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Observations On The Abundance Of Oligochaeta Along With Some Environmental Factors In An Unmanaged Freshwater Wetland Of West Bengal, India.

Observaciones sobre la abundancia de oligoquetos junto con algunos factores ambientales en un humedal de agua dulce no gestionado de Bengala Occidental, India.

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ABSTRACT

The present work was undertaked to achieve a comprehensive knowledge on the abundance of oligochaeta species as well as the results of limnological investigation along with the ecohydrologycal status of an unmanaged wetland, in the planes of West Bengal, India. For the purpose of the hydrological study standard methods of American Public Health Association has been followed and the collection of benthic fauna (oligochaeta) was made employing Ekman's dredge and standard sieve no. 60 having 0.4 mesh size.

During study the water temperature varied from 20ºC to 30.25ºC. Transparency was higher (88 cm) in winter and lower (21.15 cm) in post monsoon. pH was found to vary between alkaline (6.67) to acidic (8) in nature. Dissolved oxygen showed maximum fluctuation from 1.2 mg/lit to 11.2 mg/lit. Free CO_2 was found to be higher than dissolved oxygen and varied from 2.4 mg/lit to 17 mg/lit. Hardness was always in a lower profile with a minimum of 13 mg/lit and a maximum of 20.7 mg/lit. On the other hand Nitrate nitrogen ranged from 0.03 mg/lit to 0.08 mg/lit while dissolved organic matter varied from 0.61 to 4.13 mg/lit.

While observing the biological components total six species of oligochaeta were identified with a maximum of 3333 ind/m^2 and a minimum of 88 ind/m^2. Among these six species *Limnodrilus hoffmeisteri* was the largest species which varied between 217 ind/$m^2$and 2756 ind/m^2 with a total 7041 ind/m^2, comprised 46.81% of the total oligochaeta. *Branchiodrilus sempari,* the second largest species formed 22.8% of the total oligochaeta with a variation from 44 ind/m^2 to 1820 ind/m^2 and a total of 3429 ind/m^2. Another species *Dero digitata* varied between 22 ind/m^2 and 1267 ind/m^2 and contributed 18.96% to the total oligochaeta with a total of 2852 ind m^{-2}. On the other hand, *Aulodrilus* sp contained total 835 ind/m^2 and ranged from 22 ind/m^2 to 222 ind/m^2 while *Aulophorus farcatus* contained total 775 ind/m^2 and varied between 20 ind/m^2 and 378 ind/m^2 contributed 5.15% and 5.57% of total oligochaeta respectively. *Branchiura sowerbyi* formed only 2.92% of total population with a maximum of 178 ind/m^2 and a minimum of 44 ind/m^2. During community study it was found that the index of dominance varied from 0.345 to 0.902 and index of dominance from 0.098 to 0.655.

Key Words: Abiotic factors, Abundance, Freshwater, Oligochaeta, Unmanaged, Wetland.

RESUMEN

El presente trabajo se realizó para lograr un conocimiento integral sobre la abundancia de especies de oligochaeta, así como los resultados de la investigación limnológica junto con el estado ecohidrológico de un humedal no manejado, en los planos de Bengala Occidental, India. A los efectos del estudio hidrológico se han seguido los métodos estándar de la Asociación Estadounidense de Salud Pública y se realizó la recolección de fauna bentónica (oligochaeta) empleando la draga de Ekman y el tamiz estándar núm. 60 con un tamaño de malla de 0.4.

Durante el estudio, la temperatura del agua varió de 20ºC a 30,25ºC. La transparencia fue mayor (88 cm) en invierno y menor (21.15 cm) en el período posterior al monzón. Se encontró que el pH variaba entre alcalino (6.67) y ácido (8) por naturaleza. El oxígeno disuelto mostró una fluctuación máxima de 1.2 mg / litro a 11.2 mg / litro. Se encontró que el CO_2 libre era más alto que el oxígeno disuelto y variaba de 2.4 mg / litro a 17 mg / litro. La dureza siempre estuvo en un perfil más bajo con un mínimo de 13 mg / litro y un máximo de 20.7 mg / litro. Por otro lado, el nitrógeno nitrato osciló entre 0.03 mg / litro y 0.08 mg / litro, mientras que la materia orgánica disuelta varió entre 0.61 y 4.13 mg / litro.

