# Angiosperm Diversity and Physico-Chemical characteristic of Ramgarh wetland of Gorakhpur District, Uttarpradesh, India


## ABSTRACT

The present investigation concerns the seasonal change of angiosperm diversity and physico-chemical characteristic of water and soil in Ramgarh wetland, Gorakhpur, Uttar Pradesh, India. In this region, the wetlands are commonly called as 'Tals' or 'Pokharas' i.e. a true natural wetlands. The prominent wetlands of the district include Ramgarh Tal, Chilua Tal, Mahesra Tal etc. This investigation also encompass with the economic prospect of wetland associated angiosperm. Diversity indices of 48 plant species and the regulatory effects of the 10 physico-chemical parameters of water and soil on the plant diversity were assessed. The angiosperm diversity, richness and evenness were high in monsoon but the dominancy was high in the months of mid summer and mid winter because very few species tolerate that adverse condition i.e., high cold and high hot condition. Due to seasonal variation of angiosperm diversity and physico-chemical parameters of soil and water it was revealed that the wetland plants diversity were changed with the seasonal i.e. premonsoon, monsoon and postmonsoon changes of physico-chemical parameters.


KEY WORDS: Diversity, physico-chemical characteristics, Ramgarh Wetland , tal , Pokharas , Monsoon , Diversity indices.

## INRODUCTION

Wetlands are "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is covered by shallow water" (Cowardin et al, 1979). This includes three attributes that help to delineate a wetland: (i) the area must be permanently or periodically inundated or water must be present for at least seven successive days during the growing season, (ii) the area must support hydrophytic vegetation and (iii) the substrate is predominantly hydric soils that are saturated or flooded for a sufficiently long period to become anaerobic in their upper layers. From the utilitarian point, wetlands can be defined as transitional areas between permanently flooded deepwater environments and well drained uplands that contribute a wide array of biological, social and economic benefits

(Watzin and Gozzelink, 1992). Wetlands support a wide array of flora and fauna and deliver many ecological, climatic and societal functions. Scientists often refer to wetlands as the "kidneys" of the earth and forests as the "lungs" of the earth.

Since the wetland is considered a transitional area between land and water (Smith,1980) aptly described it as a half-way world between terrestrial and aquatic ecosystems. It is largely dominated by water and has special type of flora and fauna, which usually undergo time scheduled characteristic changes from hydric to mesic types. Wetlands are well known for high diversity in class, composition and four broad categories of functions *viz.* physical/ hydrological, chemical, biological and socioeconomic (Williams,1990). Wetland supports plant species intermediate between true aquatic and terrestrial habitats (Banerjee & Venu, 1994). The work on hydrophytes of Bangladesh by Khan & Mahbuba (1987) and Srilanka by De Thabrew (1983) are also very important particularly in Indian subcontinent since no less than 500 aquatic species of flowering plants occurring Indian subcontinent, which is about half of the world's known aquatic angiosperms and the number of endemic species (13%) is very high being second to South America. Cook's work (1996) on vascular plants found in the permanent and seasonal fresh water wetlands in the subcontinent of India is noteworthy. According to Mitsch & Gosselink (1986) wetlands support vegetation adapted to the wet conditions (hydrophytes) and conversely is characterized by an absence of flood intolerant vegetation. Wetland also harbour plants with extremely modified morphology, physiology and biochemistry, often endemic to wet sites and tolerant to some degree of soil anoxia (Bhagat, 1992). Several abiotic factors affect the occurrence and growth of macrophytes, such as water quality (Mathew *et al*., 2002), sediment properties (Kim *et al*., 2001), temperature and fluctuations in water levels (Ellery *et al*., 2003).An account of hydrophytic plants of India was published by Biswas and Calder (1937), Subramanyam (1962), Deb (1976) and Islam (1989). Recently Cook (1996) published a volume on aquatic and wetland plants of India.In Uttar Pradesh Sen and Chatterjee (1959), Trivedi and Sharma (1965), Sahai and Singh (1968),Singh and Singh(1972), Singh and Tomar(1983), Srivastava et.al.(1987), Singh and Singh (1991), Maliya and Singh(2004) and Singh (2006) have described aquatic flora of some districts. Still large areas remain unexplored.On the other hand the dynamics of organic matter in wetland sediments, closely related to biogeo- chemical cycles of nitrogen and phosphorous (Prusty *et al*., 2009). Organic Matter in Sediment, total nitrogen and their ratios are important in influencing the productivity of wetlands (Mitsch & Gosselink, 2000; Bai *et al*., 2005). Organic matter is also a sensible indicator of climate, changes with respect to time and ambient climatic conditions (Bai *et al*., 2005). Thus researches on wetland

