Biodiversity is the variability among living organisms from all resources including inter alia, terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part; this includes diversity within species, between species and of ecosystem. However, continuously extinction of species is taking place, which is a natural phenomenon. About 440 million years ago by the end of Ordovician; during first extinction, about 85% of species were wiped out. During second extinction (about 365 million years ago during late Devonian) marine species were particularly hard hit in extinction. The largest mass extinction took place about 251 million years ago (end of Permian) with an estimated extinction of 96% of all the species. During 4\textsuperscript{th} extinction (by the end of Triassic), which took place around 205 million years ago, it is estimated that 76% of all species, mostly marine creatures vanished. About 75 to 80% of all the species disappeared during the 5\textsuperscript{th} extinction (by the end of Cretaceous) which took place around 65 million years back (Arens, and West, 2006; Raup, 1986). These were the natural phases of extinction wherein during every phase a large number of species have became extinct. It has been estimated that since 1950 some 600000 species have disappeared and nearly 40,000 more currently are threatened. This situation has resulted because of human consumption, pollution of natural resources, global warming etc. There are several reports of extinction of species. It is estimated that about 27000 species become extinct every year. (Singh, 2010) This is big blow to the biological diversity that sustains life on the earth. Several aquatic species \textit{viz.} Ipomoea aquatica, Centella asiatica, Hygrophilla auriculata, Bacopa monnieri, Mullugo cerviana, Polygonum plabejum, Enhydra fluctuans, Alternanthera sessiles, A. philoxeroides, Colocasia esculanta, Marsilea minuta have been reported as vanishing species (Mandal and Mukhopadhyay, 2010). The conservation of these species is needed, therefore, a detailed study of plant diversity at different wetlands and the threats it is facing, should be worked out.
Studies on biodiversity are being carried out all over the world. These studies are performed for various purposes. Biodiversity has social, cultural and economic values and has variety of uses. Man depends on plants and animals for food, meat, fire wood, fodder, game etc. Some studies are performed for commercially harvested and marketed products e.g. timber, meat, ivory, medicinal plants etc. Apart from these consumptive uses, there are some non consumptive uses of biodiversity; these include watershed protection, photosynthesis, climate regulation, soil protection etc. These uses speak volumes of interdependence.

The Nathsagar water body at Paithan serves as haven for the migratory birds during winter. These water birds are dependent on aquatic flora and fauna for their food. The birds observed at water reservoir are having different food habits; some are chiefly herbivorous, some chiefly carnivorous and some are omnivorous. All these birds must be getting the food of their preference at the site. It is an established fact that plants are primary producers, which is true for aquatic habitat also. The zooplanktons as well as other aquatic animals are dependent on the aquatic flora. Therefore, the present study of plant diversity at Nathsagar is important, for evaluating the food chain of aquatic and avian fauna.

**Physico-chemical Parameters**

The Physico-chemical Parameters of Nathsagar reservoir are performed by Water Quality Laboratory Level-II, Aurangabad (Water Resources Department, Hydrology Project, Government of Maharashtra). Some of the parameters recorded by them are reviewed in the thesis.

1) **Turbidity:** The substances which are not dissolved in water cause turbidity. Particles of less than $10^{-9}$ m are soluble while the bigger sized particle than this result in turbidity. In natural waters clay, organic matter, phytoplanktons, zooplanktons etc. cause turbidity. Trivedi and Goel (1986) observed that turbidity
in natural water restricts light penetration, which is essential for photosynthetic activity of aquatic plants. During present period of research, turbidity was found maximum during March 2009 and minimum during August 2008 (Plate 3.1, fig. 1)

2) **Temperature**: The parameter of temperature is basically important for its effect on chemistry and biological reactions in organisms present in water. A rise in temperature of waters leads to the speeding up of the chemical reactions in water, reduces the solubility of gases and amplifies the test and odors. Water in the temperature range of 7 to 11°C has a pleasant test and is refreshing. Organisms in water have varying sensitivity to temperature. Temperature is also very important in determination of various parameters such as pH, conductivity etc. (Trivedi and Goel, 1986). During the present period of study, the water temperature of Nathsagar ranged between 25.2°C to 31.8°C (plate 3.1, fig.2). Fluctuations in water temperature at Chilika lake from 24°C to 32°C have been reported by Rath and Adhikari (2005). Gore and Pingle (2007) reported varying temperature of 20°C to 29°C in Ujani dam water. Naiknavare and Lomte (2009) reported 32°C as maximum and 27°C as minimum temperature of Bindusara river at Beed. Nanware et al., (2010) observed temperature of Godavari river ranging from 26°C to 36.2°C. They have stated that increase in temperature of water during summer might have resulted in decreased dissolved oxygen level.

