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Biomonitoring of Wetland Using Macrophytes and Macroinvertebrates

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Abstract:

Bio-monitoring is the use of biological responses to assess changes in the environment. Biological monitoring is considered to provide an integrated approach to assess water and overall environmental quality. The ultimate objective of bio-monitoring in the Rampur Ghol is to ensure that local resource users in the water sector to apply biodiversity friendly management practices within their day to day activities. In this research macro invertebrates are used to classify the Rampur Ghol into different Water Quality Classes based on Saprobic Water Quality Classification (SWQC) approach. Rampur Ghol was selected as research site for biological monitoring, situated in Chitwan district, Mangalpur VDC Ward No. 2. Macrophytes were collected from both the aquatic habitat and buffer zone of the Rampur Ghol in seasonal basis using fixed quadrate of 1×1m². Benthic macro-invertebrates were sampled by using bin sampler and grab sampler and then analysed. During study period altogether 14 families belonging to 10 orders of aquatic macro-invertebrate were found in dry season and 18 families belonging to 12 orders of aquatic macro-

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invertebrates were found in rainy season. Accessing the Biotic Index of macro-invertebrates, it was found that eight sites fall in water quality class III and site 7 and site 10 were rated class II-III and class III-IV respectively in dry season. Similarly, seven sites were rated water quality class III and three sites were rated water quality class II-III in rainy season. Study of the macrophytes in site 7, 8 and 10 concluded that the macrophytes from sites 8 and 10 showed high degree of organic pollution and showed the dominance of Pistia stratiotes throughout the study, which is considered to be indicator of organic pollution. High anthropogenic activities show fluctuation of water quality in Rampur Ghol. It can be concluded that humans are the key factor for degrading the Ghol.

Key words: Bio-monitoring, macroinvertebrates, Rampur Ghol, Saprobic Water Quality Classification Approach, Biotic Index, macrophytes,

1. INTRODUCTION

Wetland was a nascent term for common people until recently. The same holds true for Nepal too. It is said that only in the 1970's it appeared in the Oxford Dictionary. Before that wetlands were known by different names such as lake, pond, marsh, swamp, bog, fen etc. Wetlands were named according to the landscape in which they were found. Therefore, even today, the term "wetland" does not have even a universally accepted definition because of the plurality of users, regional variations, biological diversities and richness in cultural values. The meaning vary from place to place and person to person. It has many forms but the common content, i.e. water, which is the bloodstream of wetland. National Wetlands Policy of Nepal (2003) defines wetlands as follows:

> "Wetlands denote perennial water bodies that originate from underground sources of water or rains. It means swampy areas with flowing or stagnant fresh or salt water that are natural or man-made, or permanent or temporary. Wetlands

> also mean marshy lands, riverine floodplains, lakes, ponds, water storage areas and agricultural lands."

The Convention on Wetlands of International Importance (Ramsar, Iran, 2012) has defined wetlands in a broader sense as "Wetlands are areas of marsh, fen, pet lands or water, whether natural or artificial, permanent ortemporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceeds six meters."

On the basis of ecological and geographical characteristics, wetlands are classified into five major types (CSUWN, 2009):

- **Shallow lakes:** areas of permanent or semi-permanent water with little flow (e.g. Ghodaghodi Lake Area in Kailali, Kamaldaha in KoshiTappu Wildlife Reserve).
- **Marshes/Swamps:** area where water is more or less permanently at the surface or causing saturation of the soil (e.g. Rani Tal in Kanchanpur and Nakrodital in Kailali). These are also called Ghol.
- **Floodplain:** areas next to the permanent course of a river that extends to the edge of the valley (e.g. KoshiTappu in Koshi River and Bandarjhula in Narayani River).
- **Estuaries:** areas where rivers meet the sea and water changes from fresh to salt as it meet the sea (e.g. Sundarbans in India and Bangladesh).
- **Coasts:** areas between land and open sea that are not influenced by rivers (e.g. coral reefs in Australia).

Bio-monitoring is the use of biological responses to assess changes in the environment. Biological monitoring is considered to provide an integrated approach to assess water and overall environmental quality (Hynes, 1979). However, the assessment of water bodies in the Himalayan Region and in Nepal is mostly

based on the analysis of physical and chemical parameters (Sharma *et al*., 2009).