macrophytes have started gaining importance not only because systematic stock taking of biodiversity is presently given top most priority but also because these plants have implications with functional values of wetlands. In addition to stock taking and assessment of ecological functions of different forms wetlands, biodiversity pattern is studied emphatically. Vegetation pattern are likely to control major aspects of wetlands biogeochemistry and tropic dynamics and wetlands should be viewed as complex mosaics of habitats with distinct structural and functional characteristics (Rose & Crompton, 1996). So, the present investigation was carried out to explore the seasonal change of angiosperm diversity pattern with physico-chemical properties and nutrient status of water and soil.

## MATERIALS AND METHODS

### STUDY AREA

District Gorakhpur geographically situated in the north-east "Tarai" region of U.P. , India and lies between 26.5º-27.9º N and 83.4º- 84.26º E at an altitude of 95metre above sea level. There are many temporary and residential water bodies of varying size in this region. The study area Ramgarh wetland is a large,shallow, perennial eutrophic lake situated at 26º 44' 9" N, and83º 24' 16" E eastern side of the Gorakhpur town. The area falls with in the region of the monsoon climate and is very rich in wetlands which are locally called as "Tal" It covers an area of about 20 $km^2$ during summer and 30 $km^2$ in the monsoon period.

***A. Measurement of macrophytes diversity***

In the present investigation Ramgarh wetland surveyed twice a year, viz., April-June and November –January and plant sample have been collected from more than 20 randomly choosen sites in different season. During the survey ,plants occurring in different water saturated areas are collected, photographed,and identified. Collected plant samples divided into two part, one part utilised for preparation of herbarium and other part was used to grow certain rare and interesting plants under artificial condition .Prepared herbarium preserved in Botany Department of D.P.S Degree College,Barabanki,U.P. Collected plants later identified with the help of herbarium and consultation with experts. For laying 20 quadrates ($1\times1$ $m^2$) specific sites were selected. Different diversity indices were determined on the basis of individual species observed in the quadrats lay.

***B. Collection and Analysis of Water Sample***

Water samples were collected in air tight PVC bottles. The pH and conductivity were measured by pH and conductivity meters respectively and the others parameters such as

dissolve oxygen (DO), Biological Oxygen Demand (BOD) and dissolve $CO^2$ were tested by following standard methods of American Public Health Association (APHA, 1992), Jadav and Jogdan (1993) Central Pollution Control Board (CPCB, 1978), Tribedi and Goel (1992).

***C. Collection and Analysis of Soil Sample***

Soil samples were collected from surface layers (top 6″) of study sites. 5 samples of soil were collected. All the samples from each sites of wetland, were preserved in a polythene bag and labeled. About 500mg of composite sample was spread over a paper placed on polythene sheet for air drying. Then the samples were ground into fine powder by gently pressing them with mallet. The samples were then strained through 2mm sieve and again air dried. Then the analyses of Organic carbon (OC), Nitrate nitrogen ($NO_3N$) and Phosphate phosphorous ($PO_4P$) were done with the air-dried samples by following standard methods of APHA, 1992. Black 1965: Piper, 1950: and Jadav and Jogdan 1993.

***D. Statistical Analysis***

The statistical analysis like measurement of Margalef's index, Simpson's index, Shannon's index and Pielou's index were done using DINDEX VER 4.0 software.