3) **Total dissolved solids** (T.D.S.): T.D.S. denotes mainly various kinds of minerals present in water. However, if some organic substances are also present, as more often in polluted waters, they may also contribute to the dissolved solids. In natural waters, dissolved solids are composed of mainly carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of Ca, Mg, Na, K, Fe, Mn etc. Concentration of dissolved solids is an important parameter in drinking water and other water quality standards. Plants are adversely affected by the higher contents of solids in irrigation water, which increase the salinity of the soil. (Trivedi and Goel, 1986). During present investigation period, the total dissolved
solids ranged between 182.5 mg/L to 405 mg/L (plate 3.2, fig.1). Jain (2002) observed average value of T.D.S. as 78.41, 218.74 and 352.08 mg/L at three different locations of Sonwad dam. This clearly indicates that the T.D.S. values varying from place to place in the same water body. Sonawane and Saler (2010) reported that T.D.S. in Dhabadi reservoir was within the range prescribed by B.I.S., W.H.O. and I.S.I for drinking water.

4) **pH:** Most of the natural waters are generally alkaline due to presence of sufficient quantities of carbonates. pH of water gets drastically changed with time due to exposure to air, biological activity and temperature changes. In natural waters, pH also change diurnally and seasonally due to variations in photosynthetic activity which increases the pH due to consumption of CO$_2$ in the processes (Trivedi and Goel, 1980). During the period of present research, pH of the water body was 8.05 and minimum as 7.45 (Plate 3.2, fig 2). Gore and Pingle (2007) reported that pH of backwater of Ujani dam ranged from 8.44 to 8.86. Promotion of the growth of algae at higher pH values has been observed by George (1961). Kant and Kachroo (1971) and Kumawat and Jawale (2003) opined that correlation exist between pH and algal flora.

5) **Sodium:** It is one of the important cation occurring naturally. The concentration in natural fresh waters is generally lower than Ca and Mg. In natural waters, the major source of sodium is withering of various rocks (Trivedi and Goel, 1986). During the period of present research, value of sodium was found varying between 16.5 to 59.5 mg/L (plate 3.3, fig.1).

6) **Dissolved Oxygen (D.O.):** D.O. is one of the most important parameter in water quality assessment and reflex the physical and biological processes prevailing in the waters. Its presence is essential to maintain the higher forms of biological life in the water. Non polluted surface waters are normally saturated with D.O. Low oxygen in water can kill fish and other organisms present in water.
Low oxygen concentrations are generally associated with heavy contamination by organic matter (Trivedi and Goel, 1986). During the year 2009, D.O. was maximum (7.7 mg / L) during January 2009 and minimum in March 2009 (6.3 mg / L) (Plate 3.3, fig. 2). At Sonwad dam, Jain (2002) has recorded D.O. as 6.01, 6.08 and 6.18 mg / L at three different locations. The growth of Chlorophyceae and Bacillariophyceae favoured by D.O. (Udash, 1996) and also of Cyanophyceae (Jain, 2002). Rise in phytoplankton population associated with higher value of oxygen has been reported by Bharathi and Ramanibai (2002). Rath and Adhikari (2005) observed that Chilika lake is usually well oxygenated almost throughout the year, as seen by the very high productivity of the ecosystem. Karne et al., (2008) are of the opinion that D.O. influence habitat of an aquatic ecosystem. Pailwan et al., (2008) correlated submerged vegetation and high plankton diversity with high D.O. Nanware et al., (2010), while working with Godavari river water at Nanded, observed that D.O. was maximum in December and minimum in May.

7) **Chemical Oxygen Demand (C.O.D.):** The C.O.D. test indicates weather or not the waste is degradable biologically and nor does it indicate the rate which biological oxygen could proceed (Trivedi and Goel, 1986). During present investigation period, C.O.D. was maximum in July 2008 (29 mg / L) and minimum in March 2009 (20 mg / L) (Plate 3.4, fig.1). In a fish pond, Kumawat and Jawale (2003) observed the range of C.O.D. between 128 to 200 mg / L.

8) **Carbonate:** Alkalinity of water is recorded in terms of carbonate and bicarbonate also. During the period of study, the presence of carbonate was ranging between 0.94 to 1.25 mg / L (Plate 3.4, fig. 2). Kumar (2010) observed season’s fluctuation of carbonate between 8 to 27 mg / L.