The ultimate objective of bio-monitoring in the Rampur Ghol is to ensure that local resource users in the water sector to apply biodiversity friendly management practices within their day to day activities. While only one study (Baseline study by SEN) has been conducted in the Rampur Ghol, these studies are common in the rest of the world. Aquatic macrophytes, macroinvertebrates and vertebrates have been widely used to measure biological integrity of aquatic systems, particularly rivers. Macroinvertebrates are largely dependent on the aquatic environment in which they live, and the presence or absence of certain macroinvertebrates can therefore give an indication of the quality of the water and general ecological condition, also referred to as ecosystem health. They are sensitive to factors such as water quality, water quantity, habitat availability and food availability (Dallas and Mosepele 2007). In this research macro invertebrates are used to classify the Rampur Ghol into different Water Quality Classes based on Saprobic Water Quality Classification (SWQC) approach.

Under SWQC system, the quality is measured in terms of presence or absence of indicator biota. Basically this approach is used to measure the degree of organic pollution in river based on the assemblage of organisms present (Moog 1991; Onorm 1995). There are four main standard saprobic water quality classes such as Class I-non-polluted (Oligosaprobic), Class II-moderately polluted (Beta-mesosaprobic), Class III-heavily polluted (Alpha-mesosaprobic) and Class IV-extremely polluted (polysaprobic). Three transitional water quality classes are also identified: Class I-II-slightly polluted (oligosaprobic to beta-mesosaprobic), Class II-III-critically polluted (beta-mesosaprobic to alpha-mesosaprobic) and Class III-IV-very heavily polluted (alpha-mesosaprobic to polysaprobic).

2. METHODOLOGY

Rampur Ghol was selected as research site for biological monitoring. It is situated in Chitwan district, Mangalpur VDC Ward No.2 inside the compound of the Institute of Agriculture and Animal Science (IAAS), Tribhuvan University. It is located at a latitude of 27º38´14.1"N and longitude 84º21´25.2" E and at an altitude of 257 m. It is 9 km south-west from the Narayangarh Bazar and the climate over there is tropical. Ghol wetland area covers an area of 15 ha and the climate is of tropical type.

Primary data collection

Macrophytes, fishes and macro invertebrates were identified, counted and analysed to assess the biodiversity health condition of the Rampur Ghol. This verifies the result from chemical parameters of the previous studies. Fixed quadrate and grab sampler were taken as the sampling unit for biodiversity analysis in and around the Rampur Ghol. The major fauna and flora recorded were identified in IAAS (Departments: Environmental Science, Aquaculture), National Herbarium at Godavari and Natural History Museum at Kathmandu and analysed.

Sampling of macrophytes

Macrophytes were collected from both the aquatic habitat and buffer zone of the Rampur Ghol in seasonal basis. Fixed quadrate of $1\times1m^2$ were used to collect the macrophytes from different spots in random covering about 1% of the total area of the Ghol. The collected specimens were tagged and pressed to prepare herbaria and then identified in IAAS, (Department of Environmental Science), National Herbarium at Godavari and Natural History Museum at Kathmandu.

Sampling of macro invertebrates

Benthic macro-invertebrates were sampled by using bin sampler and Grab sampler. The macro-invertebrates feature were analysed by using the following indices of species structures in communities.

Density of macro-invertebrates (D) was calculated by following equation (Yadav*et al.* 1987).

$$D = \frac{total\ no.\ of\ individuals}{sampling\ area}$$

a. Shannon index of general diversity

Shannon index formula to find the level of species diversity in an area (Odum, 1996)

$$\text{Shannon Diversity Index (H)} = -\sum\left(\frac{ni}{N}\right)\log\left(\frac{ni}{N}\right)$$

Where, ni = Importance value for each species
N = Total of importance values

b. Species richness and evenness index

Species richness is simply the number of species per unit area (Pielou, 1975). Evenness index stated by Maguran (1988) as another component of diversity is calculated by using diversity index:

$$\text{Species richness (d)} = \frac{S - 1}{\log N}$$

Where, S = No. of species
N = No. of individuals

$$\text{Evenness index (e)} = S\ \text{LogH}$$

Where, S = No. of species
$0 < e < 1$

c. Index of dominance

$$\text{Index of Dominance ©} = \sum\left(\frac{ni}{N}\right)^2$$

Where, ni = Importance value of each species
N = Total of importance value

H values behave inversely with the index of dominance. Higher the value of 'H' indicates a low concentration of dominance.