Al observar los componentes biológicos en total se identificaron seis especies de oligochaeta con un máximo de 3333 ind / m^2 y un mínimo de 88 ind / m^2. Entre estas seis especies, *Limnodrilus hoffmeisteri* fue la especie más grande que varió entre 217 ind / m2 y 2756 ind / m^2 con un total de 7041 ind / m^2, comprendiendo el 46.81% del total de oligochaeta. *Branchiodrilus sempari*, la segunda especie más grande formó el 22.8% del total de oligochaeta con una variación de 44 ind / m^2 a 1820 ind / m^2 y un total de 3429 ind / m^2. Otra especie *Dero digitata* varió entre 22 ind / m^2 y 1267 ind / m^2 y contribuyó con 18.96% al total de oligochaeta con un total de 2852 ind/ m^2. Por otro lado, *Aulodrilus* sp contenía un total de 835 ind / m^2 y osciló entre 22 ind / m^2 y 222 ind / m^2 mientras que *Aulophorus farcatus* contenía un total de 775 ind / m^2 y varió entre 20 ind / m^2 y 378 ind / m^2 contribuyó con un 5.15% y 5.57% del total de oligochaeta respectivamente. *Branchiura sowerbyi* formó solo el 2.92% de la población total con un máximo de 178 ind / m^2 y un mínimo de 44 ind / m^2. Durante el estudio de la comunidad se encontró que el índice de dominancia variaba de 0.345 a 0.902 y el índice de dominancia de 0.098 a 0.655.
Palabras clave: factores abióticos, abundancia, agua dulce, oligochaeta, no gestionado, humedal.

INTRODUCTION

In freshwater wetlands few animals have proved themselves capable of living in the profoundal zone which may be often anaerobic (Eggleton, 1931) in nature. This qualitatively limited fauna is ordinarily exposed to continuously low temperature, little or no light, a pH often falling below neutrality, relatively large amount of free carbon dioxide, a total lack of dissolved oxygen and in some instances the accumulation of certain decompose gases.

The macro benthic communities in which oligochaeta belong are of fundamental importance not only in the ecology but also in the economy of the natural water because they play a vital role in the biological productivity and in the nutrition cycle of any water body. Hence, the quality and quantity of macro benthos especially oligochaeta has been used as the index of productivity due to its active involvement in nutrient cycle (Liang, 1966). The major point of interest of hydrobiology is the relationship and the probable influence of the environmental factors on the biota of different trophic levels through which energy flows (Lellak, 1965). The macro benthic communities of freshwater wetlands show a unique pattern of organization as well as constitute a distinct entity for the differential physico-chemical and biological attributes of the soft bottom.

It is well established that benthic macro zoobenthos is related with the biological productivity and in the trophic dynamics of wetland ecosystem especially in the nutrient cycle is well acknowledged. The composition, abundance and distribution of benthic organisms over a period of time provide an index to the quality and productivity of the ecosystem (Shokri et al., 2014). To assess the fundamental importance of benthic organisms in the economy of natural water one has to deal with the qualitative aspect of bottom biota of a wetland. However till date knowledge of ecology of benthic organism especially oligochaeta is far behind than that of plankton ecology in Indian freshwater system.

Annandale (1907) was the investigator for the first time in India who worked on estuarine water faunal component. Apart from the saline water benthic fauna, studies on freshwater is seems to be fragmentary. However, some information may also be available in freshwater ecosystems, which are, Ghosh and Banerjee (1992), Singh and Sinha (1993), Kumar (1996), Kumaraiah *et al*. (1999), Madhai *et al*. (2005), Barbour and Paul (2010), Mehraj and Bhat (2013), Thoker *et al.* (2015), Mahdi *et al*. (2016), Kumar *et al*. (2017), Gudoo (2019), Gudoo *et al*. (2020) and many others. Indian studies on macro invertebrate communities in relation to macrophytes have mostly been made in the littoral zones of permanent water bodies such as fish pond (Michael, 1968 a, b), Ox- bow lakes (Singh, 1989) and other wetlands (Rai and Sharma, 1991).

This necessitates the present worker to undertake the present study of abundance of oligochaeta (macro zoobenthos) in relation to some abiotic factors of an unmanaged wetland of West Bengal, India for a period of one year (January, 2017 to December, 2017) and the knowledge obtained have been analyzed in the light of most recent knowledge of literature.

MATERIALS AND METHODS

Study area: Area of the studied wetland is approximately 0.5 hectare with a depth varying between 2.5 to 3 meters at its mid-point and 1.0 to 1.5 meter at its study sites, approximately 2 meters away from its bank depending upon the height of the water column and season. It is more or less round in shape having trees on its bank. The bottom soil is sandy in nature. Almost half of the wetland is covered by macro vegetation like *Ipomia* sp, *Nelumbo* sp, *Spirodela* sp, *Azolla* sp, *Lemna* sp etc. (Plate-1). The water source of the wetland is rainwater only. Neither fish culture nor any domestic use has been noticed in this wetland. Obviously, therefore, it is unmanaged in nature.