9) **Biochemical oxygen Demand (B.O.D.):** B.O.D. is amount of oxygen utilised by micro organisms in stabilizing the organic matter. On an average, the demand of oxygen is proportional to the amount of organic waste to be degraded.
aerobically. The B.O.D. value can be used as a measure of waste strength (Trivedi and Goel 1986). During present investigation the B.O.D. was found varying between 1.55 to 2.25 mg/L (Plate 3.5, fig. 1). In Ujani dam water Gore and Pingle (2007) observed variation in B.O.D. as 6.1 to 14.5 mg/L. Karne et al., (2008) found variation in B.O.D. during pre and post monsoon season in fresh water bodies of Satara district. They stated that the permissible limit of B.O.D. for natural water is up to 3 mg/L. Naiknaware and Lomte (2009) observed B.O.D. value 5 to 11 ppm in Bindusara river, indicating pollution in the water.

10) **Total alkilinity:** Alkalinity of the water is its capacity to neutralize a strong acid. Most of the alkalinity in natural water is formed due to dissolution of CO$_2$ in water. Alkalinity in itself is not harmful to human beings, still water supplies with a less than 100 mg/L are desirable for domestic use. During the year 2008 the total alkalinity of the water reservoir was varying from 82 to 155 mg/CaCO$_3$/L, with an average of 118.5 mg/CaCO$_3$/L (Plate 3.5, fig 2). Jain (2002) observed variation in alkalinity as 253.78 to 446.49 mg/CaCO$_3$/L at different location of Sonwad dam. Gore and Pingle (2007) recorded range in alkalinity as 125 to 142.4 mg/CaCO$_3$/L. Jain (2002) state that the higher alkalinity is indicative of presence of bicarbonates, carbonates and hydroxides in water bodies. Naiknaware and Lomte (2009) observed high alkalinity in Bindusara river water at two locations in Beed and suggested that it was due to domestic and industrial waste materials entering into the river.

The physico-chemical parameters of Nathasagar recorded during the period of study were within the permissible limits.

**Plant Diversity at Nathasagar**
The algae

Comparatively very little work has been done on algal flora of Marathwada. The investigation on algae was initiated by Kamat (1973; 1974). Later the work was continued by his students *viz.* Ashtekar and Sarode (Ashtekar and Kamat 1978, 1979-a, 1979-b, 1980, 1980-a; Sarode and Kamat 1984). They have made collections from places like pools, puddles, tanks, ponds, lakes, dams, streams, rivers, moist rocks, submerged stones, moist and submerged soil, polluted waters etc. Korekar and Papdiwal (2003) have also worked on algal flora from forests of Osmanabad and Latur districts of Maharashtra. Present investigation was carried out at 4 selected sites on the southern bank of Nathsagar. These sites were Sonewadi, Dahiphal, Ramdoh and Pravara sangam (Map 4.2 and 4.3). The plant diversity was studied at these 4 locations of Nathsagar, and is first report of plant diversity at these locations. Sonewadi site is adjacent to the earthen wall of the dam and Pravara Sangam is at the rear end of the water reservoir. The other two spots *viz.* Dahiphal and Ramdoh were inbetween these two locations. The algae were collected from these locations during the years 2008-2011; and they are reported in the present thesis.

The plant diversity at Nathsagar includes algae, pteridophytes and angiosperms. The algal form ranges from unicellular to multicellular, coccoid to filamentous, sometimes branched filamentous; variously coloured, planktonic to benthic, free floating to epipellic, autotrophic forms.

During the present investigation, in all 266 taxa of algae have been recorded belonging to Chloroophyceae (170 spp.) Bacillariophyceae (46 spp.) Cyanophyceae (48 spp.) and Euglenophyceae (2 spp.) (Tables 8.1)

a) Chloroophyceae: During present study, the taxa belonging to class Chlorophyceae were observed at all the 4 selected sites of Nathsagar. In all 170 species belonging to 43 genera were recorded. It is observed from Table 5.7 that
some algal taxa were observed at particular locations only and were absent at other locations. *Onychonema leave* var. *latum* and *Xanthidium sexmamillatum* were observed only at Pravara Sangam; which is rear end of the water body. Some species observed at two locations only eg. *Sorastrum, Crucigenia, Uronema, Geminella, Pithophora, Basicladia, Debarya, Cylindrocystis, Penium, Desmidium, Sphaerozosma, Triploceras,* and *Asterococcus* (Table 5.14). It is also observed (Table 5.14) that certain species of algae were location specific. Maximum number of species were of *Cosmarium* (31spp.) followed by *Spirogyra* (19spp.). The species belonging to these 2 genera were observed at all the locations of the study, during the period of investigation.

