hence it can support a wide diversity of species, all of which have evolved to live in a river's variable flow. Molluscan species were predominant in the oxbow lakes where current velocity is feeble in the Subnsiri River ecosystem [21]

Table 1: Distribution of Macroinvertebrate fauna of Subansiri River

S. No.	Macroinvertebrate species	Family	Sector
1	*Macrobrachium carcinus*	*Palaemonidae*	I &II
2	*M. malcolmsonii*	*Palaemonidae*	II - IV
3	*M. choprai*	*Palaemonidae*	II - IV
4	*M.assamense assamense*	*Palaemonidae*	II - IV
5	*M.birmanicum birmanicum*	*Palaemonidae*	II -IV
6	*M. gangeticum*	*Palaemonidae*	II - IV
7	*Ranatra filiformis*	*Nepidae*	II -IV
8	*Ranatra fusca*	*Nepidae*	All
9	*Curicta sp*	*Nepidae*	I &II
10	*Isonychia sp.*	*Siphlonuridae*	All
11	*Nasiaeschna sp*	*Aeshnidae*	All
12	*Enallagma sp*	*Agrionidae*	I &II
13	*Hesperagrion sp*	*Agrionidae*	All
14	*Hyponeura sp.*	*Agrionidae*	All
15	*Belostoma indicum*	*Belostomidae*	I &II
16	*Eretes sticticus*	*Belostomidae*	I &II
17	*Hydaticus vittatus*	*Belostomidae*	I &II
18	*Notonecta indica*	*Notonectidae*	II -IV
19	*Dineutus spinosus*	*Gyrinidae*	II -IV
20	*Hydrophilus indicus*	*Hydrophilidae*	II -IV
21	*Laccophilus parvulus*	*Dytiscidae*	II -IV
22	*Lestes sp.*	*Lestidae*	II -IV
23	*Gomphus sp.*	*Gomphidae*	I &II
24	*Astenophylax sp*	*Limnephilidae*	I-III
25	*Chironomus sp.*	Chironomidae	All
26	*Culex sp.*	Culicidae	All
27	*Brotia costula*	*Thiaridae*	II -IV
28	*Thiara tuberculata*	*Thiaridae*	II -IV
29	*Thiara scabra*	*Thiaridae*	II -IV
30	*Corbicula striatella*	*Margaritiferidae*	II -IV
31	*Bellamya bengalensis*	*Bulimidae*	II -IV
32	*Bellamya crassa*	*Bulimidae*	II -IV
33	*Paludomus ornatus*	*Bulimidae*	II -IV
34	*Pila globosa*	*Pilidae*	II -IV

3.2 Statistical Analysis [Different indices]
Shannon – Weiner index "H" which depends on both the number of species present and the abundance of each species. Sector wise Shannon diversity index of macroinvertebrate was highest in Sector II (3.286) and lowest (2.457) in Sector I. Pielou equitability or evenness index "J" was highest in Sector II (0.932), followed by Sector III (0.916), Sector I (0.907) and lowest in Sector IV (0.828). The value of Margalef index was also highest in Sector II (6.288), followed by Sector III (4.712), Sector IV (4.272) and lowest in Sector I (3.213). Among the studied sectors, the value of Simpson's Index of Dominance (D) was highest in Sector IV (0.101) and lowest in Sector II (0.047) but Simpson's index of diversity (1-D) was highest in Sector II (0.953) and lowest (0.899) in Sector IV. Maclintos index of diversity (Mc) was highest in sector II (0.838) followed by sector III (0.791), sector I (0.752) and sector IV (0.713). Maclintos index of evenness was also following the trend of Pielou index in all the study sectors (Table 2a). From Sorensen similarity index, it was found that diversity in Sector III and IV was almost identical followed by sector II and III while least similarity was found between Sector I and IV (Table 2b).