## RESULT AND DISCUSSION

Rio Earth Summit held in 1992 emphasized the need to conserve the biodiversity of the earth, especially of the tropics. The meaning of conservation involves thorough understanding of the flora and fauna on regional basis including those of wetland as they form the bulk of the wetland flora and have immense functional values (Brix, 1997), the present work keeps its taxonomic account confined to them. As many as 115 species of angiosperm belonging to 87 genera of 43 families that are associated with this wetland have been taken into account in this work (Table 1). In the floristic composition of this wetland angiosperms have participation in form of 72 species of 55 genera belonging to 31 families of dicot and 43 species of 32 genera representing 12 families of monocot. The ratio of monocot and dicot in terms of species is 1:1.67 , in respect of genera is 1:1.71 and in relation of to families is 1:2.58, thus indicating the major share of the dicot.

**Table-1**

**Statistical analysis of aquatic angiosperm plants of Ramgarh wetland .**

| Taxa | Monocots | | Dicots | | Total |
|---|---|---|---|---|---|
| | No. | % | No. | % | |
| **Family** | 12 | 27.90 | 31 | 72.09 | 43 |
| **Genera** | 32 | 37.64 | 55 | 64.70 | 85 |
| **Species** | 43 | 37.39 | 72 | 62.60 | 115 |

Altogether 115 species belonging to 43 families were recorded from study area. Out of them Poaceae turned out as dominant family having 15 species followed by Cyperaceae with 13 species , Asteraceae with 10 species, Scrophulariaceae with 5 species, Polygonaceae with 5 species and Acanthaceae with 4 species aloso have highest species diversity, however many of their species are not restricted only to wetland but to nearlymoist soil also . Out of the total observed species ,78 species were recorded as wetland hydrophytes(WL), 16 species as Emergent amphibious hydrophytes (EA),5 species as free floating (FF) and submerged anchored (SA),6 species as floating leaf anchored (FLA),2 species as submerged hydrophytes (SH), and 1 species as floating shoot anchored hydrophytes(FSA).

**Table-2**

**Name of aquatic angiosperm plants of Ramgarh wetland of Gorakhpur**

| S.No. | Family | Name of Plant | Flowering Period | Habit |
|---|---|---|---|---|
| 1. | Ranunculaceae | *Ranunculus sceleratus* L. | Jan-June | WL |
| | | *R.aquatilis* L. | Jan-April | WL |
| 2. | Nymphaeaceae | *Nymphaea nouchali* Burm.f. | Aug-Nov | FLA |
| | | *N.pubescens* Willd. | Aug-Nov | FLA |
| 3. | Nelumbonaceae | *Nelumbo nucifera* Gaertn. | Aug-Oct | FLA |
| 4. | Brassicaceae | *Rorippa islandica* (Qeder)Bor. | Sept-Nov | WL |
| 5. | Elatinaceae | *Bergia ammannioides* Roxb. | Sept-Nov | EA |
| 6. | Sterculiaceae | *Melochia corchorifolia* L. | Aug-Dec | WL |
| 7. | Tiliaceae | *Corchorus capsularis* L. | Sept-Nov | WL |
| | | *C.aestuens* L. | Sept-Jan | WL |
| 8. | Oxalidaceae | *Oxalis corniculata* L. | Jan-Dec | WL |
| | | *O.Corymbosa* DC. | April-June | WL |