In the absence of earlier reports in literature (Kamat, 1973, 1974; Ashtekar, 1978, 1979 - a & b, 1980; Kamble, 2008; Talekar; 2009 and Yadav, 2010), the following 70 green algae appear to be the first record for Marathwada region:

*Chlorococcum infusionum* (Schrank) Meneghini

*Pediastrum sculptatum* G.M.Smith.

*Oocystis ecallocystiformis* Iyengar

*Scenedesmus indicus* Philipose

*Geminella minor* (Naegeli) Heering

*Cladophora fracta* (Dillw.)Kuetzing

*C. fracta* var.*lacustris* (Kuetz.) Brand ex Heering

*C. insignis* (C.A.Ag.) Kuetzing

*Basicladia chelonum* (Collins) Hoffman and Tilden

*Oedogonium cymatosporum* Wittr. Nordst.
O. globosum Nordst.

O. patulum Tiffany

Zygnema khannae Skuja

Z. pectinatum (Vauch.) C.A. Agardh

Z. synadelphum Skuja

Debarya costata Randhawa

Spirogyra borgeana Transeau

S. collinsii (Lewis) Printz

S. crassa Kuetzing var. minispora Prasad and Misra

S. fallax (Hansg.) Wille

S. parvispora Wood

S. pratensis Transeau

S. propria Transeau

S. pulchrifigurata Jao

S. rivularis (Hassal) Rabenhorst

S. spreeiana Rabenhorst

S. stictica (Engl.Bot) Wile

S. weberi Kuetzing

Closterium calosporum Wittr. var. maius W.et. G.S.West.

C. kuetsingii Breb.
C. sigmoideum Lagerh. et. Nordst.

C. cynthia De Not.

Penium spinospermum Josh.

Micrasterias foliacea Bail.

M. mahabuleshwarensis Hobson

M. pinnatifida (Kuetz.) Ralfs.

M. radians Turner

M. zeylanica Fristch

Euastrum ansatum Ralfs var. pyxidatum Delp.

E. bidentatum Nag.

E. coralloides Josh. var. trigibberum Lagerh.

E. elegans (Breb) Kutz.

E. platycerum Reinsch

E. pseudotuddalense Messik

Cosmarium. calcareum Witter.

C. forceps Bruehl et. Biswas

C. obsoletum (Hantzsch) Reinsch. var. sitvense (Gutw.) Krieger

C. polygonum (Naeg.) Arch.

C. pseudoconnatum Nordst.

C. pseudogranatum Nordst var. rotundatum (Krieger.) Messik.
C. radiosum Wolle

C. reniforme (Ralfs) Arch.

C. sexnotatum Gutw.

C. subalatum W. et G.S.West

C. subcrenatum Hantzsch

Arthrodesmus convergens Ehrneb.

A. curvatus Turner f. major Turner

Staurastrum granulosum (Ehrenb.) Ralfs

S. leave Ralfs

S. pachyrhynchum Nordst.

S. sexangulare Lund var. productum Nordst

S. sexcostatum Breb.ex Ralfs var. productum (W.West) G.S.West

S. wildemanii Gutw.

Xanthidium sexmamillatum W and G.S.West

Desmidium baileyi (Ralfs) Nordst. var. baileyi f. tetragonum Nordst.

D. swartzii (Ag.) Ag. ex Ralfs

Onychonema leave Nordst var. latum West et West.

Sphaerozosma excavata Ralfs.