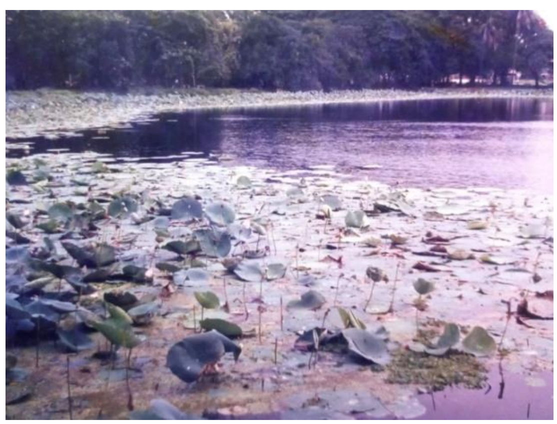

Plate-1: The studied wetland showing macro vegetation and trees on its bank.

The present programme was started in January, 2017 and continued up to December, 2017 for 12 months in the unmanaged freshwater wetland of West Bengal, India. The collection of water and Zoobenthos (Oligochaeta) were done fortnightly between 8 am and 10 am in the morning of the sampling day. Fortnightly data were pooled together as monthly average. Tables and Figures representing the variation of biotic and abiotic parameters have been drawn accordingly.

HYDROLOGY

Collection of water sample: Water samples were collected from the wetland covering the less disturbed area by directly deeping polythene bottles, washed without detergents, rinsed with 10% HCl, then with distilled water and dried at 95ºC before use. For the estimation of dissolved oxygen the sample was collected in 250 ml glass stoppered bottles taking all precaution and replacing the stopper tightly under water.

Analysis of water: The physico-chemical parameters of water studied are Water temperature (WT), pH, Dissolved Oxygen (DO), Carbon dioxide (CO_2), Dissolved Organic Matter (DOM), Hardness (HAR), Transparency (TRAN) and Nitrate nitrogen (NO_3-N). All the analysis of water samples were done according to the procedure stated by American Public Health Association (APHA), 2005.

Collection of macrobenthic (Oligochaeta) fauna: Five sites were selected in the wetland having different depth range for collection of macro benthic (oligochaeta) fauna. Fortnightly benthic collections were made by employing Ekman's dredge with a transverse area of 529 cm (Welch, 1952). In the wetland the dredge was operated at three adjacent places of the site and samples were pooled together. Thereafter, the sample was filtered through standard sieve of No. 60 having 0.4 mm mesh size taking care that no damage is done to the organisms present. Then the remaining mud from the sieve was shifted to a large petri dish with black and white back ground and washed successively and thus the sorting of living organisms (oligochaeta) was made. Organisms after preliminary sorting were preserved in 5% formalin.

Quantification of fauna was done and expressed as individuals per meter squire (ind m^{-2}) using the formula given by Welch, 1952.

$$N = \frac{b}{as} \times 10{,}000$$

Where N = no. of macro fauna of bottom in sq. m.
b = number of animals actually counted.
a = transverse area of Ekman dredge in sq. m.
s = number of sample taken in one site.

Community analysis:-

Following indices have been used to quantify species dominance and diversity.

1) Index of diversity (D) (Simpson, 1949; Quoted by Krebs, 1985)

$$D = 1 - \sum_{i=1}^{S} (ni/N)^2$$

ni = No. of individuals of i^{th} species
N = Total no. of individuals of all species.
S = Total no. of species.

2) Index of dominance (C) (Simpson, 1949)

$$C = \sum_{i=1}^{S} (ni/N)^2$$

ni = No. of individuals of i^{th} species
N = Total no. of individuals of all species.
S = Total no. of species.

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RESULTS

Physico-chemical parameters: The present investigation was designed to monitor eco-hydrology of an unmanaged freshwater wetland and the observation was made for twelve months. The results of the investigation on some of the hydrological parameters have been presented in Table-1 and are briefly describe below.

During the entire study the minimum water temperature (WT) (20°C) was recorded in January while maximum (30.25°C) was in June.

During observation October month showed lowest (6.67) value whereas April showed highest (8) value of pH. In January, July to October and December pH showed acidic values (<7) while in May and November it was almost neutral, except these all the other months showed alkaline pH (>7).

Table – 1: Monthly variations of physico-chemical parameters of water.