Water quality classification

Water Quality Classification was done using Saprobic Water Quality Class (SWQC) approach. In Saprobic system, diversity and abundance of benthic macro invertebrates are used to classify wetland water quality, since they represent the specific characteristic features of the different sites of a wetland and include pronounced response to pollution, and a sessile-attached mode of life that reduces the influence of neighbouring water conditions on the organism. On top of all, the size of benthic macro invertebrates can be seen without aid. Most of them are sensitive to pollution. Their abundance and diversity are subject to change due to human interventions.

Calculation:

$$\text{Biotic Index } BI = \sum_{i=1}^{n} \frac{(Wi * hi)}{H}$$

Where,

Wi = Tolerance Score of i^{th} Taxon

hi = No. of i^{th} Taxon

H = Total No. of Taxon

This BI Value was then compared with weight assigned to each SWQC (Table 3) and water quality class of each site were determined.

Table 1 Saprobic water quality classes and their assigned weights

S.N.	SWQC	Assigned weight	Degree of pollution
1	I	10 & above	Non-polluted (Oligosaprobic)
2	I-II	7.5-9-9	Slightly polluted
3	II	6.2-7.4	Moderately Polluted(Beta-mesosaprobic)
4	II-III	4.9-6.1	Critically Polluted
5	III	3.6-4.8	Heavily Polluted (Alpha-mesosaprobic)
6	III-IV	2.3-3.5	Very heavily Polluted
7	IV	1-2.2	Extremely Polluted(Polysaprobic)

Coring and Kuchenhoff, 1994

3. RESULT AND DISCUSSION

Macro invertebrates

During rainy season altogether 18 macro-invertebrate taxa (families) belonging to 13 orders were recorded in the Ghol whereas in the dry season 14 taxa belonging to 10 orders were recorded in the Ghol area. The higher taxa were documented in rainy season while the lower in dry season as presented in Appendix 1. Family Thiaridae (70 individuals) followed bySphaeridae (45 individuals) was found in higher number in dry season while Gerridae (1 individual) and Gomphdae (2 individuals) were found in lower number. Family Ditiscidae (56 individuals) followed by Lymnaeidae (52 individuals) were found higher in rainy season where as family Gerridae (2 individuals), Unionidae (2 individuals) and Chironomidae (2 individuals) were found in fewer number. Family Salifidae, Protoneurodae, Potamidae and Mycidae were absent in dry season as shown in Figure 1.

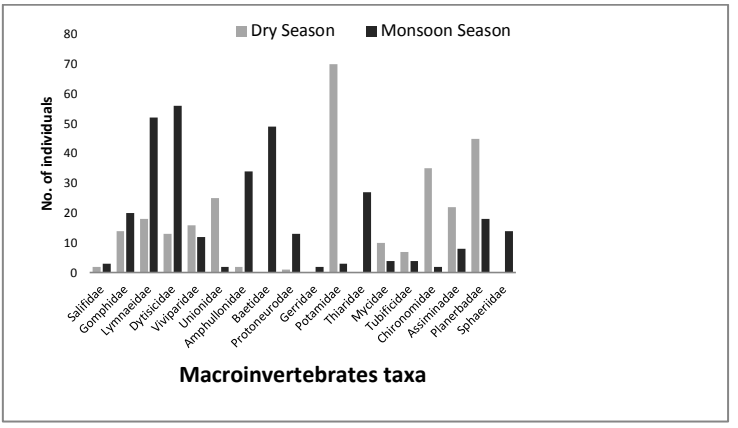

Figure 1. Number of taxa found in different season

The species diversity of Rampur Ghol was found to be 2.25 and 2.43 in dry season and rainy season respectively. The species diversity value of rainy season was higher than dry season. The evenness index of Rampur Ghol was found to be 0.85 and 0.84 in dry season and rainy season respectively. The seasonal

variation of diversity index and evenness index of macro-invertebrates in the Rampur Ghol is shown in Figure 2.

