

PHYTOPLANKTON DIVERSITY ASSESSMENT OF GANDOMAN WETLAND, WEST OF IRAN

J. Cheraghpour, S. Afsharzadeh, M. Sharifi, R. Ramezannejad Ghadi & M. Masoudi

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Gandoman wetland is one of the main aquatic ecosystems of Chaharmahal and Bakhtiari province in the mid western of Iran. It is located close to Choghakhor international wetland. The phytoplankton diversity of the Gandoman wetland was investigated in four consecutive seasons from September 2006 to August 2007. This is the first floristic study of phytoplankton in this wetland. Six divisions of algae, Bacillariophyta, Chlorophyta, Cyanobacteria, Euglenophyta, Dinophyta and Chrysophyta had the main abundance respectively in studied sites. In total 95 species and varieties belonging to 54 genera were recorded. Bacillariophyta was presented with 51 species and varieties as the most abundant group, followed by Chlorophyta, with 18 species and 12 genera. According to this study, Gandoman wetland present an acceptable diversity of phytoplanktons according to the published algal checklist of Iran.

Javad Cheraghpour (correspondence <cheraghpourjavad@gmail.com>) and Mozafar Sharifi, Department of Biology, Faculty of Science, Razi University, Kermanshah, Iran <sharifimozafar@gmail.com>. -Saeed Afsharzadeh, Department of Biology, Faculty of Science, University of Isfahan, Iran. <s.afshar@biol.ui.ac.ir>. -Reza Ramezannejad Ghadi, Department of Biology, Faculty of Science, Golestan University, Gorgan, Iran. <rrghadi@yahoo.com>. -Morteza Masoudi, Academic Center for Education, Culture & Research (ACECR) Mazandaran, Iran. <m.masoodie@yahoo.com>.

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ارزیابی تنوع فیتوپلانکتونی تالاب گندمان، غرب ایران

جواد چراغپور، دانشجوی گروه بیولوژی دانشکده علوم، دانشگاه رازی کرمانشاه.
سعید افشارزاده، دانشیار دانشکده علوم، گروه زیست‌شناسی، دانشگاه اصفهان.
مظفر شریفی، استاد گروه زیست‌شناسی دانشکده علوم، دانشگاه رازی کرمانشاه.
رضا رمضان‌نژادقادی، عضو هیئت علمی گروه زیست‌شناسی دانشگاه گلستان.
مرتضی مسعودی، جهاد دانشگاهی مازندران.

تالاب گندمان یکی از اکوسیستم‌های آبی مهم استان چهارمحال و بختیاری در غرب ایران می‌باشد. این تالاب در نزدیکی تالاب بین‌المللی چغاخور واقع شده است. در این مطالعه تنوع فیتوپلانکتونی تالاب گندمان برای یک دوره یکساله بطور فصلی از شهریور ماه ۱۳۸۵ تا مرداد ماه ۱۳۸۶ مورد بررسی قرار گرفت. این نخستین مطالعه در ارتباط با فلور فیتوپلانکتونی تالاب گندمان به شمار می‌آید. تاکسون‌های مربوط به شش شاخه از فیتوپلانکتون‌ها در این مطالعه مورد شناسایی قرار گرفت. باسیلاریوفیتا، کلروفیتا، سیانوفیتا، اوگلنوفیتا، داینوفیتا و کریزوفیتا بترتیب حائز بیشترین فراوانی بودند. در مجموع ۹۵ گونه و واریته متعلق به ۵۴ جنس به ثبت رسید. در میان تاکسون‌های شناسایی شده، شاخه باسیلاریوفیتا با حضور ۵۱ گونه و واریته از بیشترین فراوانی برخوردار بود و پس از آن شاخه‌های کلروفیتا با ۱۸ گونه و ۱۲ جنس قرار داشت. بر حسب اطلاعات این پژوهش تالاب گندمان تنوع قابل قبولی از فیتوپلانکتون‌ها را در مقایسه با چک لیست‌های منتشره از جلبک‌های ایران ارائه می‌نماید.