| | | | | |
|---|---|---|---|---|
| 9. | Fabaceae | *Aeschymomene spera* L. | Oct-Nov | EA |
| | | *A.indica* L. | Oct-Nov | EA |
| | | *Sesbania procambens* Wright et Arnott. | Feb-April | WL |
| 10. | Mimosaceae | *Neptunia oleracea* Lour. | Sept-April | FF |
| 11. | Rosaceae | *Potentiella supine* L. | Jan-April | EA |
| 12. | Lythraceae | *Ammania auriculata* Willd. | Nov-Feb | EA |
| | | *A.baccifera* L. | Nov-April | EA |
| | | *A.multiflora* Roxb. | Nov-Feb | EA |
| | | *Ratala indica* Willd. | Jul-Nov | WL |
| 13. | Onagraceae | *Ludwigia adscendens* L. | Jan-June | FSA |
| | | *L..octavalis* (Jacq.) Raven | Nov-Jan | EA |
| | | *L.Perennis* L. | Nov-Jan | EA |
| 14. | Trapaceae | *Trapa natans* L. | Sept-Oct | FF |
| 15. | Molluginaceae | *Glinus lotoides* L. | Throughout year | WL |
| | | *Molluga pentaphylla* L. | Sept-Oct | WL |
| 16. | Apiaceae | *Centella asiatica* L. | Nov-Jan | WL |
| | | *Seseli diffusum* Roxb. | April-June | WL |
| 17. | Rubiaceae | *Dentella repens* L. | Throughout year | WL |
| | | *Oldenlandia corymbosa* L. | Sept-March | WL |
| | | *O.pumila* (L.f) DC | Dec-Feb | WL |
| 18. | Asteraceae | *Adenostema lavenia* (L.)Kuntze. | Dec-Aug | WL |
| | | *Caesulia axillaris* Roxb. | Sept-March | WL |
| | | *Centipeda minima* (L.)Br.&Asch. | Nov-March | WL |
| | | *Eclipta prostrate*(L.)L. | Throughout year | WL |
| | | *Enhydra fluctuans* Lour. | Jan-March | WL |
| | | *Ganphalium indicum* L. | March-Nov | WL |
| | | *G. pulvinatum* Delile. | Nov-April | WL |
| | | *Pluchea labceolata* (DC.) C.B.Clarke | Feb-June | WL |

| | | | | |
|---|---|---|---|---|
| | | *Sphaeranthus indicus* L. | Dec-April | WL |
| | | *Spilanthes paniculata* Wallich ex DC. | March-April | WL |
| 19. | Sphenocleaceae | *Sphenoclea zeylanica* (G.) | Aug-Nov | EA |
| 20. | Primulaceae | *Anagalis arvensis* L. | Dec-March | EA |
| 21. | Gentinaceae | *Centaurium centaurioides* Roxb. | Feb-April | EA |
| | | *Canscora diffusa* (Vahl.) R.Br. | Sept-March | FF |
| | | *Hoppea dichotoma* Willd. | Sept-Jan | EA |
| 22. | Menyanthaceae | *Nymphoides hydrophylla* (Lour.) Kuntze. | July-Nov | FLA |
| | | *N.indica* (L.)Kuntze. | Aug-Nov | FLA |
| 23. | Hydrophyllaceae | *Hydrolea zeylanica* (L.) Vahl. | Sept-Nov | EA |
| 24. | Convolvulaceae | *Ipomoea aqutica* (Forssk) | Sept-Feb | FSA |
| | | *I.cornea* Jacq. | Throughout year | WL |
| 25. | Scrophulariaceae | *Bacopa monnieri* (L.) Wettst. | July-Dec | WL |
| | | *Limnophila indica* (L.) Druce | Sept-Feb | WL |
| | | *Lindernia anagallis* (Burn.f.) Pennell | Aug-June | WL |
| | | *Majus pumilus* (Burn.f.) Steenis | Nov-April | WL |
| | | *Veronica anagallis-aqutica* L. | Jan-April | WL |
| 26. | Lentibulariaceae | *Utricularia stellaris* L.f. | Dec-March | SH |
| 27. | Acanthaceae | *Hygrophila auriculata* (Schum.) Heine | Oct-Jan | WL |
| | | *H.polysperma* (Roxb.)T.Anderson | Oct-April | WL |
| | | *Justicia quinqueangularis* Koening ex Roxb. | Aug-April | WL |
| | | *Rungia repens* (L.)Nees | Oct-Feb | WL |
| 28. | Verbenaceae | *Phyla nodilfora* (L.)E Greena | Throughout year | WL |
| 29. | Amaranthaceae | *Alternanthera sessilis* (L.) R.Br.ex DC. | Throughout year | WL |
| | | *Amaranthus virides* L. | March-June | WL |
| | | *Celosia argentea* L. | Aug-Dec | WL |
| 30. | Polygonaceae | *Polygonum barbatum* L. | Aug-April | WL |
| | | *P.glabrum* Willd. | Aug-April | WL |

