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Eco-hydrobiology with Special Reference to Entamofauna and Avifaunal Diversity of Sothuparai Reservoir, Periyakulam, Theni District, Tamilnadu, India

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Abstract: Sothuparai reservoir is located at the foothills of the Western Ghats. The water quality parameters such as water temperature, PH, turbidity, total dissolved solids, total hardness, electrical conductivity, magnesium, calcium and chloride were analyzed and are within the permissible limits and can be used for irrigation and domestic purpose. A total of 2,670 individuals of aquatic entamofauna were represented by 43 genera categorized under 32 families and 9 orders during the study period. The diversity, evenness and the Ephemeroptera, Plecoptera and Trichoptera families were higher in upperstream than in downstream. Ephemeropteran was most diverse and its presence is an indicative of good water quality. The abundance of organic pollution tolerant Baetis species was found in downstream. To compare with the upperstream has the better water quality than the downstream of the reservoir. This may be due to the interruptions by anthropogenic activities in the downstream. The diversity and structure of bird communities is essential to delineate the importance of regional or local landscapes for avian conservation. Total count method was used and a total of 1,348 individuals belonging to 38 species of 25 families were observed in Sothuparai reservoir. Out of 25 Families, Muscicapidae dominated with 4 species and Culicidae with 3 species. Thus the present investigation depicts that the Sothuparai reservoir supports variety of bird's population and aquatic insect communities. Regular monitoring of the reservoir using aquatic insects and birds as indicators will facilitate better conservation and management.

Keywords: Water Quality Parameters, Diversity of Aquatic Insects & Birds, Sothuparai Reservoir, Bio Indicator

1. Introduction

India is rich in water resources being endowed with a net work of rivers and blessed with snow cover in the Himalayan range that can meet a variety of water of requirement of country [1]. Biodiversity is a precious heritage which is blessed by nature to save the planet and mankind. It is a variety of life which encompasses different genus, species, community and ecosystem along their relative abundance.

Freshwater is the blood of society [2]. Water is the major indispensable source on the living planet. It serves as the driving force for physical, chemical and biological changes throughout the world [3]. Fresh water is a finite resource, influences on almost every aspect of development of the natural ecosystem and mankind [4, 5]. Freshwater is an unique ecosystem and they are of great ecologically significant for an area as they support different features such as food chain, food webs, regulate hydrological cycle, recharge ground water trapping of energy and shelter to large numbers of flora and fauna having great ecological and economical values [5 & 6]. The healthy aquatic ecosystem is dependent on the physico chemical and biological characteristics which actually fluctuate with seasons and degree of pollution [7 & 8]. For the past two decades, conservation of our natural commodity is very essential. Water resources have been severely affected by rapid economical development and intensified human

activities [4] any change in the natural quality induces ecological imbalance [5 & 9]. Such activities can result in stream bank erosion, increased sedimentation, and alteration of geomorphology, riverine habitats, loss of species diversity and other detrimental effects [10]. The study of riverine ecosystem – limnology involves principally the casual interaction of biotic communities to their surroundings.

In the recent years environmental monitoring through regular assessment of water quality for variety of purpose like drinking, agricultural, industrial, aquaculture, recreational and domestic purpose has become a crucial factor in the conservation of aquatic resources [11 & 12]. Rivers are water ways of strategic importance across the world, providing main water resources for domestic, industrial and agricultural purpose [13]. They are the prime factors controlling the global water cycle and the most dynamic agents of transport [14].

The quality and quantity of surface water in a river basin is influenced by natural factors such as rainfall, temperature and weathering of rocks and anthropogenic changes that curtail natural flow of the river, or alter its hydrochemistry [15]. The entire array of life in water is affected due to pollution in water [16 & 17].

Karr *et al.* [18] reported that chemical analysis of water provides only the indication of chemical quality of the ecosystems. But the physical, chemical and biological nature determines the floral and faunal diversity [19]. Population Pressure, urbanization, industrialization and increased agricultural practices have significantly contributed to the pollution and toxicity of aquatic ecosystems. Pollutants bring about a change not only in physical and chemical quality of water but also modify the biotic components, resulting in the limitation of the valuable species [20].

Since Biological communities integrate the environmental effects of water chemistry, in addition to the physical and geomorphological characteristics of rivers and lakes, biological assessment is an effective alternative tool for analyzing the ecological quality of aquatic ecosystem.