Triploceras gracile Bailey

Asterococcus limneticus G.M.Smith
b) Bacillariophyceae: During the period of present investigation, 46 species belonging to 18 genera of diatoms were observed. Among them Cymbella was represented by maximum number of species (12) followed by species of Amphora (4) and Eunotia (4) (Table 5.18). Lichmophora abbreviata was observed only at site Ramdoh. Species of Cyclotella, Eunotia, Navicula, Diploneis, Pinnularia, Gomphonema, Amphora, Cymbella and Surirella were recorded at all the 4 sites of study area. Remaining taxa were observed either at 2 or 3 sites. Sarode and Kamat (1984) reported all these species (Table 5.18) from this region. However, Lichmophora abbreviata is reported from the southern bank of Nathsagar water reservoir for the first time.

c) Cyanophyceae

48 species belonging to 19 genera of Cyanophyceae were observed during the period of present investigation (Table 5.22). It is noted that species of Oscillatoria were maximum in number (7) followed by species of Chroococcus, Microcystis and Scytonema (5 species each). Plectonema radiosum was recorded only at Sonewadi. However, species of Gloeocapsa, Chroococcus, Microcystis, Aphanocapsa, Merismopedia, Oscillatoria, Spirulina, Lyngbya, Scytonema, Gloeotrichia were recorded at all the 4 sites selected for present study. Other species of blue-green algae were observed either at two or three locations selected for present investigation.

In the absence of earlier reports in literature (Kamat, 1973, 1974; Ashtekar, 1978, 1979 - a & b, 1980; Kamble, 2008; Talekar; 2009 and Yadav, 2010), following 9 blue green algae appear to be the first record for Marathwada region:

Gloeocapsa kuetzingiana Nag.

Microcystis marginata (Menegh.) Kuetz.

Gloeothecce rhodochlamys Skuja
Anabaena subcylindrica Borge

Scytonema arcangelii Born. et Flah.

S. javanicum (Kuetz.) Born. ex Born.et. Flah.

S. ocellatum Lyngbye ex. Born. et Flah var. capitatum Ghose

S. simplex Bharadwaja

Stigonema informe Kuetz ex Born. et Flah

d) Euglenophyceae

Two species of Phacus viz. P. curvicauda and P. pseudoswirnkoi were observed during present investigation, except at Sonewadi site.

In the absence of earlier reports in literature (Kamat, 1973, 1974; Ashtekar, 1978, 1979 - a & b, 1980; Kamble, 2008; Talekar; 2009 and Yadav, 2010), P. pseudoswirnkoi appear to be the first record for Marathwada region:

During the present course of investigation it was noted that maximum numbers of species (188) were recorded at site Dahiphal and minimum (142) at site Pravara Sangam. In all 266 algal taxa were recorded during the years 2008 to 2011. This includes 170 species of Chlorophyceae, 46 of Bacillariophyceae 48 of Cyanophyceae and 2 of Euglenophyceae.

Cyanobacteria

In Bergey`s Manual of Systematic Bacteriology, the prokaryotic domains are divided into two domains – Archaea and Bacteria. Domain Bacteria is subdivided into 23 phyla. In Phylum B X Cyanobacteria - Oxygenic Photosynthetic Bacteria, the members of Cyanophyceae are included. This phylum B X is further divided into 5 sub sections. It is mentioned in the manual that the nomenclature of the taxa
ascribed to this phylum is governed by the Botanical Code of Nomenclature, rather than the Bacteriological Code (Boone and Castenholz, 2001)

**Recent nomenclature**

In “International Code of Botanical Nomenclature” (McNeill 2006) some corrections in the botanical nomenclature have been suggested. In the book corrections regarding the authority of some algal genera have been suggested. As per that it is suggested that the authorities of following algal taxa, observed in present investigation be corrected.

<table>
<thead>
<tr>
<th>New</th>
<th>Old</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Gomphonema</em> Ehrenb.</td>
<td><em>Gomphonema</em> Ag.</td>
</tr>
<tr>
<td><em>Cyclotella</em> (Kutz.) Breb.</td>
<td><em>Cyclotella</em> Kuetz.</td>
</tr>
<tr>
<td><em>Sphaerozosma</em> Ralfs</td>
<td><em>Sphaerozosma</em> Corda</td>
</tr>
<tr>
<td><em>Microcystis</em> Lemmerm</td>
<td><em>Microcystis</em> Kutz.</td>
</tr>
</tbody>
</table>

It is felt that, these corrections suggested by them be made in the forthcoming publications.