INTRODUCTION

Chemical analysis of water provides a good indication of the chemical quality of the aquatic systems, but does not integrate ecological factors such as altered riparian vegetation or altered flow regime and therefore, do not necessarily reflect the ecological state of the system (Karr et al., 2000). Biological assessment is a useful alternative for assessing the ecological quality of aquatic ecosystems since biological communities integrate the environmental effects of water chemistry, in addition to the physical and geomorphological characteristics of rivers and lakes (Stevenson & Pan, 1999). Phytoplankton encountered in the water body reflects the average ecological condition and therefore, they may be used as indicators of water quality (Bhatt, et al., 1999; Saha et al., 2000). Furthermore, taxonomic diversity is one of the most important characteristics of biological communities that reflects evolutionary processes, and maintains ecological functions and stability of ecosystems.

Wetlands are nutrient rich environments. There are many small and large lakes and wetlands in Iran. They are distributed in different geographical area, from coastal zones to the highlands. The study of such regional floras in the context of local physico-geographical environment is an important contribution to biodiversity assessments and floristic studies in Iran. The number of algological studies on inland water has increased considerably in recent years in Iran by various authors including (Dogadina et al. 2002, Afsharzadeh et al. 2003, Ramezanpoor 2004, Nejadstari et al. 2005, Jamallou et al. 2005, Noroozi et al. 2009, Zarei-Darki 2009b, Zarei-Darki 2009a, Masoudi et al. 2012, Ramezannejad Ghadi et al. 2012 a, b). However, despite extensive floristic studies that have been carried out, the algal flora of many geographical areas are still poorly known. Therefore there is a need to determine the environmental conditions and water quality of these ecosystems.

No previous studies have been recorded for the algal flora of Gandoman wetland in Chaharmahal and Bakhtiari province, west of Iran. Therefore we report the phyco-diversity characteristics, phytoplankton composition and seasonal dynamics of algae in Gandoman wetland.

MATERIALS AND METHODS

Study Site

Gandoman wetland is recorded as a valuable habitat for birds by the International Waterfowl Research Bureau (IWRB) in 1992 (Asadi Broujeni et al. 1992). Gandoman is a shallow wetland by an average depth of 2 meters, located 90 km. to Shahrekord in Chaharmahal and Bakhtiari province. The extent of this wetland is

about 1.07×10^7 m² and is located between 31° 49' N to 31° 53' N and 51° 05' E to 51° 07' E. Average altitude of 2219 meters above sea level (Fig. 1). Its average rainfall and temperature is 1800 mm and 13.5 °c , respectively.

Field sampling, collection and analysis

The water samples for the algae study and physico-chemical analysis were collected seasonally, from three sites of Gandoman wetland for a period of a year starting from September 2006 to August 2007. The three sites have been chosen based on water depth and distant (Table 1). Phytoplankton samples were collected from the surface in a 1 liter polyethylene bottle and from a depth of 50 centimetre using Sibata sampler (Sourina, 1978; Watzel & Linkens, 1991). In addition, water samples were gathered by a tube in water shaft to decrease the sampling error (Goodwin & Goodard, 1974). Plankton net in size of 55 microns had used to collect algae by hand. For further analysis, the samples were fixed in 4% formaldehyde and concentrated by sedimentation (Stein, 1973).

All samples except to the Bacillariophyta were examined with temporary slides. Diatoms cleaning was carried out by an oxidation method with hydrogen peroxide and potassium dichromate (Komulaynen, 2009). Number algal species estimated by Sedgwick-Rafter (Wetzel & Linkens, 1991). Taxonomic study was carried out by light microscopy (Zeiss - Axiostar plus microscope) at magnification 400 x and 1000 x and based on Dillard (1990-1993), Dillard (1999), Patrick & Reimer (1966- 1975), Prescott (1970), Desikachary (1987- 1988), Wehr & Sheath (2002), Tiffany & Britton (1971), Whitford & Schumacher (1984), Baker & Fabbro (2002) and John et al. (2002).