Freshwater habitats including both lentic and lotic habitats serves as a home to greater entamofauna. Aquatic insects are among the most prolife animals on earth, but are highly specialized and represent less than 1% of the total animal diversity [21]. Aquatic insects have been used to assess the biological integrity of stream ecosystem in various studies [22 & 23]. Over 95% of the total individual in fresh water particularly streams comprise of these immature life stages of aquatic insects. They play an important role in food chain of stream ecosystem. Some freshwater insects have specific requirements regarding their nutrients, water quality, substrate and vegetation. The impact of human on freshwater were assessed by the use of indicator species [24]. Indicator species are those taxa known to be particularly sensitive to specific environmental factors. Any changes in their incidence and abundance may directly reflect on environmental changes [25].

Among the 56% of insects, only 3-5% is aquatic and they are minor fraction of all insects. Nearly 3% of all the insects initiate their life cycle as aquatic larvae before emergence as winged terrestrial forms [26]. The limited number is probably the result of the limited amount of fresh water habitat in comparison with the land surface [2]. The use of aquatic insects as bio indicators provides data to estimate the degree of environmental impact and its potential effects on other living organisms [27]. In general, aquatic insects are largely ignored in the contemporary estimation on Indian biodiversity and hence the present study documents the diversity of aquatic entamofauna in Sothuparai reservoir, Theni District.

Birds are the most conspicuous and significant component of different habitats, their presence or absence may indicate the ecological conditions of the particular area [28]. Birds are the best monitors of an environmental change. Due to the spreading of urbanization and modern technology, distribution of species may change with the local scale processes. The preservation of global species diversity has emerged as one of the most important issues today [29].

Seasonal variations in the food availability also determines the regular pattern of migration and local movements. Food availability is the major factor determining the seasonality of breeding. Cody [30] explored the resource division in grassland bird communities and found that the influx of migratory bird population was due to the availability of arthropods [31]. Unfortunately global diversity of birds is decreasing incessantly primarily due to anthropogenic disturbances and climate change [32].

The Sothuparai reservoir supplies water to the nearby villages of Periyakulam Taluk. The reservoir not only supplies water for drinking and irrigation but also maintain the ecosystem of the area through preservation of many species of plants, fishes, aquatic insects, birds *etc*. Thus the present investigation was undertaken to study the ecological parameters and assessment of abiotic and biotic potential of the reservoir with special reference to entamo and avifaunal diversity.

2. Materials and Methods

2.1. Description of the Study Site

Sothuparai is located at 9 km. from Periyakulam and situated between the longitude 77º 28' 4" and latitude 10º 7' 45" in Theni District. Sothuparai dam is built across the Varaganathi in Periyakulam, Theni District of Tamilnadu, Southern India. Sothuparai dam supplies drinking water to Periyakulam throughout the year. Full reservoir level is 405.5cm. Length of dam is 345 meter. Height of the dam is 1035.00 feet. Maximum water level is 100.22 feet. The wide expanse of stored water is an impressive sight.

Plate 1. *Map Showing the Study Area.*

2.2. Analysis of Water Quality Parameters

The study was conducted during the early hours of the day from June, 2014 to November, 2014. For the present investigation the water samples were collected in sterilized plastic bottles every month on the early hours. The physical chemical parameters of the water samples were analyzed in the laboratory following the standard methods as prescribed by APHA [33].

2.3. Sampling of Aquatic Insects

D - frame net and kick net was employed to trap specimens clinging to vegetation, root mats *etc.* along the boundary [34]**.** The collected specimens were preserved and identified with the help of standard keys [35-36].

2.4. Bird Census

The bird census using the method of total count was employed to survey the bird population [37].

2.5. Data Analysis

Species diversity indices such as Shannon -Weiner, Eveness were computed to understand the biotic community of each study site [38].

3. Results & Discussion

3.1. Limno-Chemistry

Water temperature is an important parameter as it has influence over the biotic communities in their behavior reproduction and metabolism. The water and air temperature was high in June and it was low in November (Figure 1). De, in 2002 [39] reported that temperature variation in an aquatic system affects osmoregulation and respiration of the animal. Similar observations was made by Shivasankar and Venkataramana [40] at Bhadra River, Karnataka, whereas Pramod *et al*. [41] reported minimum temperature throughout his study of Bhandura Reservoir, Maharstra.