	WT	pH	DO	CO_2	TRAN	HAR	NO_3-N	DOM
January	20	6.9	10.4	8.0	88	19.6	.03	4.13
February	22.5	7.55	11.2	8.1	80.3	18.6	.03	2.55
March	29	7.85	10.4	10	77.7	20	.05	0.61
April	28	8.0	7.6	2.4	68.8	20	.04	2.44
May	30	7.1	2.0	10	50.2	18	.08	0.98
June	30.25	7.18	2.7	13.5	45.6	19.3	.04	0.87
July	29.63	6.88	2.1	15	40.78	20.7	.06	2.38
August	29.3	6.8	2.1	15	31.83	20.65	.04	2.23
September	29.75	6.77	4.3	11.25	21.15	20	.05	2.63
October	27.56	.67	1.5	14.5	28.45	15.6	.06	2.57
November	26.38	7.02	1.8	12	38.5	13	.05	1.79
December	20.38	6.74	1.2	17	46	17.1	.04	0.8

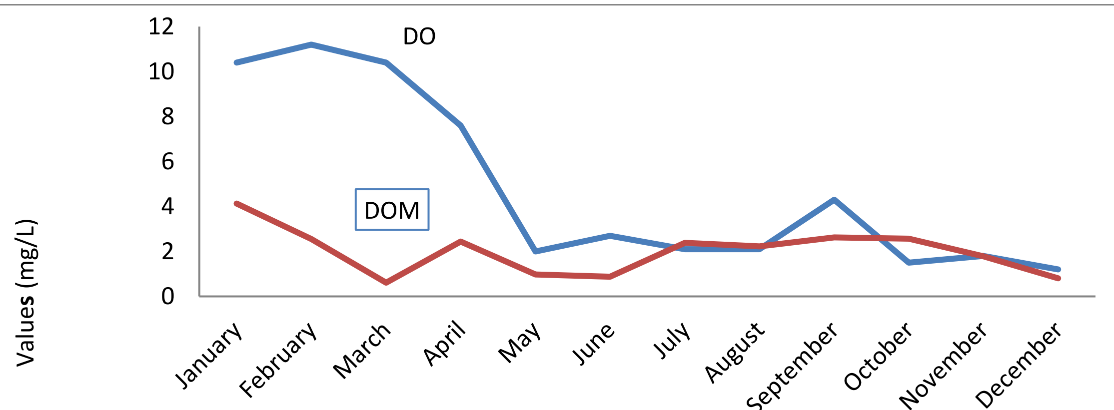

Fig- 1: Monthly fluctuations of Dissolved oxygen (DO) and Dissolved organic matter (DOM) of water.

During the study the minimum value (1.2 mg/lit) and maximum value (11.2 mg/lit) of dissolved oxygen (DO) were recorded in the month of December and February respectively with four peaks. (Fig-1)

It is evident from the study that the values of free CO_2 varied from 2.4 to 17 mg/lit. The highest (17 mg/lit) and the lowest (2.4 mg/lit) values were observed in December and April respectively.

The minimum value (21.15 cm) of transparency was found in September and maximum value (88 cm) in January. It is noticeable that transparency was higher in winter months whereas lower in monsoon and post monsoon.

Hardness in this wetland was always in a lower profile in winter months. Throughout the study the values varied from 13 mg/lit in November to 20.7 mg/lit in July.

On the other hand Nitrate nitrogen ranged from 0.03 to 0.08 mg/lit during the study with four peaks (Fig-2).

The amount of DOM varied from 0.61 to 4.13 mg/lit during the study. Not only that, four peaks were also observed during the study (Fig- 1).

Biological Parameter

The collection of the oligochaeta was made from the bottom sediment in every fortnight and the numbers available were computed and expressed as ind/m^2. The results (mean values) have been presented in Table – 2 and are described below.

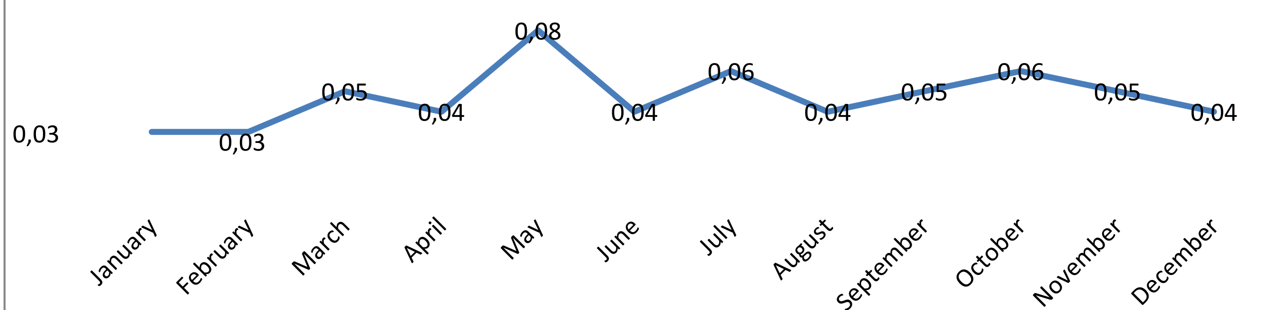

Fig- 2 : Monthly fluctuations of Nitrate nitrogen (NO_3-N) of water.