Several physico-chemical factors of water were recorded during the sampling period for each site. These include water temperature, dissolved oxygen (DO), pH, Electric conductivity (EC) and TDS, SO₄, PO₄ and BOD. These measurements carried out according to Descy et al. (1994). Some of these parameters measured in the field using a multimeters portable system (Consort C535). In order to investigate trophic conditions of aquatic habitat, it is important to measure these parameters because the principal application of BOD, COD and TSS is in characterizing of water quality and pollution (Heng et al, 2006). Biochemical Oxygen Demand (BOD) is the amount of dissolved oxygen needed by aerobic biological organisms in water to decompose organic material present in a water ecosystem. The BOD value is expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20 °c (Nollet & Leo, 2000).

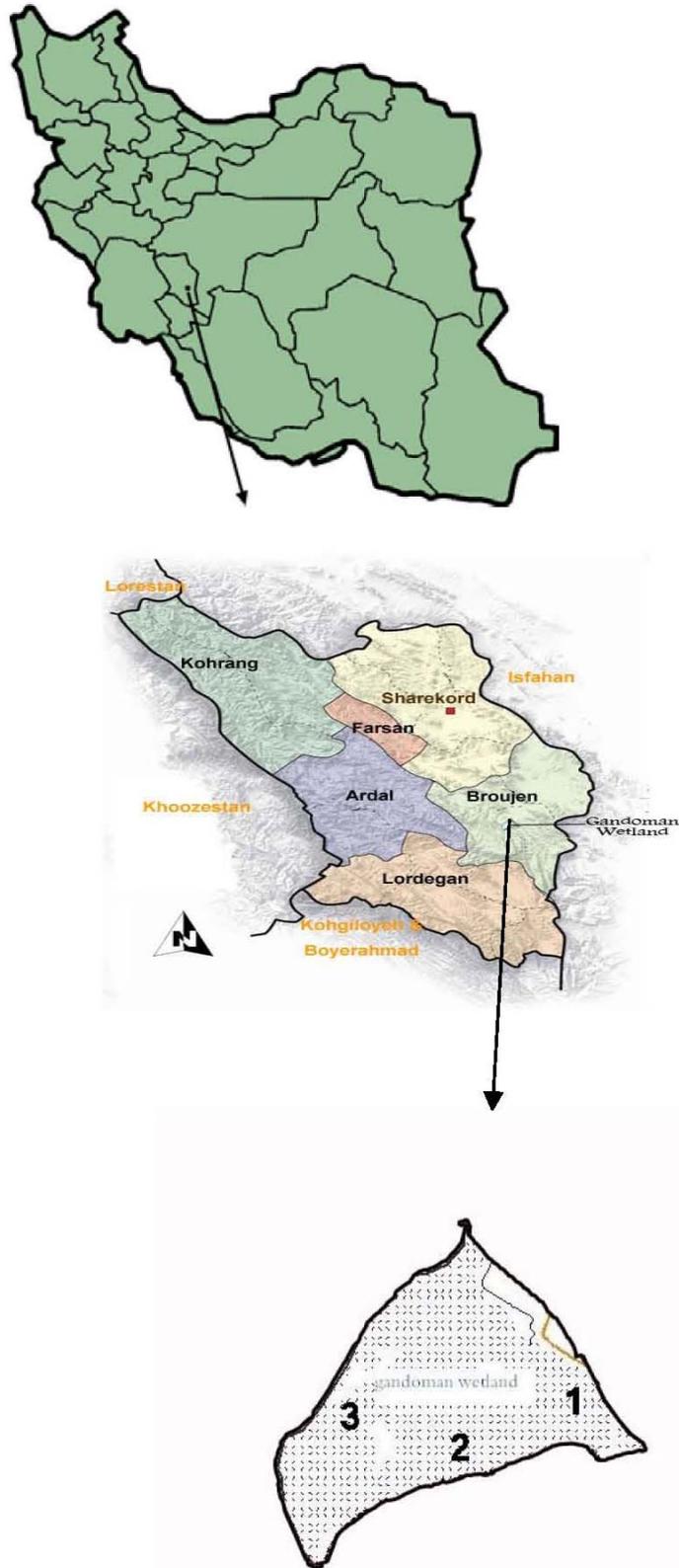


Fig. 1. Geographical location of Gandoman wetland (Iran Department of Environment).