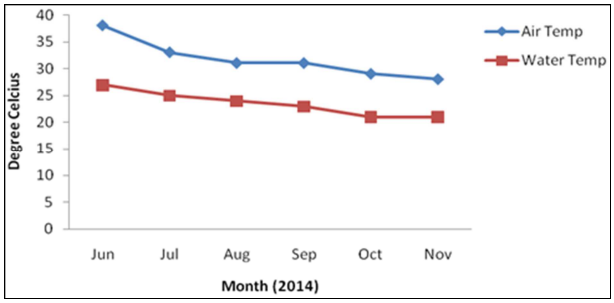

Figure 1. *Temperature of Sothuparai Reservoir during June – November 2014.*

3.1.1. Turbidity

Turbidity was high in October and it may be due to influx of rain water, silt and high organic matter during this month (Table 1). This is in par with the observations made by AshokKumar *et al*. and Narayana *et al*. [42 & 43] in rivers of Uttarkhand. Minimum turbidity was observed in June and such results have been reported by [12] in Vembakottai water reservoir and Garg *et al.* [44] in Ramsagar reservoir.

3.1.2. Total Dissolved Solids (TDS)

Total dissolved solids were below the specified range. Higher values of TDS was recorded in August (55 mg/l) it may be due to siltation, deterioration, heavy precipitation and mixing runoff which carries mud, sand *etc*. mixed in the water of the reservoir (Table 1). Shivasankar and Venktaramana and Pullugandi, [40 & 12] also recorded the same results during their studies.

3.1.3. Electrical Conductivity

Electrical conductivity of the Sothuparai Reservoir was within the permissible limit as prescribed by APHA [33]. The EC values were found to be comparatively high in August and lower in November (Table 1). This is due to increased rate of evaporation leading to high concentration of salts and same results were obtained by Shivasankar and Venkataramana [40]. A high level of conductivity reflects the pollution status as well as trophic level of the aquatic body [12]. Similar seasonal variation was examined by Verma *et al*. [45] in Kalpi River; Amal kumar *et al*. [17].

Table 1. *Physical Parameters of Water Samples in Sothuparai Reservoir during June - Nov, 2014.*

Physical Parameters	June	July	August	September	October	November
Turb. NT units	2	3	4	4	5	4
TDS (mg/1)	49	49	55	53	55	54
EC mho/cm	70	70	76	72	62	60

3.1.4. Potentio of Hydrogeny

pH of the natural water is usually between 6.0 to 8.5 [46 & 47]. PH values of the Sothuparai Reservoir lies between 6.1 to 7.1 (Table 2). Deviprasad *et al.* and Smitha *et al*. [48 & 49] investigated the pH variation in the water samples of wetlands in Mysore. In Nacharam lake high alkaline pH was noted by Motalagh *et al*. [50]. In the present investigation the p^H of the Sothuparai reservoir is within the specified range as in the studies of MedonaMary *et al*. [51 & 52]. According to [53] Jhigran and Sugnan, the pH ranged between 6 - 8.5 which is the medium productive aquatic system.

3.1.5. Total Alkalinity

During the study period the total alkalinity values ranged between 20 and 22 mg/l and the values were within the limit (Table 2). Mohammad *et al*. [5] and Ashokumar *et al*. [42] recorded similar values in their studies at Wygra reservoir and rivers of Uttrakand. According to Singhal *et al*. [54] an increase in the free CO_2 may result in the increase of alkalinity.

Table 2. *Chemical parameters of water samples in Sothuparai Reservoir during June - Nov, 2014.*

Chem. Parameters in mg/l	June	July	August	September	October	November
pH	6.2	7	6.1	6.5	7	7.1
Total Alkalinity	20	22	22	22	20	20
Total Hardness	26	24	26	26	21	24
Calcium	5	4	5	5	5	4
Magnesium	3	3	3	3	3	3
Iron	5	8	7	7	5	5
Ammonia	0.4	1	0.5	0.5	1	1.4
Nitrite	0.01	0.04	0.02	0.02	0.04	0.04
Nitrate	2	2	2	2	4	4
Chloride	7	10	6	6	5	4
Fluoride	1.2	0.8	0.6	0.7	0.7	0.7
Sulphate	6	4	5	5	4	4
Phosphate	0.4	1	0.5	0.5	0.6	0.5
Dissolved oxygen	0.63	0.63	0.63	0.63	0.63	0.63
Biological Oxygen Demand	8	8	7	8	7	8

3.1.6. Total Hardness

The variation in total hardness ranged from 21 mg/l to 26 mg/l (Table 2). The least value of hardness was recorded in October and the maximum value was recorded in August and this may be due to heavy shower which carries sedimentary rocks, run off and other silt as in the study of Kalavathy *et al*. [55] and Pulungandi, [12].