| | | | | |
|---|---|---|---|---|
| | | *P.lanigerum* R.Br. | Aug-April | WL |
| | | *P.hydropiper* L. | Aug-April | WL |
| | | *Rumex dentatus* L. | Jan-June | WL |
| 31. | Ceratophyllaceae | *Ceratophyllum demersum* L. | Oct-Feb | SH |
| 32. | Hydrocharitaceae | *Hydrila verticillata* (L.f) Royle | Dec-April | SA |
| | | *Vallisnaria spiralis* L. | Dec-April | SA |
| 33. | Pontederiaceae | *Eicchornia crassipes* (Mart.) Solms | April-Nov | FF |
| 34. | Commelinaceae | *Commelina benghalensis* L. | July-Nov | WL |
| | | *C.erecta* L. | July-Nov | WL |
| | | *C.longifolia* Lam. | Aug-Nov | WL |
| 35. | Typhaceae | *Typha angustifolia* L. | Oct-April | WL |
| 36. | Araceae | *Acorus calmus* L. | July-Nov | WL |
| | | *Colocasia eesculenta* L. | July-Nov | WL |
| 37. | Alismataceae | *Sagittaria trifolia* L. | Dec-May | EA |
| 38. | Najadaceae | *Najas indica* (Willd.) Cham. | Aug-Oct | SA |
| 39. | Aponogetonaceae | *Aponogeton natans* L.Engl.&Krause | Aug-Nov | FLA |
| 40. | Potamogetonaceae | *Potomogeton crispus* L. | Jan-April | SA |
| | | *P.pectinatus* L. | Nov-April | SA |
| 41. | Eriocaulaceae | *Eriocaulon cinereum* R.Br. | Aug-Nov | EA |
| 42. | Cyperaceae | *Bulbostylis dense* (Wall.) Hand. | Jul-Dec | WL |
| | | *Carex fedia* Nees | Feb-April | WL |
| | | *Cyperus difformis* L. | July –April | WL |
| | | *C.esculentus* L. | July-April | WL |
| | | *C.iria* L. | Aug-Feb | WL |
| | | *C.niveus* Retz. | Aug-Dec | WL |
| | | *C.pilosus* Vahl. | July-March | WL |
| | | *C.procerus* Rottb. | Sept-Dec | WL |
| | | *C.pumilus* L. | Aug-Nov | WL |

| | | | | |
|---|---|---|---|---|
| | | *C.ritundus* L. | July-April | WL |
| | | *Eleocharis acutangula* (Roxb.) Schutt. | Aug-Oct | WL |
| | | *Fimbristylis ovate* (Burm.f.) Kern | Aug-May | WL |
| | | *Scirpus articulates* L. | Oct-Dec | WL |
| 43. | Poaceae | *Arundo donax* L. | Sept-Feb | WL |
| | | *Brachiaria ramose* L.Stapf. | June-Oct | WL |
| | | *Coix lachrymal-jobi* L. | Sept-Feb | WL |
| | | *Cymbopogon citrates* Stapf. | Sept-Feb | WL |
| | | *Echinochloa colonum* (L.)Link | Aug-April | WL |
| | | *E.crusgalli* (L.) P.Beauv | Aug-Nov | WL |
| | | *Eleusine indica* (L.) Gaertn. | Dec-Feb | WL |
| | | *Eragrostis gangatica* (Roxb.) Steud. | Sept-Nov | WL |
| | | *Hygroryza aristata* (Retz.)Nees ex Wight &Arnott | Oct-Dec | WL |
| | | *Imperata cylindrical* (L.)Raeu. | Aug-Dec | WL |
| | | *Oryza rufipogon* Griff | Sept-Nov | WL |
| | | *Paspalum vaginatum* Swartz | Aug- Nov | WL |
| | | *Phragmites vallatoria* (Plunk. ex L.) | Sept-July | WL |
| | | *Vetiveria zizanioides* (L.)Nash | Aug-Nov | WL |