Table 1. Geographical coordinates of stations.

Stations	Latitude	Longitude	Height (m)
Gol Khochak (1)	31° 49' 305" N	51° 05' 865" E	2231
Gol Bozorg (2)	31° 49' 905" N	51° 05' 724" E	2233
Moradan (3)	31° 49' 115" N	51° 05' 614" E	2234

Table 2. Average of the physical-chemical and biological characteristic of Gandoman wetland (DO= Dissolved Oxygen, BOD= Biochemical Oxygen Demand).

Season Parameter	Spring	Summer	Fall	Winter
Temperature (°C)	19.3	18.1	8.3	11.3
pH	8.17	8.37	7.83	8.03
DO (mg/l)	5.85	5.93	9.00	8.43
EC (µS/cm)	268.33	290.33	238.33	268.00
NO ₃ (mg/l)	0.75	1.01	2.30	1.26
PO ₄ (mg/l)	0.07	0.09	0.91	0.03
BOD (mg/l)	2.50	4.53	1.00	1.20
COD (mg/l)	10.43	12.33	8.20	8.73
TS (mg/l)	226.3	207.7	177.0	198.3
TSS (mg/l)	27.33	25.33	14.00	17.66
TDS (mg/l)	202.66	182.00	166.00	180.66

RESULTS

Physico-chemical analysis results

The physical-chemical and biological properties of Gandoman wetland is shown in table 2. BOD was between 0.9 to 5 mg/l that the most amounts were in August, 2006 in the first station and the least amount in November, 2006 in the first station and third station. COD was between 7.2 to 12.6 mg that its most amounts were in summer in the third station and its least amount in fall, 2006 in the third station. Nitrate changes were between 0.5 to 2.6 mg/l that the most amount was in November, 2006 in the first and the second stations and its least amount was in April, 2007 in the third station. Phosphate changes were between 0.02 to 1.6 mg/l. The most amount of Phosphate 1.6 mg/l observed in November and in the first station. Overall changes of total dissolved solid (TDS) were between 162 to 222 mg/l that its most amounts was gained in April, 2007 in the third station and its least amount in November, 2006 in the second station.

Phytoplankton flora

In the present study, a moderate diversity of phytoplankton flora was discovered in the Gandoman wetland with a total of 95 species and infra-species belonging to 54 genera in 6 divisions. A checklist of described algae is presented in Table 3. These species

belong to Bacillariophyta (51 species), Chlorophyta (18 species), Cyanobacteria (16 species), Euglenophyta (6 species), Dinophyta (3 species) and Chrysophyta (1 species). Among these divisions Bacillariophyta were dominant with representing 52.6% of the algal community (Fig. 2). In this study, most of the diatoms were pennate, while some species belonging to order centrales were important quantitatively.

The genera *Navicula* Bory de Saint-Vincent, *Nitzschia* Hassall, *Cymbella* C. Agardh, *Synedra* Ehrenberg, *Scenedesmus* Meyen and *Oscillatoria* Vaucher ex Gomont were represented by diverse species. Some species of phytoplanktons were observed throughout the study period; *Cymbella affinis* Kützing., *Diatoma vulgare* Bory, *Navicula radiosa* Kützing was the dominant species in each site seasonally. Quantitative counts showed clear seasonal variation in algal cell numbers with maxima during late spring and early summer (Fig. 3). The Bacillariophyta comprise most of the total abundance of all stations studied. Not all phytoplankton could be identified to species level. The result of diversity index is shown in table 4 and fig. 4. According to Shannon – waniers index the most of the phytoplankton diversity was in August, 2006 in the second station ($H' = 2.29$) and its lowest amount was in November, 2006 in the third station ($H' = 0.91$).