3.1.7. Macro Elements of Water Samples

Calcium ranged from 4 to 5 mg/l. The values were below the permissible limit. The amount of calcium decreases in the month of July and November and this may be due to absorbtion of calcium by living aquatic organism and less oxidation. Increased amount of calcium was observed in August and October (Table 2). Kiran [56] and Pulugandi, [12] observed that the increase in calcium level during monsoon was due to rapid oxidation of organic matter being present in rocks.

The amount of magnesium present in the water sample was higher in October and lower in June (Table 2). The optimum range of Mg lies between 30 mg/l to 100 mg/l. As per the Indian standards WHO and BIS they were below the permissible limit and the high level of magnesium is may be due to the mixing of animal organic waste [58]

Bureau of Indian standards [46] prescribe that the optimum range for sulphate is 400mg/l - 1000 mg/l. During the study period sulphate concentration ranges between 4 mg/l to 6 mg/l (Table 2) and the value was much below the Permissible limit [40].

The results in (Table 2) showed that the nitrate and nitrite concentrations were within the permissible range. The amount of nitrate was high in August and October. The values of nitrite ranged between 0.01 and 0.04mg/l. Maximum amount of nitrite and nitrate plays an important role in the process of eutrophication [62]. Similar observations were made by Rajasekar *et al.,* [63] in Minor reservoir, Andrapradesh.

Table 1 tabulates the amount of ammonia present in the water sample. The values varied between 0.4 to 1 mg/l and it was above the permissible limit. This may be due to the natural breakdown of nitrogenous organic compounds in water and soil and also by the breakdown of biota [64 & 12].

In the present investigation the phosphate concentration ranged from 0.4 to 20 mg/l (Table 2). These values were within the permissible limit. Comparatively an increase in phosphate concentration was in August and minimum in June. The present study also coincides with the findings of [64]. The report showed that the low level of phosphate

indicates that water is free from domestic sewage or effluent [65].

3.1.8. Micro Elements of Water Samples

The permissible amount of iron in natural water is to be 0.7 mg/l to 3.0 mg/l. In Sothuparai reservoir the concentration of iron was higher (8mg/l) than the permissible values (Table 2). Cari-AnnHayer *et al.* [57] observed that stream with high concentration of iron more than 5 mg/l had reduced periphyton biomass and invertebrate abundance.

The maximum amount of chloride ion in Sothuparai reservoir was recorded during the month of August (10 mg/l) and the minimum value (4 mg/l) is in November (Table 2). This may be due to leaching of rocks in reservoir [59]. Level of chloride in the aquatic ecosystem is one of the indicators of water pollution [60]. The increase in chloride level in rivers and dam is due to discharge of industrial and municipal wastes [61]. In the present study the level of chloride was below the permissible limit and therefore there is no mixing of industrial and municipal waste into the reservoir.

The concentration of fluoride in fresh water is a vital factor of hydro geochemistry as it has an impact on human health. The fluoride concentration in this study ranged between 0.7 mg/l to 2 mg/l (Table 2). The present study coincides with the observation made by Vinitkumar *et al.* [58].

3.1.9. Biological Oxygen Demand (BOD) and Dissolved Oxygen

The permissible limit of BOD is 6.0 mg/l according to Indian standards. The values of water samples in Sothuparai reservoir were higher than the permissible limit (Table 2). Ashokkumar *et al.* [42] observed much lower BOD values in the rivers of Uttarkahand, where as Vahana *et al.* [64] observation showed a higher BOD values in Ambhir Lake and Chinnarayani Lake.