The seasonal variation of different diversity indices of plant species in Ramgarh wetland have been studied and find out that the species richness index was more or less same through out the year. The highest richness of wetland plants were shown in July followed by May and June that means in the intermediate time of premonsoon and monsoon the species richness was highest and lowest in October and November at the time of winter. The Simpson's dominance index was highest in January followed by March, February and November that is in mid winter only few species were dominated. It

was because of the Ramgarh wetland, Gorakhpur is the portion of tarai region and for this the environmental temperature of Gorakhpur was low in winter. On the other hand the Shannon's general diversity index was high in mainly monsoon season (June to September) followed by pre monsoon (February to May).Similarly the pielou's evenness index was shows at the mid monsoon time (June to September) the macrophytes were highly evenly distributed (Table 3).

**Table-3**

**Seasonal variation of different indices of plant species in Ramgarh wetland**

| Months | Margalef's Richness Index ($R_1$) | Simpson's Index (Lambda) | Shannon's Index (H') | Pielou's Evenness Index |
|---|---|---|---|---|
| **JAN** | 5.123634 | 3.561239 | 2.234332 | 0.661256 |
| **FEB** | 5.134515 | 3.355021 | 2.291232 | 0.674321 |
| **MAR** | 5.105916 | 3.380239 | 2.283622 | 0.672372 |
| **APR** | 5.095002 | 3.328219 | 2.287788 | 0.673249 |
| **MAY** | 5.184559 | 3.342239 | 2.293043 | 0.678832 |
| **JUN** | 5.135112 | 3.227229 | 2.313009 | 0.682955 |
| **JULY** | 5.236354 | 3.268286 | 2.319123 | 0.684042 |
| **AUG** | 5.124640 | 3.323898 | 2.292143 | 0.681823 |
| **SEPT** | 5.106018 | 3.187298 | 2.318029 | 0.683102 |
| **OCT** | 5.071254 | 3.223123 | 2.302341 | 0.679323 |
| **NOV** | 5.082427 | 3.358271 | 2.273373 | 0.672313 |
| **DEC** | 5.098289 | 3.343237 | 2.273918 | 0.672829 |

The present investigation also carried out to explore seasonal variation in physio-chemical properties and nutrient status of water and soil. In the study site four physio-chemical parameters of water i.e. water pH (WpH), dissolve oxygen (DO), biological oxygen demand (BOD) and dissolve carbon dioxide ($CO_2$) and six physic-chemical parameters of soil i.e. soil pH (SpH), Specific conductance (SCON), nitrate-nitrogen ($SN_2$), phosphate ($SPO_4$), organic carbon (SOC) and carbon-nitrogen ratio (C/N) were determined **(**Table 4).

**Table-4**

**Seasonal variation of physico-chemical characters of water and soil in Ramgarh wetland**

| Parameter | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WpH** | 7.16 | 8.15 | 8.27 | 8.48 | 8.10 | 6.50 | 6.56 | 7.10 | 7.25 | 6.74 | 6.81 | 7.23 |
| **DO(mg/lit)** | 8.19 | 11.19 | 12.33 | 13.27 | 13.15 | 7.57 | 8.27 | 7.19 | 8.59 | 9.31 | 8.49 | 7.17 |
| **BOD(mg/lit)** | 6.85 | 9.85 | 10.9 | 11.99 | 11.53 | 6.83 | 6.99 | 7.46 | 6.85 | 7.93 | 6.90 | 6.14 |
| **$CO_2$(mg/lit)** | 10.9 | 29.98 | 31.02 | 33.9 | 28.86 | 9.5 | 10.0 | 10.16 | 8.3 | 9.2 | 10.9 | 8.3 |
| **SpH** | 6.59 | 6.42 | 6.48 | 6.62 | 6.38 | 6.27 | 6.32 | 6.37 | 6.48 | 6.43 | 6.51 | 6.52 |
| **SCON (u.mhos.cm)** | 227 | 212 | 207 | 219 | 212.5 | 178 | 186 | 184 | 187 | 225 | 214 | 220 |
| **$SN_2$(g/kg)** | 2.75 | 2.17 | 2.27 | 2.22 | 2.29 | 1.76 | 1.92 | 1.89 | 1.85 | 2.55 | 2.65 | 2.56 |
| **$SPO_4$(g/kg)** | 0.95 | 1.46 | 1.62 | 1.66 | 1.23 | 1.11 | 0.95 | 0.84 | 0.87 | 0.78 | 0.82 | 0.69 |
| **SOC(%)** | 2.8 | 2.6 | 2.8 | 2.85 | 2.87 | 2.92 | 2.99 | 3.02 | 3.16 | 3.5 | 3.65 | 3.30 |
| **C/N** | 1.16 | 1.38 | 1.41 | 1.46 | 1.43 | 1.76 | 1.75 | 1.91 | 1.90 | 1.51 | 1.51 | 1.43 |