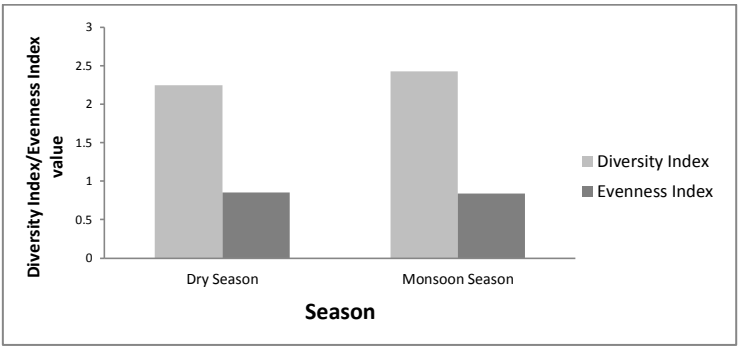

Figure 2. Diversity index and evenness index value in different seasons

The density of families Salifidae, Gomphidae, Lymnaedae, Dytiscidae, Viviparidae, Unionidae, Ampullariidae, Baetidae, Gerridae, Thiaridae, Tubificidae, Chironomidae,Assiminadae, Planorbidae and Sphaeriidae was recorded 7.81 ind/m2, 54.69ind/m^2, 70.31ind/m^2, 50.78 ind/m^2, 62.50ind/m^2, 97.66ind/m^2, 7.81 ind/m2, 3.91 ind/m^2, 273.44ind/m^2, 39.06ind/m^2, 27.34ind/m^2, 136.72ind/m^2, 85.94ind/m^2 and 175.78ind/m^2 respectively in dry season.

Families Salifidae, Protoneurodae, PotamidaeandMycidae were not found in dry season. Similarly, density of family Salifidae, Gomphidae, Lymnaedae, Dytiscidae, Viviparidae, Unionidae, Ampullariidae, Baetidae, Protoneurodae, Gerridae, Potamidae, Thiaridae, Mycidae, Tubificidae, Chironomidae, Assiminadae, Planorbidae and Sphaeriidae was recorded 11.72 ind/m^2, 78.13 ind/m^2, 203.13ind/m^2, 218.75ind/m^2, 46.88 ind/m^2, 7.81ind/m^2, 132.81ind/m^2, 191.41ind/m2, 50.78 ind/m^2, 7.81ind/m^2, 11.72 ind/m^2, 105.47ind/m^2, 15.63 ind/m^2, 15.63 ind/m^2, 7.81 ind/m^2, 31.25 ind/m^2, 70.31 ind/m^2 and 54.69ind/m2 respectively in rainy season as shown in figure 4.8. The average highest density value was recorded family Thiaridae (273.44 ind/m2) followed by Sphaeridae (175.78 ind/m^2) in dry season. Similarly,

the highest density was recorded 218.75ind/m^2 of family Dytiscidae followed by Lymnaedae (203.13ind/m2) and Baetidae (191.41ind/m^2) in rainy season as shown in Figure 3.

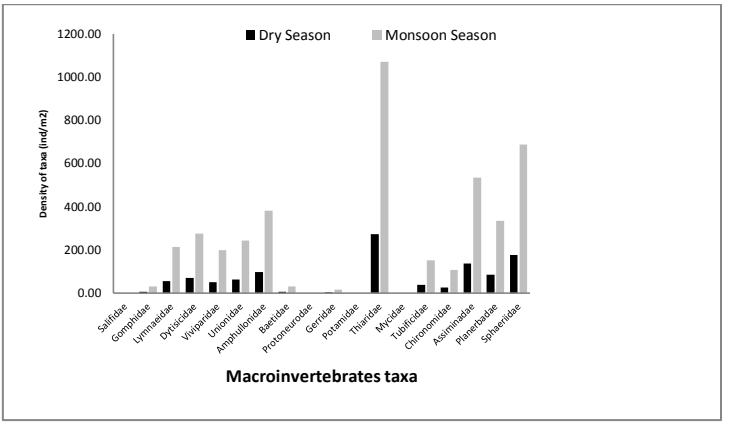

Figure 3. Density of macroinvertebrates taxa in different seasons

4.2 Biological water quality index

Biological water quality index of Rampur Ghol area was calculated by using SWQC Approach (Coring and Kuchenhoff, 1994). The seasonal trend of Biotic Water Quality Index (BWQI) value for all the sites is given in Figure 6.According to the value, eight sites were rated water quality class III i.e. heavily polluted and remaining two sites site 7 and site 10 were rated class II-III i.e. critically polluted and class III-IV i.e. very heavily polluted respectively in dry season. Similarly, seven sites were rated water quality class III i.e. heavily polluted and three sites were rated water quality class II-III i.e. critically polluted in rainy season. In general, the low water pollution was observed in rainy season whereas high water pollution was observed in dry season as shown in the Table 2.