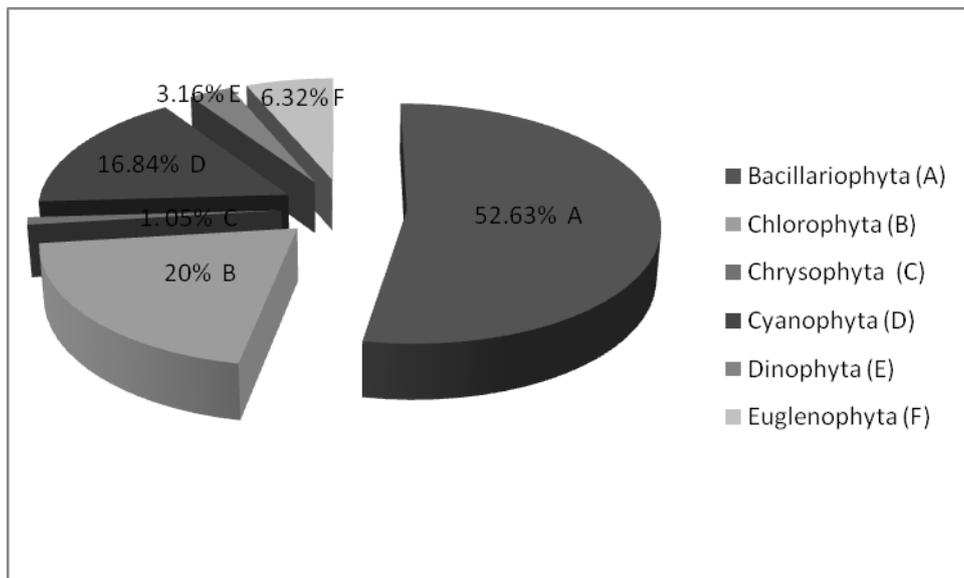


Fig. 2. The abundance of phytoplankton divisions in Gandoman wetland (cells/ml).

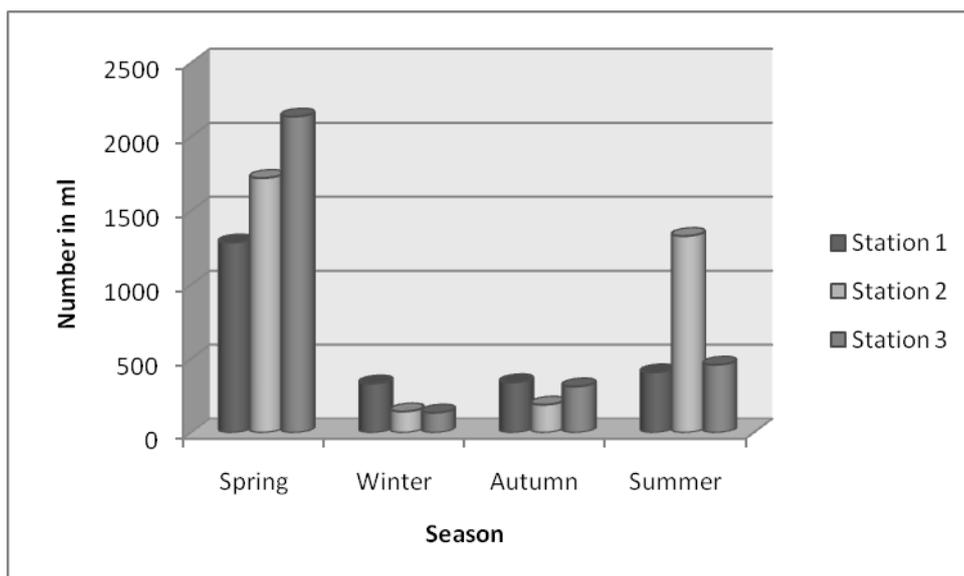


Fig. 3. Relative frequency of phytoplanktons in different stations of Gandoman wetland.

DISCUSSION

In this study 95 species belonging to 6 divisions of phytoplanktons were identified. Some phytoplanktons of Gandoman wetland has a wide distribution in Iran (Dogadina et al. 2002, Nejatkhah et al. 2003, Afsharzadeh 2003, Zarei-Darki, 2009a, Masoudi et al. 2012). According to distribution data on the Algae base website, some of them are widespread or cosmopolitan species too (Guiry & Guiry, 2012).