[Water pH **(WpH),** Dissolve oxygen **(DO),** biological oxygen demand **(BOD)** and dissolve carbon dioxide **($CO_2$)** and six physico-chemical parameters of soil i.e. soil pH **(SpH),** Specific conductance **(SCON),** nitrate-nitrogen **(SN2),** phosphate **($SPO_4$),** organic carbon **(SOC)** and carbon-nitrogen ratio **(C/N).**]

In the present investigation from the study site four physico-chemical parameters of water i.e. water pH (WpH), dissolve oxygen (DO), biological oxygen demand (BOD) and dissolve carbon dioxide (CO2) and six physicochemical parameters of soil i.e. soil pH (SpH), Specific conductance (SCON), nitrate-nitrogen (SN2), phosphate (SPO4), organic carbon (SOC) and carbon-nitrogen ratio (C/N) were considered**(**Table-4). The water pH was high in during summer time and low in monsoon season due to heavy rainfall. As from February the solar radiation slowly increasedthe photosynthesis rate and decomposition rate also increased and for that the dissolve oxygen and carbon dioxide also increased up to the month of June. Increased of photosynthesis rate increased primary productivity added with respiration rate and decomposition rate increased the BOD value high in pre monsoon season. The soil pH slightly differs throughout the year and specific conduction was high in October to January and low in June to September. The soil phosphate, nitrate-nitrogen and organic carbon mainly varied with the loading rate from municipal drainage, automobile washing water, monsoon runoff and adding of food and fertilizer for pisciculture. The nitrate-nitrogen and organic carbon load throughout the year more of less not to much differ, but due to decrease of water level in summer and increase of municipal loading the phosphate concentration was high in February to June. The carbon-nitrogen ratio was highest during late monsoon i.e. August- September.