Total Oligochaeta

Table – 2: Monthly variations of different species of Oligochaeta.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Aulophorus farcatus	44	-	22	-	-	311	378	22	-	20	-	-
Aulodrilus sp	78	-	-	222	-	133	22	22	60	-	133	168
Branchiura sowerbyi	-	-	128	-	42	178	-	-	-	-	44	89
Branchiodrilus sempari	756	1820	-	-	-	178	44	45	-	-	356	230
Limnodrilus hoffmeisteri	667	1174	-	-	340	440	217	623	-	248	2756	576
Dero digitata	80	238	-	45	-	1067	1267	45	122	-	44	44
Total oligochaeta	1625	3232	150	267	382	1996	1906	757	182	268	3333	1107

In this wetland oligochaeta comprises of six species (*Aulophorus farcatus, Aulodrilus* sp, *Branchiura sowerbyi, Branchiodrilus sempari, Limnodrilus hoffmeisteri, Dero digitata)*. During study higher value (3333 ind/m^2) was recorded in November while lower value (82 ind/m^2) was in September.

Aulophorus farcatus

This species was recorded only in five months with a maximum of 378 ind/m^2 in July and a minimum of 20 ind/m^2 in October. Total 775 ind m^{-2} of this species comprised 5.29% of the total oligochaeta. (Fig-3)

Aulodrilus sp

In this wetland this species was recorded during eight months with a maximum (222 ind/m^2) in April and a minimum (22 ind/m^2) in July and August. A total of 838 ind/m^2 formed 5.57 % of total oligochaeta (Fig- 3).

Branchiura sowerbyi

This species was observed only in four months. Among them the minimum (44 ind/m^2) was recored in November and maximum (178 ind/m^2) in June. This species comprised only 3.19 % of total oligochaeta (Fig- 3).

Branchiodrilus sempari

During study this species was recorded in seven months with a total of 3429 ind/m^2 which formed 22.8% of total oligochaeta (Fig-3). In the study minimum value (44 ind/m^2) was noticed in July and maximum (1820 ind/m^2) in February. This species is the second largest among all the species of the oligochaeta.

Limnodrilus hoffmeisteri

This was the largest species of this population which formed 46.81 % of the total ologochaeta of this wetland (Fig-3). During study this species was recorded in nine months with a maximum of 2756 ind/m^2 in November and minimum of 217 ind/m^2 in July. Total 7041 ind/m^2 was recorded in this wetland.

Dero digitata

It was recorded nine months with a maximum of 1267 ind/m^2 in July and a minimum of 2 ind/m^2 in September. A total of 2852 ind/m^2 formed 18.96 % of the total oligochaeta (Fig-3).

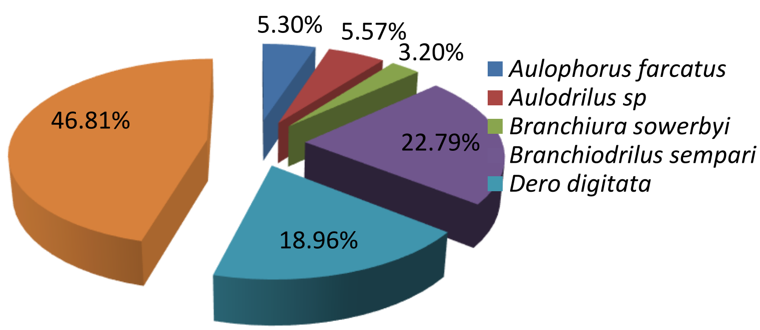

Fig- 3 : % composition of different species of oligochaeta.

Table – 3: Monthly variations of different indices during study.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Index of dominance	0.386	0.454	0.750	0.719	0.902	0.397	0.495	0.686	0.558	0.862	0.697	0.345
Index of diversity	0.614	0.546	0.250	0.281	0.098	0.621	0.505	0.314	0.442	0.138	0.303	0.655

Community Analysis

Index of diversity (D): In the present observation this index showed lowest (0.98) and the highest (0.655) values in the month of May and December respectively with four peaks (Fig- 4).