The high number of single-species families and

few-species genera in this study are typical of most freshwater systems of Iran. In this study, it could be a symbol of the ongoing succession level or environmental factors created by human. Another reason could be higher species richness, which lead to extensive development of aquatic macrophytes and thus the availability of a large diversity of habitats and microhabitats. These diverse habitats are favorable for diverse species.

Table 3: Checklist of identified phytoplankton taxa in this study.

Bacillariophyta	<i>Ankistrodesmus fosiformis</i> Corda ex Korshikow
<i>Amphora lybica</i> Ehrenberg	<i>Closterium</i> sp.
<i>Amphora ovalis</i> (Kützing) Kützing	<i>Cosmarium</i> sp.
<i>Asterionella formosa</i> Hassall	<i>Desmodesmus quadricaudatus</i> (Turpin) Hegewald
<i>Cocconeis pediculus</i> Ehrenberg	<i>Mougeotia</i> sp.
<i>Cocconeis placentula</i> Ehrenberg	<i>Oedogonium</i> sp.
<i>Cyclotella meneghiniana</i> Kützing	<i>Pediastrum</i> sp.
<i>Cymatopleura solea</i> (Brébisson) W. Smith	<i>Stauridium privum</i> (Printz) Hegewald
<i>Cymbella affinis</i> Kützing	<i>Scenedesmus bijuga</i> (Turpin) Lagerheim
<i>Cymbella helvetica</i> Kützing	<i>Scendesmus</i> sp.
<i>Cymbella aspera</i> (Ehrenberg) Cleve	<i>Spirogyra</i> sp.
<i>Cymbella lanceolata</i> (C. Agardh) C. Agardh	<i>Spirogyra weberi</i> Kützing
<i>Denticula kuetzingii</i> Grunow	<i>Staurodesmus dejectus</i> var. <i>apiculatus</i> (Brébisson)
<i>Diatoma hyemalis</i> (Roth) Heiberg	Croasdale
<i>Diatoma vulgare</i> Bory De saint-Vincent	<i>Tetradron lunula</i> (Reinsch) Hansgirg
<i>Diatoma anceps</i> (Ehrenberg) Kirchner	<i>Volvox tertius</i> Meyer
<i>Diploneis ovalis</i> (Hilse) Cleve	<i>Zygnema</i> sp.
<i>Delicata delicatula</i> (Kützing) Krammer	
<i>Epithemia adnata</i> (Kützing) Brébisson	Chrysophyta
<i>Epithemia sorex</i> Kützing	<i>Dinobryon divergens</i> Imhof
<i>Frustulia rhomboides</i> (Ehrenberg) De Toni	
<i>Fragilaria capucina</i> Desmazieres	Cyanobacteria
<i>Fragilariforma virescens</i> (Ralfs) Williams and Round	<i>Anabaena</i> sp.
<i>Fragilaria crotonensis</i> Kitton	<i>Anacystis</i> sp.
<i>Gomphonema olivaceum</i> (Hornemann) Brébisson	<i>Anathece clathrata</i> (W. West & G.S. West) Komárek,
<i>Gomphonema truncatum</i> Ehrenberg	Kastovsky & Jezberová
<i>Gomphonema angustatum</i> (Kützing) Rabenhorst	<i>Cyanoptyche gloecystis</i> Pascher
<i>Gyrosigma acuminatum</i> (Kützing) Rabenhorst	<i>Merismopedia elegans</i> A. Braun ex Kützing
<i>Martyana martyi</i> (Heribaud) Round	<i>Merismopedia punctata</i> Meyen
<i>Melosira</i> sp.	<i>Microcystis aeruginosa</i> Kützing
<i>Navicula radiosa</i> Kützing	<i>Nostoc</i> sp.
<i>Navicula tenelloides</i> Hustedt	<i>Nostoc paludosum</i> Kützing ex Bornet & Flahault
<i>Navicula rhynonocephala</i> Kützing	<i>Oscillatoria</i> sp.
<i>Cymbella lanceolata</i> (Agardh) Agardh	<i>Oscillatoria anguina</i> Bory ex Gomont
<i>Navicula oblonga</i> (Kützing) Kützing	<i>Psuedanabaena limnetica</i> (Lemmermann) Komárek
<i>Navicula</i> sp.	<i>Phormidium nigrum</i> (Vaucher ex Gomont)
<i>Navicula salinarum</i> Grunow	Anagnostidis & Komárek
<i>Navicula rhynchotella</i> Lange- Bertalot	<i>Planktolyngbya limnetica</i> (Lemmermann) Komárková-
<i>Navicula salinicola</i> Lange -Bertalot	Lagnerová & Cronberg
<i>Nitzschia</i> sp.	<i>Rhabdogloea smithii</i> (R. Chodat & F. Chodat)
<i>Nitzschia palea</i> (Kützing) W. Smith	Komárek
<i>Nitzschia hantzschiana</i> Rabenhorst	<i>Spirulina major</i> Kützing ex Gomont
<i>Pinnularia major</i> (Kützing) Cleve	
<i>Pinnularia rupestris</i> Hantzsch	Dinophyta
<i>Pinnularia sudetica</i> (Hilse) Hilse	<i>Ceratium hirundinella</i> (Müller) Dujardin
<i>Pinnularia viridis</i> (Nitzsch) Ehrenberg	<i>Glenodinium quadridens</i> (Stein.) Schiller
<i>Planthidium lanceolatum</i> (Brébisson ex Kützing)	<i>Peridinium cinctum</i> (Müller) Ehrenberg
Lange-Bertalot	
<i>Tetracyclus rupestris</i> (Braun) Grunow	Euglenophyta
<i>Surirella roba</i> Leclercq	<i>Euglenaria caudata</i> (Hübner) A. Karnowska-Ishikawa,
<i>Synedra acus</i> Kützing	E. Linton & J. Kwiatowski
<i>Synedra ulna</i> (Nitzsch) Ehrenberg	<i>Lepocinclis fusca</i> (Klebs) Kosmala & Zakrys
<i>Ulnaria capitata</i> (Ehrenberg) Compere	<i>Lepocinclis globulus</i> Perty
	<i>Trachelomonas acanthostoma</i> Stokes
Chlorophyta	<i>Trachelomonas australica</i> (Playfair) Deflandre
<i>Ankistrodesmus falcatus</i> (Corda) Ralfs	<i>Trachelomonas intermedia</i> Dangeard