**Tree Diagram for 12 Variables Single Linkage Euclidean distances (Figure-1)**

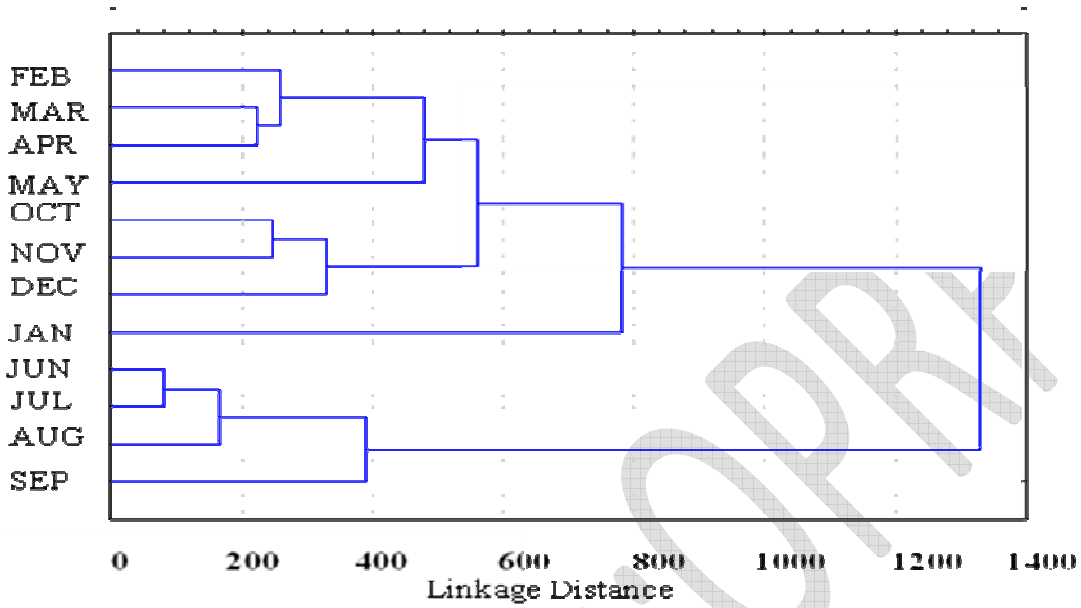


**Figure 1. Hierarchical cluster analysis of the months under study of Ramgarh wetland depending on the total number of plant species present in quadrat study.**

The single linkage euclidian distance graph **(Figure1)** significantly shown that angiosperm diversity is much more similar in February – May that is pre-monsoon season and this type of relation also observed in June-September that is Monsoon season and October –January that is post-monsoon seasons and on the other hand the obtained single linkage eucladian distance graph **(Figure2)** of physico-chemical parameter of water and soil shows exact same pattern of similarity as like as angiosperm diversity graph. That means the angiosperm diversity of Ramgarh wetland change along with the changes of physico-chemical parameters of water and soil of that wetland.

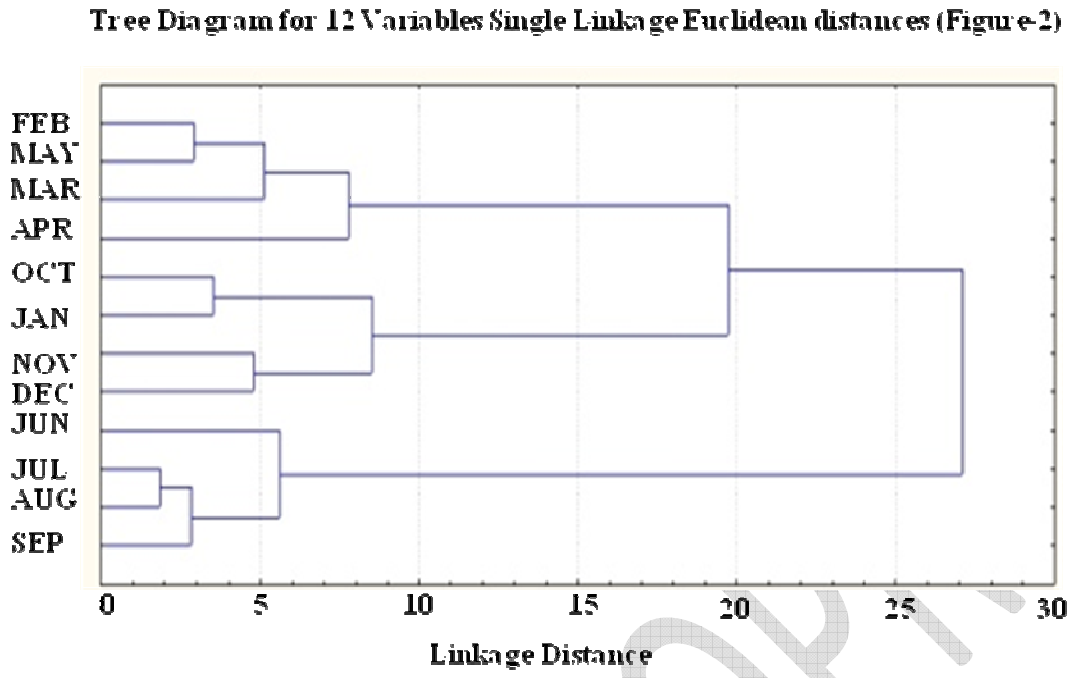


**Figure 2. Hierarchical cluster analysis of the months under study of Ramgarh wetland depending physic-chemical parameter of waterand soils.**

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**Good study but take care of the comments and revive the paper as such**

**You have confined the study from taxonomy point of view so I think it will be much more distinct if you highlight the photographs of the plant species found in that area.**