**Toxic algae**

Several cases of deaths of animals have been reported form different parts of the world. Rose (1953) has reported a serious outbreak of algal poisoning due to *Anabaena flos-aquae* in Storm lake, Iowa. This caused loss of 5000 to 7000 gills, 560 ducks, 400 coots, 200 pheasants, 50 fox squirrels, 18 muskarats, 15 dogs, 4 cats, 2 hogs, 2 hawks in 1952. Ingram and Prescott (1954) have reported the blue green algae causing death or illness in mammals, birds and fishes through toxic action. Kamat (1982) mentioned *Scenedesmus* spp. *Lyngbya biergi* and *L.*
majuscule as toxic algae. Krishnamurthy et al., (1986) characterized a toxic peptide from fresh water Cyanobacteria viz. *Microcystis aeruginosa* and *Anabaena flos-aquae*. The toxic peptides found to consists of equimolar amounts of glutamic acid, alanin, arginin and leucine. Falconer (1999) reported the toxins of blue green algae included heaptotoxic peptides, a cytotoxic alkaloid, neurotoxic alkaloids and saxitoxin derivitives. Exposure to water containing toxic blue green algae cause illness ranging from acute pnemonia and hepatenteritis to mild skin irritation and gastroenteritis. Pan et al., (2008) have reported occurrence of harmful algal blooms more frequently and extensively among many shallow lakes in China.

As some of the toxic blue green algae viz. *Micocystis flos-aquae*, *Anabaena aeruginosa*, *Scenedesmus* spp., *Lyngbya biergi* have been recorded at certain locations of Nathasagar; it is felt that a continuous monitoring at these locations is essential. These algae should be studied for their toxic effects. Kodarkar et al., (1990) have suggested that control of toxic blue-green algae should be given top priority in the conservation of any water body.

**Biodiesel Production from algae**

Hossain and Salleh (2008) stated that biodiesel is biodegradable, less CO₂ and NOx emissions. Continuous use of petroleum sourced fuels is now widely recognized as unsustainable because of depleting supplies and the contribution of these fuels to the accumulation of carbon dioxide in the environment. Renewable, carbon neutral, transport fuels are necessary for environmental and economic sustainability. Algae have emerged as one of the most promising sources for biodiesel production. It can be inferred that algae grown in CO₂-enriched air can be converted to oily substances. Such an approach can contribute to solve major problems of air pollution resulting from CO₂ evolution and future crisis due to a
shortage of energy sources. In the study they used common species of *Oedogonium* and *Spirogyra* to compare the amount of biodiesel production. Algal oil and biodiesel (ester) production was higher in *Oedogonium* than *Spirogyra* spp. However, biomass (after oil extraction) was higher in *Spirogyra* than *Oedogonium* spp. Sediments (glycerin, water and pigments) was higher in *Spirogyra* than *Oedogonium* spp. There was no difference of pH between *Spirogyra* and *Oedogonium* spp. These results indicate that biodiesel can be produced from both species and *Oedogonium* is better source than *Spirogyra* sp.

All algae primarily comprise of Proteins, Carbohydrates, Fats and Nucleic acids in varying proportions. While the percentages vary with the type of algae, there are algae types that are comprised up to 20% of their overall mass by fatty acids. *Scenedesmus dimorphus, Chlorella vulgaris, Spirogyra* spp., *Euglena gracilis*. It is this fatty acid (oil) that can be extracted and converted into biodiesel. (http://www.castoroil.in)

Talukdar *et al.*, (2008) reviewed biodiesel production from fresh water micro-algae. They have stated that *Botrychoccus braunii* Kuetz. (member of Chlorococcales) is investigated worldwide for biodiesel production. They have also stated that there are some species of Chlorophyceae and Bacillariophyceae having potential for biodiesel production.

**Aquatic Pteriophytes**

2 aquatic pteridophytes *viz. Azolla pinnata* and *Marsilea minuta* were observed on the southern bank of Nathsagar reservoir. This is the first report from the four selected sites of the water reservoir. *Azolla* has been used, for atleast 1000 years in rice, paddies as a companion plant; because of its ability to both, fix nitrogen and block out light to prevent any competition from other plants, aside from rice. An additional benefit is its role in controlling mosquito’s larvae in rice
fields. *Azolla* is rich in proteins, essential amino acids, vitamins and minerals. Studies describe feeding *Azolla* to daily cattle, pigs, ducks and chickens, with reported increases in milk production, weight of broiler chickens and egg production of layers, as compared to conventional feed. (http://en.wikipedia.org/wiki/azolla)

In recent years, the genus *Azolla* has become more and important in waste water treatment to eradicate different metals or to remove nitrogenous compounds from the water (Ghobrial and Siam, 1998, Costa *et al.*, 1999, Allison *et al.*, 2000; Shiny *et al.*, 2004, Gardea *et al.*, 2005). Saini (2005) has reported that the paste of *A. pinnata* is used to treat fungal and bacterial skin diseases. It is also used for manure and bird feed.