The values for dissolved oxygen were below the permissible limit (Table 2). Hujara, [66]; Shivasankar and Venkatarama, [40], reported high DO levels which indicates higher autotrophic, low organic and inorganic load. Dissolved oxygen is vital for the survival of aquatic organisms. It is also used to evaluate the degree of freshness of water [67 & 58]. The Dissolved Oxygen values remain lower in the system, where the rate of respiration and organic decomposition is high [68].

3.2. Aquatic Entamofauna

3.2.1. Composition of Aquatic Insect Assemblages

In Sothuparai Reservoir a total of 2670 individuals of aquatic entamofauna were represented by 43 genera categorized under 32 families and 9 orders during the study period. The aquatic entamofauna of upper stream constituted 2,053 individuals belonging to 32 families, 9 orders & 39 genera, and in downstream 617 individuals belonging to, 22 families, 9 orders & 27 genera were recorded. The number of individuals and abundance was higher in upperstream than in downstream (Figure 2 & 3). Similar observations were made by Wahizatul *et al*. [27] and MedonaMary *et al*. [52].

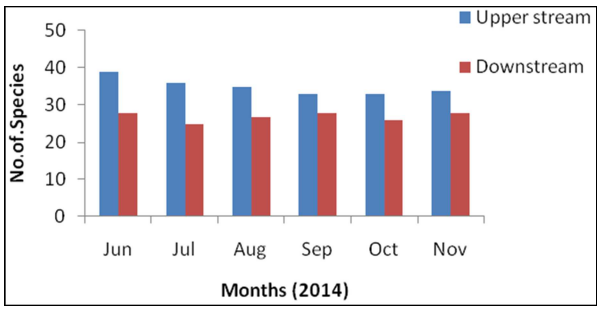

Figure 2. *Number of Aquatic Entamofauna recorded in Sothuparai Reservoir.*

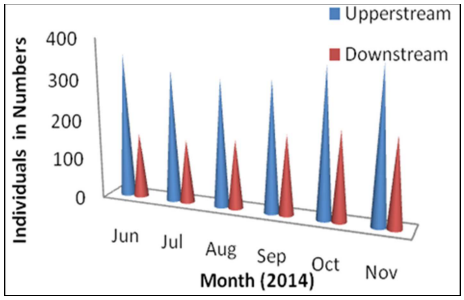

Figure 3. *Abundance of Aquatic Entamofauna recorded in Sothuparai Reservoir.*

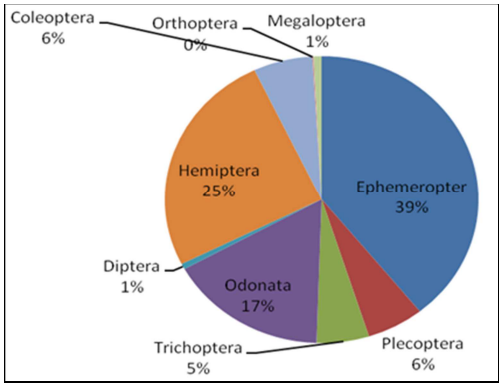

Figure 4. *Composition of Aquatic insects in the Upperstream of Sothuparai Reservoir.*

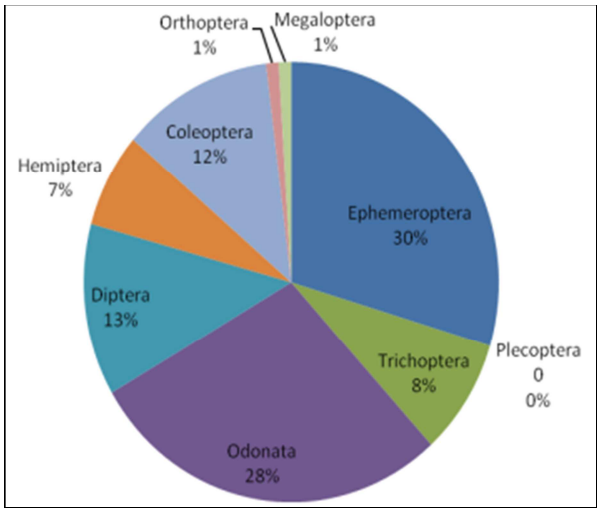

Figure 5. *Composition of Aquatic Insects in the Downstream of Sothuparai Reservoir.*

Figure 4 & 5 shows the composition of various insect orders collected from the upperstream and downstream of Sothuparai Reservoir. Ephemeroptera were the dominant groups with highest number and numerical abundance followed by Hemipterans. Such type of observations were done by Gupta and Nazzary, [69] and MedonaMary *et al*. [52]. Ephemeroptera found to have highest number of taxa where as the plecoptera has the least number of taxa where as in the study of Hoang *et al*. [70] recorded highest number of hemiptera in Du River was recorded.