Index of dominance (C): During study this index showed its highest (0.902) and lowest (0.345) values in the month of May and December with five peaks (Fig- 4).

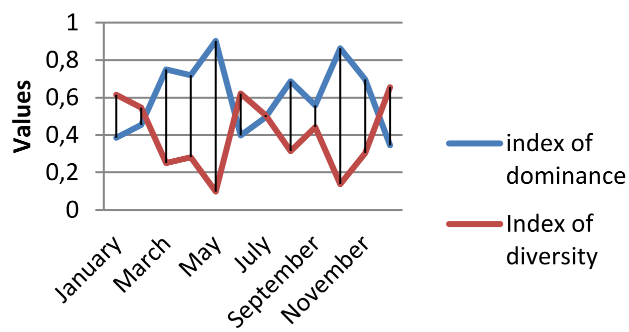

Fig:4- Monthly fluctuation of different indices.

DISCUSSION

The present papers have been elucidated and interpret the variation as well as the interaction of the abiotic and biotic factors of water of an unmanaged freshwater wetland of West Bengal, India. This is especially important from the ecological viewpoint because abiotic factors as ecological indices give a picture of water quality (Paloheimo and Fulthrop, 1987).

The present wetland being small and located in an open area, temperature change can take place rapidly (Welch, 1952). In the present study water temperature (WT) was found always below 35ºC and above 15ºC. Therefore such a seasonal variation in WT is the optimum temperature range for good growth of aquatic organisms. The vertical profile of the WT in the wetland did not strictly obey the Brige’s rules as Ruttner (1931) ruled out the strict applicability of this rule in case of tropical and subtropical wetland.

Therefore a seasonal thermal stratification dividing the wetland’s water into a worm epilimnion, a cold anoxic hypolimnion and a barrier of thermocline between the two did not feature in the wetlands because due to shallowness and widespread condition of the wetland in which the resultant convictive movement of water breaks the ‘thermal resistant’ of water. Hence the wetland under study is polymictic in nature.

Water transparency is an effective indicator of the presence of both autochthonous and allochthonous suspended materials. It is essentially a function of light passing through the water column and occurs due to the scattering and absorption (Chapman, 1992). In the present study less transparency was noticed in summer which may be attributed to the increase in phytoplankton population (Bashir *et al*., 2015). At the onset of monsoon the transparency value have been diminished to its minimum level which is caused due to increase allochthonous materials from the surface run off. On the other hand higher transparency was recorded during winter perhaps due to presence of less suspended organic matter because it settle to the bottom as the wetland is undisturbed (Shindle *et al.* 2010). According to Schofield (1972) and Schmidler (1980) acidification increase transparency of natural water. In the present study also the pH of water remains slightly acidic for six months which may be the causes of high transparency.

The pH of water is generally governed by carbon dioxide → bicarbonate → carbonate activities (Hutchinson, 1975). Decrease in pH in monsoon and post monsoon during study may be attributed to resulting in the formation of carbonic acid (H_2CO_3) which after dissociation into H^+ and HCO_3^- ions displays acidic characters (Khan and Chowdhury, 1994). The presence of organic matter in appreciable quantity in monsoon may lower the pH valve due to release of carbon dioxide and sulfur dioxide (Tripathi and Sikandar, 1989). On the other hand higher values were noted in summer, it possibly results from higher rate of photosynthesis at high temperature and prolonged photoperiod (Goldman, 1972, Akthar *et al.,* 2015). Natural waters mainly have alkaline pH (Golterman and Kouwe, 1980) although it varies in most cases from 6 to 8.5 (Chapman, 1992). In the present study also it varies from 6.67 to 8.

The dissolved oxygen (DO) has great significance as an indicator of water quality especially to understand the magnitude of eutrophication. The variation of DO in the present study has been found to be between 1.2 to 11.2 mg L^{-1} which is in agreement with Bhatnagar, 1984. DO concentration of water has a dtrect role in selfpurification of any water body. Higher value of DO was recorded during winter due to low temperature and high transparency (Ali, 2015) and decrease consumption rate of oxygen by decomposer (Ahangar, 2014). On the other hand low DO value was recorded during summer, the reason behind it is high temperature and increase consumption rate of oxygen by decomposers (Arimoro *et al.,* 2007) and increase intensity of biological process (Olomukoro, 2008). In the present study aquatic macrophytes perhaps play a significant role for the wide variations of DO content as oxygen release from submerged aquatic macrophytes influence the dissolved O_2 concentration of water (Sand-Jensen *et al*., 1982).