Table 4: The amount of diversity index (H').

Seasons stations	Fall	Winter	Spring	Summer	average
1	1.08	1.12	2.09	2.22	1.62
2	1.05	0.95	1.94	2.29	1.55
3	0.91	1.45	1.83	1.98	1.54
average	1.01	1.17	1.97	2.16	1.57

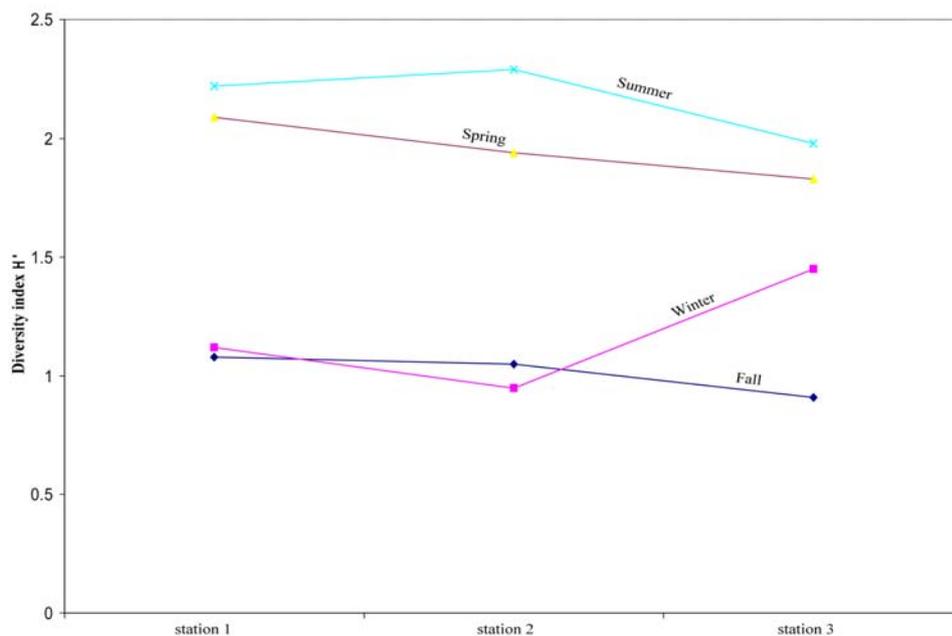


Fig. 4. The amount of diversity index in different stations.