3.2.2. Diversity and Evenness of Aquatic Entamofauna

Higher diversity of aquatic insect communities was observed in upperstream than in downstream. The diversity was high in June and low in October (Figure 6). This is in par with the observations made by Medona Mary *et al*. [52]; Kalayarasi, [71] Dinakaran and Anbalagan [72]. Evenness of aquatic entamofauna of the present study was higher in upperstream whereas it was lower in downstream (Figure 7). In upperstream, the evenness was observed high in September and low in June & July, where as in downstream the value was high in July and low in September (Figure 7). Even distribution of aquatic insects was observed in upperstream than in downstream. The values were in concordance with the findings of Medona Mary *et al*. (2015) [52].

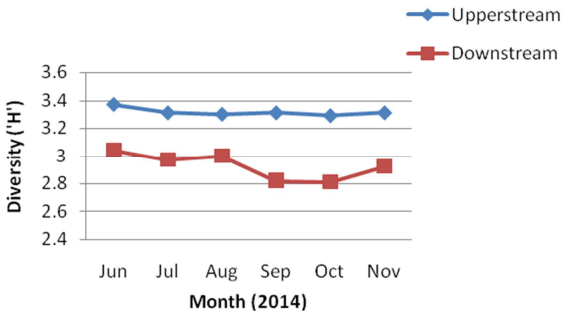

Figure 6. *Diversity of Aquatic Entamofauna recorded in Sothuparai Reservoir.*

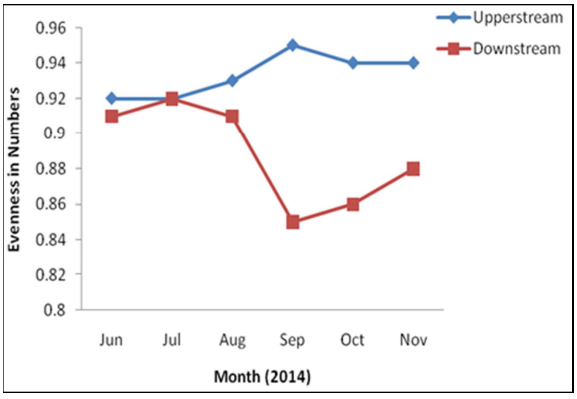

Figure 7. *Evenness of Aquatic Entamofauna recorded in Sothuparai Reservoir.*

3.2.3. Ephemeroptera, Plecoptera Trichoptera Richness

In the present investigation 51% of EPT taxa were observed in upperstream and 38% in downstream (Figure 8). The downstream has the highest (49%) non EPT taxa richness. This study indicates that the richness of pollution sensitive organism dwells in upperstream and pollution tolerant organism such as Baetis, Pilaria Tipula, Lamelligomphus in downstream. To compare with, the upperstream has the better water quality than the downstream of the reservoir. This may be due to the interruptions by anthropogenic activities in the downstream. Such type of observations were made by Wahizatul *et al*. [27]; Medona Mary *et al*. [52] and Abijna *et al.* [73].

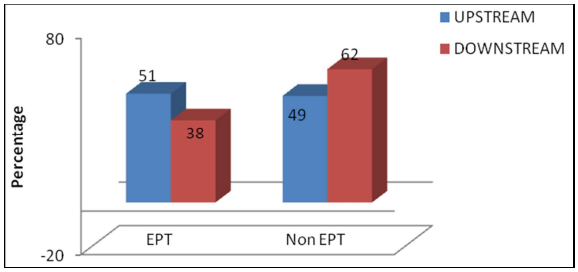

Figure 8. *EPT and Non EPT Taxa Richness of Aquatic Entamofauna in Sothuparai Reservoir.*

3.3. Avifaunal Diversity

A total of 1,348 individuals belonging to 38 species of 9 families were observed in Sothuparai reservoir. Out of 9 Families, Muscicapidae dominate with 4 species and Culicidae with 3 species. Maximum numbers of birds were observed in November and Minimum in July and the condition is same for the abundance of birds (Figure 9 &10). Seasonal difference in the abundance of food resources result in seasonal changes in the species abundance of birds Gaston *et al*. [74]. Donar *et al*. [75] observed the high occurrence of bird species in the aquatic area is because of birds breeding, feeding and nesting.