*Marsilea minuta* is given for various eye diseases and for increase in eye sight. The ash of the plant is used as tooth powder in the treatment of toothache (Saini, 2005). *M. minuta* plant as a whole is used as sweet, astringent, cooling, digestive, diuretic, hypnotic and expectorant. Treatment for psychopathy, diarrhoea, cough, bronchitis, skin diseases and fever are also reported in Ayurveda (Sivarajan and Balchandran 1994; Warrier *et al.*, 1994; Bhattamisra *et al.*, 2007) have observed anxiolytic activity of *M. minuta* in rodents. The “Marsiline” isolated from *M. minuta* has immense utility and is used in psychopathy, diarrhea, cough, skin diseases, dyspepsia fever and insomnia. (Singh *et al.*, 2010). Some pteridophytes like *Pteris vittata*, *Marsilea minuta*, *Equisetum debile*, *Salvinia molesta*, *Azolla pinnata* have been experimentally determined as a hyper accumulator of carcinogenic heavy metals *viz.* Arcenic, Cadmium, Mercury, Copper and Chromium, respectively (Singh *et al.*, 2010). It is important to note that *M. minuta* is one of the vanishing species (Mandal and Mukhopadhyay, 2010), therefore it needs to be conserved.
Aquatic angiosperms.

During the period of present research 11 aquatic angiosperms, belonging to 10 genera were recorded (Table 7.1). Amongst these, *Potamogeton perfoliatus*, *Typha domingensis*, *Najas minor*, *Hydrilla verticilata* and *Ipomea aquatica* was observed at all the 4 sites of present study. Other plants were recorded either at 2 or 3 locations of study. All these plants have been reported earlier from Marathwada by Naik (1998).

The Food chain of Birds

The waterbody of Jayakwadi Project near town Paithan, called as Nathsagar, and the adjacent Sant Dyaneshwar Udhyan is declared by Government of Maharashtra as Jayakwadi Bird sanctuary. Every year thousands of local and migratory birds of more than 250 species are observed at this water reservoir (Plate 4.3). Yardi (2008) has published a checklist of birds at this bird sanctuary. It can be presumed that the environmental conditions and safeness at the reservoir might be favourable for the birds during the period of their visits. Migratory birds are having different food habits. A large number of birds are chiefly carnivorous, while others like ducks are chiefly herbivorous and like Brown-capped Pygmy woodpecker are chiefly omnivorous. Kamat (1966-b) stated that the ducks feed on the carophytes and it is presumed that these birds help in dispersal of these plants. Kamat (1967-b) observed *Chara corallina*, *C. zeylanica*, *C. brachypus*, *Nitella hyalina*, *Lychnothamnus barbatus*, *Hydrilla* spp., *Najas* spp., and *Vallisneria* spp. at lake Ambazari in Nagpur. He has observed parts of *Chara* plants in the intestinal contents of Pintails (*Anas acuta* L), which are the winter visitors at the lake from central Asia. In the microscopic study of droppings of these birds, he has observed crushed parts of axis, stipulodes, antheredia and oogonia of *Chara* plants. Kamat (1982) has also reported that the bloom of Cyanophyceae provide the major source
of food for the flocks of Flamingoes. Salim Ali (2002) mentioned that majority of ducks are chiefly herbivorous. Birds feeding on aquatic pteridophyte *Azolla pinnata* have been observed by Saini (2005). Rajalakshmi et al., (2007) stated that phytoplanktons mainly consisting of diatoms, green algae, blue green algae and *Euglena* are primary producers in an aquatic ecosystem and are prime component in the food chain.

The present studies carried out during the years 2008-2011, at the 4 sites of the Nathsagar, revealed the presence of 266 taxa of algae, 2 pteridophytes and 11 aquatic angiosperms. Therefore, it can be suggested that the chiefly herbivorous and chiefly omnivorous birds may be dependent on this aquatic vegetation for their food.