Bacillariophyta formed dominant group in phytoplankton communities representing 53.6%, and *Navicula radiosa* was the dominant species. Similar conditions have been observed in other area of Iran (Dogadina et al. 2002; Afsharzadeh 2003, Zarei-Darki 2009a, Ramezannejad Ghadi et al. 2012a) and other parts of the world (Moore 1979). Moore pointed out that in more temperate areas diatoms are usually the most common elements of phytoplankton communities (Moore 1979). Pennate diatoms are richer in number of taxa than centric forms in this system, as expected for freshwater ecosystems (Kadri & Bulten, 2006). *Navicula radiosa* was the dominant species at all stations and founded during most of the studied period.

Chlorophyta were the second most important group. They contributed a large number of species (17.1%) but lower cell numbers compared with Bacillariophyta.

Cyanobacteria were the second subdominant group in this area. This group of algae have also many species in Gandoman wetland. They were dominant in

summer and they were rare in autumn. This is an explainable case according Branco comment that Cyanobacteria are successful in a wide range of environments because they have a versatile metabolism (Branco et al. 2001).

Other divisions of phytoplankton with phytoplanktonic taxa (Euglenophyta, Dinophyta and Chrysophyta) were presented only seasonally and with minor numerical importance. In Dinophyta, *Glenodinium quadridens* (Stein.) Schiller., *Peridinium cinctum* (Muell.) Ehr., and *Ceratium hirundinella* (O. F. Muell.) Duj. showed the most abundance. From Chrysophyta, *Dinobryon* was found only in spring and summer. The lacking of high concentrations of nutrients required for Euglenophyta and stress conditions suppressing phytoflagellate development may be associated with the seasonal presence of Euglenophyta.

The phytoplankton species composition showed at the highest diversity in spring and the lowest in autumn

(Fig. 3). Also, with respect to Shannon- waniier's index, the most species diversity was got in the summer, and the least in autumn that is similar to Barone & Flore (1994) studies, Shannon diversity is changed by water level vibrations or phytoplankton's pressure (Table 4). Generally average of diversity index increase from fall to summer (Fig.4). The environmental factors such as BOD, COD, pH, temperature, DO, EC, Nitrate and Phosphate has influenced phytoplanktonic species composition and distribution. The amount of DO in summer and spring is less than other seasons that this was because of increase in organic compound in these seasons. at the result is coused decrease phytoplankton's composition. The amount of BOD showed any difference between stations, but its maximum average was in summer and the minimum in winter. Since in this season, phosphate amount was low, therefore, we can comment that decrease in organic matters like phosphate and increase in turbidity, and decrease in temperature and light causes decrease in phytoplankton's composition in this season (winter) and then caused decrease in required oxygen for the oxidation of carbon and nitrogen compounds. COD amounts between stations showed any significant difference. COD amount in autumn showed a significant decrease than other seasons that this was because of decrease in organic compounds in these seasons and consequently caused decrease in phytoplankton's composition in autumn. On the whole, because of increase in composition of organic matters, mixture and communities of phytoplankton changes (Fig. 2).

Taxonomical survey is useful to indicate trophic conditions of lakes and rivers (Shubert 1984, Stoermer & Julius 2003). Some identified taxa in Gandoman wetland are characteristic of the oligotrophic lakes such as *Pinnularia* Ehrenberg, *Pediastrum* Meyen, *Cymbella affinis* Kützing, *Asterionella formosa* Hassall and *Fragilaria capucina* Desmazieres (Rawson, 1956). As expected, based on the analysis of the phytoplankton flora composition, and physico-chemical analysis, Gandoman wetland has an oligotrophic character.

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