Free carbon dioxide (CO_2) experienced wide fluctuations during study and no definite trend has been observed. Higher values in monsoon and post monsoon months may be attributed to its influx through rain water in the form of carbonic acid (Mansoori *et al*., 1995) and the lower values during summer might be due to high photosynthetic activity using free CO_2 (Yousuf *et al.,* 1986; Aura *et al*., 2011). In winter higher values of free CO_2 in association with low pH (Wetzel, 2001) is probably due to decrease photosynthesis (Adamse, 1968) and reduced macrophytic growth at low temperature (Zuber, 2007). Not only that higher value of CO_2 is due to presence of macro vegetation also. The O_2 and CO_2 are reciprocal to each other in the ecosystem. The O_2 content are closely linked with CO_2 cycle and higher values of CO_2 generally coincided with minimum DO content (Sarkar and Krishnamoorti, 1979). In the present study also the wetland generally follow the above contention.

The dissolved organic matter (DOM) is usually added to the water bodies in the form of extra cellular substances liberated by phytoplankton and macrophytes during their growth and from excretion of fauna (Fogg, 1963 and Cole, 1983). In the present study the macrophytes plays a significant role for the variation of DOM. The higher values of it was a result of surface run off and increased decomposition rate while the lower values may be due to assimilation of salts and other ions by the phytoplankton and macrophytes to attain maximum growth (koria et al., 2008; Ahanger, 2014).

The extensive study by Sawyer (1944) indicates that nitrogen and its compounds (ammonia and nitrite) are one of the major agents which are responsible for ageing of water body. The main source of Nitrate- nitrogen (NO_3-N) in natural water is atmospheric nitrogen, surface run off and decomposition of organic matter. It is the most oxidized form of nitrogen and is an important nutrient for proper growth of biota including macrophytes. According to Raymont (1980) and Wetzel (1983) it is a growth limiting factor and also an important element in relation to nutrient limitation of productivity in aquatic ecosystem. The Nitrate-nitrogen content in the studied wetland was not found in appreciable quantity. Wetzel (op. cit.) is of the opinion that concentration of nitrogen in unpolluted freshwater ranges from undetectable levels to 19 mg L^{-1} but it is highly variable seasonally. The higher values of Nitrate- nitrogen was obtain in summer, monsoon and post monsoon while lower values were recorded in winter and post winter season. The higher values of Nitrate- nitrogen in monsoon and post monsoon can be attributed due to surface run off (Pahwa and Mahrotra, 1966 and Kulkarni *et al*., 1988). On the other hand higher value during summer months may be due to continuous release of the nutrient from the decomposed bottom sediment at higher temperature (Zuber, 2007 and Naik *et al*., 2015). The lower values during winter and post winter months may be due to low decomposition rate at low temperature and continuous utilization of the nutrient by the macrophytes and the phytoplankton during spring and summer which decreases the nitrate towards winter (Bagde and Verma, 1985, Gudoo *et al.,* 2020).Hardness is important parameters for the assessment of the water quality and in decreasing the toxicity effect of poisonous element (Howrath and Sprague, 1978). The maximum value of hardness which was recorded in monsoon and post monsoon was due to excess addition of calcium and magnesium salts by organic matter brought by surface run off and the minimum values recorded in winter and post winter season are due to consumption of carbonates and bicarbonates by phytoplankton as a source of carbon and reduced solubility of calcium ions (Bhat et al., 2013; Ahangar, 2014). The values of hardness indicated the soft water type nature of the wetland (Sawyer, 1960).

In the present study six species of oligochaeta were encountered of which five are dominant. In the present observation higher oligochaeta was observed during winter and monsoon months. *Aulodrilus* sp and *Limnodrilus hoffmeisteri* among oligochaetes were found to be responsible for peaks and troughs of the total population. According to Eggleswa, 1964 in the studied wetland the supply of macrophyte detritus increase oligochaeta population not only that abundant macrophytic growth offer macrohabitat and suitable breeding ground to them (Petrovici *et al*., 2010; Elipek *et al*., 2010) and decomposed organic matter maintain the favourable condition for growth (Ibanez *et al*., 2002). *Aulodrilus* sp has been found to be dominant during winter and summer. *Limnodrilus hoffmeisteri* exhibits maximum growth during February and November. On the other hand *Branchiura sowerbyi* was recorded during four times. Abundance during winter and monsoon was showed by *Branchiodrilus sempari.* The range of temperature variation of the wetland probably favours all the oligochaeta species to survive (Ghosh, 1999). The maximum abundance of oligochaeta in monsoon was probably due to relatively high precipitation and consequently surface run off favouring the growth as remarked by Sarangi (1983) and dense macrophytic growth, which provide food, accommodation and suitable breeding place (Kouame *et al.,* 2011). High abundance during winter parallels the finding of Gupta (1976). In the present observation dominance of oligochaeta was noticed during January, February, June, July, November and December. Michael (1968b) studied the bottom fauna of ponds near Calcutta and estimated a rich population of oligochaeta between January and April. On the other hand, Ghosh (1999) in his observation noted the richness of oligochaeta during January, August and November. Seasonal variations in the abundance of *L. hoffmeisteri* as noted presently corroborate those of Sarangi (1983) and Ghosh (1999). However, according to Veal and Osmond (1968) the qualitative changes in the benthic community were due to the increase in the abundance of the pollution tolerant tubificid *L. hoffmeisteri*.