Apart from different types of plants, the water reservoir is also having a large fauna, including zooplanktons, some invertebrates and fishes. A list of fishes reported at Nathsagar has been given in table 2.3. These fishes vary in their food habits as herbivorous, omnivorous and carnivorous. During his investigation of algal flora of Kolhapur, Kamat (1962-b) has examined the intestinal contents of the Tadpoles present in the water bodies. He found species of *Spirogyra, Oscillatoria, Oedogonium, Hydrodictyon, Anabaena, Cosmarium, Closterium, Phacus, Euglena* and a large number of diatoms in the intestinal contents. He has further opined that the Tadpoles do not feed on all available algae in the water bodies; as he could not trace species of *Pithophora, Cladophora* and *Chara*, which were common in the ponds he studied. In the microscopic study of the intestinal contents of snail *Planispira nagporensis*, Kamat (1966-b) observed algal species of *Oscillatoria, Pithophora, Aphanothece, Spirogyra, Euglena and Phacus*. Based on this observation, Kamat (1966-b) opined that the snails show no selectivity in its feeding habits and hence the intestinal contents does not give correct idea of its food, as all the algae eaten by the snails are not digested. Kamat (1969) observed the intestinal contents of *Barbus conchonius*, a common fish in streams of Nagpur.
and concluded that a simple analysis of the intestinal gut contents of the fish do not give a correct idea of its food habits.

The herbivorous fishes use the aquatic plants like algae, pteridophytes and angiosperms as their food. Species of algae like Cosmarium, Closterium, Fragillaria, Navicula, Spirogyra, Nitzschia, Anabaena, Oedogonium, Cymbella, Gomphonema, Oscillatoria, Microcystis, Pediastrum, Ankistrodesmus, Scenedesmus, Chara, etc.; pteridophyte like Salvinia and angiosperms like species of Potamogeton, Hydrilla, Vallisneria etc. are used as food by the herbivorous, omnivorous and few carnivorous fishes (Moitra and Das 2002). When the list of fishes consisting aquatic plants as food; given by Moitra and Das (2002) was compared with the list of fishes at Nathasagar (Khedkar, 2005); some herbivorous fishes like Labeo rohita, L. calbasu, Cirrhinus mrigala, omnivorous fishes like Catla-catla, Puntius sarana, Osteobrama catio and carnivorous fish like Mystus spp. were found appearing in both the lists. Accordingly, it can be presumed that the algae, pteridophytes and angiosperms might be serving as food for these fishes. The fishes are used as food by the majority of birds (Salim Ali, 2002). Therefore, it can be stated that the aquatic vegetation may be used by herbivorous and omnivorous birds and fishes. The carnivorous birds use the fishes from the water body for their food.
Based on these studies, it can be suggested that the aquatic flora including algae, pteridophytes and angiosperms present in the Nathsagar water reservoir, may be used as food by the herbivorous and omnivorous birds and fishes. The fishes and other aquatic animals present in the water body might used as foods by the carnivorous migratory birds; during their stay at the bird sanctuary. Furthermore the ecological conditions at the water body must be suitable for the migratory birds for their stay during the winter.

**Food Chain of Migratory Birds at Jaykwadi Birds Sanctuary**

![Food Chain Diagram]

**Uses and threats to wetlands.**

There are some natural and human threats to any wetland. The natural threats include global warming, climate change, shifting of rainfall pattern, droughts, floods, storms, decay of flora and fauna etc.; and the human threats include discharge of pesticides, herbicides, sewage in the water bodies. (http://
www.unepscs.org/wetlands_training/wetlands....). However, in some cases it is difficult to differentiate between a use and threat. Lopez and Mundkar (1997) stated that, in some cases, it is difficult to differentiate between a use and a threat. For example, fishing can be recorded as a use of a wetland, whereas heavy or overfishing can be categorized as a threat to the site and to other forms of wildlife, including birds, that may be disturbed by the fishing activities.

A review of uses and threats to sites reporting more than 20,000 water birds during Asian water bird Census: 1997-2001, has been taken by Wei and Mundkar (2004). They have stated that fishing, agriculture at and around the sites and overgrowth of vegetation as main on site uses and threats. There is growing concern about dwindling of wetland due to human interference. Experts opine that loss of wetland brings with it a number of inevitable dangers for the environment; one of which is loss of wetland biodiversity. There is indiscriminate exploitation, particularly of species such as Centella asiatica, Hygrophilla auriculata, Bacopa monnieri, Mullugo cerviana & Marsilea minuta, by local people who ignorantly harvest and supply them to some pharmaceutical agency, apart from harvesting for regular consumption (Mandal and Mukhopadhyay, 2010). There is also adverse effect on the plant diversity because of global warming.

The rate at which the wetlands are dwindling is alarming. The survival of the little known plant community depends on survival of wetlands. Once their habitats are lost, they will be under inevitable threat (Mandal and Mukhopadhyay, 2010). Therefore, the plant diversity of wetlands needs to be conserved.

Therefore, it is felt that these factors should be considered with regard to plant diversity at Nathsagar also.