Table 2. Water quality class of different sites calculated by using SWQC approach

Season/sites	1	2	3	4	5	6	7	8	9	10
Dry season	III	III	III	III	III	III	II-III	III	III	III-IV
Rainy Season	III	II-III	II-III	III	III	III	III	II-III	III	III

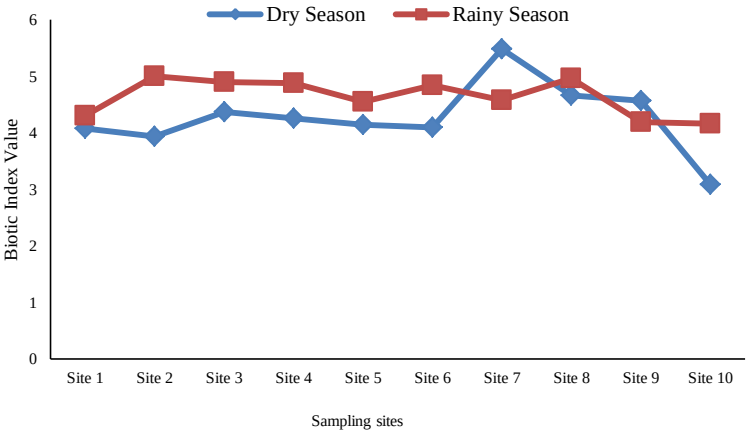

Figure 4. Seasonal biotic water quality index value

During dry season the Biotic Water Quality Index value was fluctuated in all sites as shown in the figure 4.4. Highest value of biotic index was recorded 5.4 at site 7 in dry season. However, lowest index value was recorded 3.09 at site 10 in dry season. Similarly, highest value of biotic index was recorded 5 at site 2 and lowest value was recorded 4.16 at site 10 in rainy season as shown in figure 4. Higher value of index indicates better water quality and vice versa.

Fishes

During Monsoon and Post-Monsoon season 19 species of fishes belonging to 10 families were found and in Pre-Monsoon season 16 species of fishes belonging to 8 families were found.

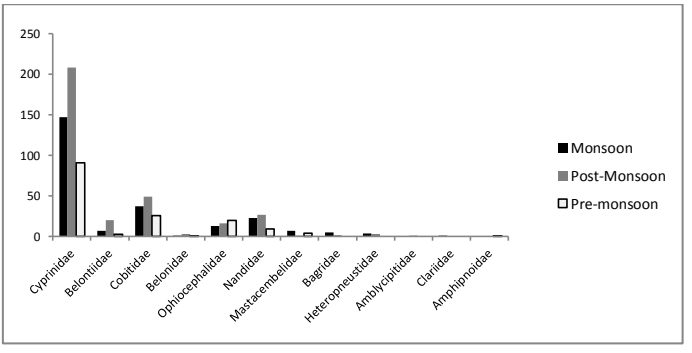

Figure 5. Fish diversity of Rampur Ghol in different seasons

Altogether 22 species of fishes belonging to 12 different families were found annually. Cyprinidae (147 individuals) was found highest in number while Belonidae and Calridae (1 individual each) were found lowest in number during Monsoon season. In Post- Monsoon season again Cyprinidae (208 individuals) was found highest in number and Mastacembelidae and Amblycioitidae (1 individual each) were found lowest in number. Similarly, in Pre-Monsoon Season Cyprinidae (91 individuals) was found highest in number while Belonidae and Amphipnoidae (1 individual each) were found lowest in number as shown in Figure 5.

The Shannon Weaver Diversity Index value of fishes of Rampur Ghol was found to be 2.48, 2.38 and 2.39 in Monsoon, Post-Monsoon and Pre- Monsoon season respectively. Greater diversity was found in Monsoon season than in dry seasons as shown in Figure 6.

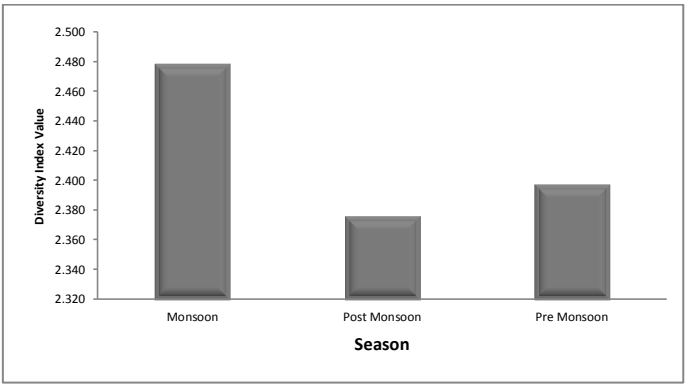

Figure 6. Diversity index of fishes in Rampur Ghol in different seasons

Macrophytes

During SWQC approach classification of the wetland in dry season, three different classes of water quality were found, i.e. Class II-III, Class III and Class III-IV. So, macrophytes were studied on three sites, Site 7, 8 and 10 of these classes.More than 45 species of macrophytes found during the study at these three different sites of Rampur Ghol, frequently recorded

species from sampling stations were*Flascopa scandens, Erasgrostis gagentica, Persicaria barbata, Phyllanthus urinaria, Gonostegia pentandra, Vallisneria spirallis, Ageratum houstonianum, Alternanthera sessilis, Commelina benghalensis, Lemna minor, Pistia stratiotes, etc.*