Table 2a: Diversity Indices of macro invertebrates

Sites	Shannon Index H	Pielou Index J	Simpson Index D	Simpson 1-D	Marglef Index Ma	Maclintos Evenness Index McE	Maclintos Index Mc
Sec I	2.457	0.907	0.100	0.900	3.213	0.899	0.752
Sec II	3.286	0.932	0.047	0.953	6.288	0.940	0.838
Sec III	3.051	0.916	0.062	0.938	4.712	0.919	0.791
Sec IV	2.728	0.828	0.101	0.899	4.272	0.841	0.713

Table 2b: Sorensen Similarity index (percent) between study sectors

Study Sector	Sector I	Sector II	Sector III	Sector IV
Sector I	-	61.20	42.80	38.10
Sector II	-	-	90.30	88.50
Sector III	-	-	-	98.20
Sector IV	-	-	-	-

Sector- wise diversity indices of macroinvertebrate reflect the ecological status of the R. Subansiri. In Sector I, which is having comparatively faster water current and hard rocky bed showed lowest Shannon index (H) value (2.457), but in remaining sectors (II to IV) the value was substantially high (Sector II, 3.286> Sector III, 3.051> Sector IV, 2.728). Again, the Pielou equitability index (J) was highest in Sector II (0.932) and lowest in Sector IV (0.828). The macro invertebrates of all the study sectors of Subansiri are evenly distributed as calculated value is closer to 1. Margalef index also follows the similar trend with that of Shannon index. On the basis of macroinvertebrate diversity index, the R. Subansiri may be considered as healthy as Margaleff's index value greater than 3 indicate clean conditions [22]. High variability of population observed during the investigation period can be explained by a number of causes including normal die off, hatching of eggs, pupation, emergence, and patterns of predation, local movements and uneven distribution [23]. Simpson's index (D) indicated poor macroinvertebrate diversity in Sector IV
(0.101) and Sector I (0.100) while higher macroinvertebrate diversity in the remaining sectors. McIntosh Diversity Index also reflecting the better habitat condition of Sector II.

3.3 Probable Impact Analysis

In the winter months (lean months), there is more or less consistent flow throughout the day in the Subansiri River ranging between 450 to 550 m^3 s^{-1} at dam site regulates the downstream ecological balance and nourishes the Subansiri river and its associated ecosystem as per the seasonal requirements [24, 25, 26]. Changes in the rate of water level fluctuation in the river is obvious, because hydropower dam operate in "hydro peaking" mode to provide energy when it is most needed. Water is detained behind the dam during hours when energy demand is low and released only when energy demand is high. While this may sound like an intelligent way to provide energy on demand, it means that the river downstream of the dam is exposed to near-dry conditions while water is filling up behind the dam, followed by large surges of water released to produce energy. After commissioning of the dam project, National Hydel Power Corporation (NHPC) will release only 06 m^3 s^{-1} of water for 20 hours of day only, thereby drying the river bed completely and releasing 2579 m^3 s^{-1} of water in peak 4 hours! Finally, the release of turbinated waters to the channel may impose dramatic and sudden changes (hydropeaking) not only in discharge, but also in chemical and physical properties of waters, reduction in peak flows and changes in duration, timing and extent of inundation in the downstream floodplain by altering the overflow and seasonal flooding cycles of the Subansiri River system. Damming will lead to excessive trapping of sediment and debris behind dams, resulting in lack of natural substratum (i.e. stones, gravel, or cobble), sediment-starved conditions in the downstream, because trapped reservoir sediments will no longer provide important organic and inorganic nutrients to its downstream, causing depletion in dissolved oxygen contents leading to which may resulting in poor growth of phytoplankton, the prime food of macroinvertebrate .Flushing of reservoir sediment may be the prime cause of habitat degradation of macroinvertebrates. Probable alteration in the trophic structures of the macroinvertebrates my lead to the degradation of downstream river health.

4. Conclusion

The baseline data that it provides can be compared to future aquatic macroinvertebrate inventories and offer insight into any changes occurring after operation of this large dam. There is lots of information on post impact of dam on the river ecology but in this aspect pre impact study is very limited. Study of this nature will help in future to assess the impact of dam on the various aspects of river ecology.

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