Tubificids are branched as sludge worms and their high density at the deoxygenated as well as less oxygenated water has been reported by Hynes (1960) and Brinkhurst (1971). Welch (1980) suggested that the success of *L. hoffmeisteri* in environment that become anaerobic for extended periods, partly results from their prolific reproductive rate, they can quickly reproduce the area once the anaerobic period has passed. Mason (1991) mentioned that in more deteriorated condition of an aquatic ecosystem most of the species of tubificids are gradually eliminated leaving *L. hoffmeisteri* to multiply in the absence of competitors and predators. The *L. hoffmeisteri* and *Branchiodrilus sempari* in this stressed environment survive due to their ability to respire at very low oxygen tension. Aston (1973) showed that *Branchiura* sp maintained a normal rate of respiration in DO even at twenty percent of saturation. Presence of well-developed capillary system in the body wall of tubificid (Palmer, 1966) helps it to maintain its rate of oxygen consumption. Hynes (1960) inferred that a river bed enriched with organic solid and poor oxygen content harbours the tubificid especially *Limnodrilus* along with other macrobenthic groups. Due to the ability of respire at very low oxygen limitation *Limnodrilus hoffmeisteri, Branchiura sowerbyi* are able to survive in the present wetland. However shallow water rich in organic matter exhibits dominance of tubificid accompanied with a few clean water species of Naididae. In the present study also few species of Naididaes viz. *Dero digitata* have been recorded in profuse number in the studied wetland. During the study *Dero digitata* found with a maximum number during monsoon. Higher density at deoxygenated as well as less oxygenated water has been reported earlier (Brinkhurst, 1971).

Environmental perturbations in the aquatic ecosystem can be evaluated by community delineation through biological indices that summarize large amount of information in a very meaningful manner (Wilhm and Dorris, 1968). Species diversity is based on the theory that an aquatic community, which is free from environmental perturbations, is characterized by large number of species and less number of individuals of each species. Any changes in the community structure resulting less number of species with higher abundance reflects the environmental stress.

In the present observation the values of diversity (D) showed a wide variation and in maximum cases it showed higher values (> 0.45). The value of dominance (C) seems to be rather low except in few cases when the value exceeded 0.5. From the result it is obvious that the most abundant species composition is higher in this wetland. This is perhaps the results of more sensitiveness of dominance (C) to most abundant species in a sample (Ghosh, 1999).

Simpson's diversity (D) is used to discern the probability of every successive sampling drawn at random, would represent similar species composition as in the first sampling. This index as opposed to the concentration of dominance (C) not only denotes the extent of species diversity existing in a malty community population but also illustrates the degree of competition or compatibility among the species of the same population. Therefore, the greater the value of D, the more is the chance of coexistence of species with rational resource utilization.

CONCLUSION

From the present observation it is evident that individual species of different oligochaeta has different seasonal changes in abundance but in average the high density of its species mostly restricted to summer, winter and post monsoon periods. It is probable that monsoon run off carry organic nutrients from the adjacent areas as well as pond margins with surface run off which results in the increase of the food resources of the benthic organisms especially for the oligochaeta that promotes them to flourish. It may also conclude that the concentration of different physico-chemical factors in the wetland definitely favoured the luxurious growth of oligochaeta and much more facts and evidences will have to be produce to clarify the reasons of wide fluctuations of the index of diversity as well as dominance.

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Abbreviation used:
Biological Oxygen Demand = BOD
Carbon di Oxide = CO_2
Dissolved Organic Matter = DOM
Dissolved Oxygen = DO
Hardness = HAR
individuals per meter squire = ind/m^2
Milligram/liter = mg/lit
Nitrate nitrogen = NO_3-N
Squire meter = sq. m.
Total alkalinity = TA
Transparency = TRAN
Water temperature = WT

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