Site 7 showed weeds like *Commelina forsskalaei and Ammannia baccifera* is commonly growing plants on the bank of flowing water. As the water enters into urban influence, inflow of sewage helps to increase plant nutrients, particularly phosphate and nitrates, thereby increasing growth of plants. Species among plant, indicative of organic enrichment are *Pistia stratiotes* and *Lemna minor*. These species are also found in large population in downstream sites8 and 10.The macrophytes from sites 8 and 10 showed high degree of organic pollution and showed the dominance of *Pistia stratiotes* throughout the study, which are considered to be indicators of organic pollution.

On the basis of quantitative estimate, overall species number rank order is site-7>site-8>site 10. The Shannon-Weaver diversity index was calculated for all the three sampling sites. Based on the Shannon-Weaver index the sequence among the stations from highest to lowest diversity, site7>site8>site10 (Figure 9). Site7 represented as most diverse, it has highest species richness due to relatively less pollution, whereas station 8 and 10 were having the least species Shannon diversity index as a result of higher pollution. Low species diversity is correlated with due to change in water level during summer months. The species having wide range of distribution and abundant in occurrence include *Alternanthera sessilis, Ludwigia hyssopifolia, Pistia stratiotes, Lemna minor,*etc were spread all over downstream sitesof the Ghol.

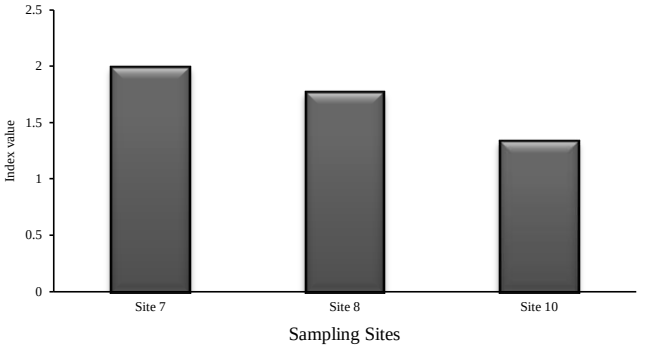

Figure 7. Diversity Index of macrophytes in different sampling sites of Rampur Ghol

4. CONCLUSION

The Rampur Ghol is rich in terms of aquatic macro-invertebrates, macrophytes and fishes taxa composition and its biodiversity. During study period altogether 14 families belonging to 10 orders of aquatic macro-invertebrate were found in dry season and 18 families belonging to 12 orders of aquatic macro-invertebrates were found in rainy season. The total density, Shannon Weiner diversity index and evenness index of aquatic macro-invertebrates of Rampur Ghol were found to be 1094 ind/m^2, 2.25 and 0.85 in dry season and 1262 ind/m^2, 2.43 and 0.84 in rainy season respectively.

Accessing the Biotic Index of macro-invertebrates, it was found that eight sites fall in water quality class III i.e. heavily polluted and remaining two sites site 7 and site 10 were rated class II-III i.e. critically polluted and class III-IV i.e. very heavily polluted respectively in dry season. Similarly, seven sites were rated water quality class III i.e. heavily polluted and three sites were rated water quality class II-III i.e. critically polluted in rainy season.

Study of the macrophytes in site 7, 8 and 10 concluded that the macrophytes from sites 8 and 10 showed high degree of organic pollution and showed the dominance of *Eichhornia*

crassipes, Pistia stratiotes throughout the study, which are considered to be indicators of organic pollution. On the basis of quantitative estimate, overall species number rank order is site-7>site-8>site 10. Based on the Shannon-Weaver index the sequence among the stations from highest to lowest diversity, site 7>site 8>site 10. Site 7 represented as most diverse, it has highest species richness due to relatively less pollution, whereas station 8 and 10 were having the least species Shannon diversity index as a result of higher pollution.

High anthropogenic activities show fluctuation of water quality in Rampur Ghol. It can be concluded that humans are the key factor for degrading the Ghol. The over harvesting of wetland resources only aggravate deteriorating ecological condition of Rampur Ghol.

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