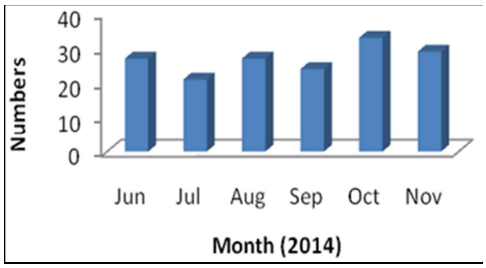

Figure 9. *Number of Bird Species in Sothuparai Reservoir.*

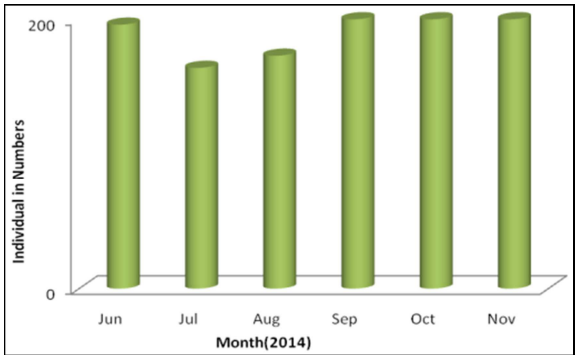

Figure 10. *Abundance of Bird Species in Sothuparai Reservoir.*

Diversity of birds was higher in August and lower in July (Figure 11). Evenness was high in October and it was low in July (Figure 12). Diversity and eveness was low in july may be due to the scarcity of water before monsoon. The bird species throughout the study were evenly diversified and distributed. Rana, 2005 [76] suggested that in natural habitats where the anthropogenic activities were less and minimum, the diversity of the bird species will be higher than the fragmented habitat.

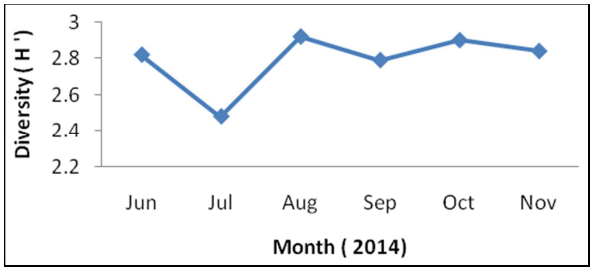

Figure 11. *Diversity of Avifauna in Sothuparai Reservoir.*

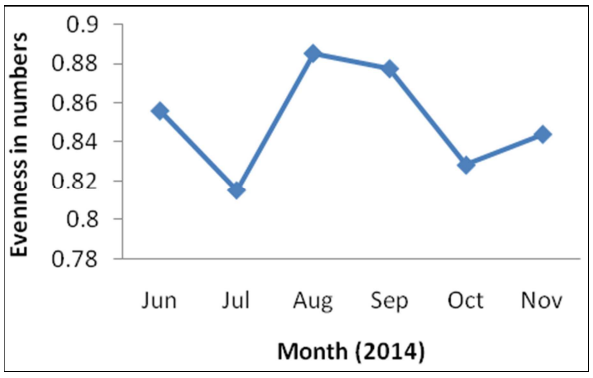

Figure 12. *Evenness of Avifauna in Sothuparai Reservoir.*

4. Conclusion

Though there are some of the physico chemical parameters are below the permissible limit, it has not much effect on the organism and the aquatic ecosystem. The iron content in Sothuparai reservoir was much higher than the permissible limit. The water quality parameters of Sothuparai Reservoir clearly visualize the suitability of the water for the aquatic life and proper functioning of the ecosystem and for the welfare of human beings. Assessment of the abiotic parameters is vital for analyzing the aquatic ecosystems. The homeostatic of a healthy reservoir was determined by the physico-chemical characteristic of the freshwater which intern assess the diversity of aquatic insect and bird communities. Thus the present investigation describes that the bio-monitoring of the Reservoir using bio-indicators (aquatic insects and birds) in the reservoir is an effective tool for the better management of the Sothuparai Reservoir.

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