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Physicochemical Status and Primary Productivity of Ana Sagar Lake, Ajmer (Rajasthan), India

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Abstract:

Primary productivity and physico-chemical parameters were estimated in Ana Sagar Lake, Ajmer from September 2007 to August 2008. GPP value ranged between 1.93 and 6.24 gC/m^2/day, NPP ranged between 0.72 and 4.99 gC/m^2/day and Community respiration ranged from 0.26 to 3.6 gC/m^2/day. Water temperature varied from 16.4°C to 31.2°C. pH and transparency ranged between 6.7 and 10.2 and 34 cm and 65 cm respectively. Variation in dissolved oxygen (DO) was from 6.7 to 10.7 mg/l. Biological oxygen demand (BOD) and alkalinity varied from 9.2 to 25.2 mg/l and 176 to 264 mg/l. Concentration of nutrients viz. chloride (18.5 to 32.4 mg/l), nitrate (12.9 to 26.4 mg/l) and phosphate (1.2 to 3.2 mg/l) also varied independently. Primary productivity and physico-chemical values of the lake were found high, mainly due to sewage discharged, industrial effluents and the agricultural runoff by surrounding city population. High values of productivity and nutrients also exposed its eutrophic condition.

Keywords: Ana Sagar, Biological oxygen demand, Community respiration, Eutrophic, GPP, NPP, Physico-chemical

1.0 Introduction:

Primary productivity is the rate at which the sun's radiant energy is stored by photosynthetic and chemosynthetic activities of producers (phytoplankton, algae and macrophytes in water) in the form of organic substances (Odum, 1971). Biological production in any aquatic body gives direct correlation with its physico-chemical status which can be used as trophic status and fisheries resource potential (Jhingran *et al.*, 1969). Primary production studies are of paramount interest in understanding the effect of pollution on system's efficiency. High rates of production both in natural and cultural ecosystems occur when physico-chemical factors are favorable (Sultan *et al.,* 2003).

Several workers have studied lentic ecosystem in India with reference to physico-chemical status and primary productivity (Sharma and Durve, 1991; Kaur *et al.,* 1996; Birasal 1996; Bais *et al.,* 1997; Jain *et al.,* 1997; Sharma *et al.,* 2000; Thomas and Abdul, 2000; Shukla and Pawar, 2001; Ranu, 2001; Meena, 2001; Chisty, 2002; Sultan *et al.,* 2003; Rani *et al.,* 2004; Umavathi *et al.,* 2007; Vijayvergia *et al.,* 2007; Feresin *et al.*, 2010; Fatima *et al*., 2011; Uveges *et al.*, 2011). The Ajmer city, located in the heart of the state, has many freshwater lakes which are highly influenced by biotic components. Major studies of limnology were concentrated on Pushkar lake region in Ajmer district (Kar, 1986; Parvateesam and Mishra, 1993; Patni *et al*., 2006). Ana Sagar is one of the important ancient freshwater lake and situated middle of the city. No study has been carried out with reference to primary productivity on this lake. In the present investigation an attempt has been made to study physico-chemical parameters and primary productivity of Ana Sagar Lake. This study may help in optimum utilization and sustainable management of this Lake.

2.0 Material and Methods:

Ana Sagar Lake (26°27'-26°29' N and 74°36'- 74°37' E) is located in middle of the Ajmer city. Catchment area of the lake includes Nagpahar hills and Taragarh hills. Interrupted catchment area is about 45% and 60% under free catchment, which includes 5 (4 full and 1 partial) villages and some part of the city. Average annual rainfall is 500 mm. Capacity of lake is 2052 million liters. Average depth is 5 meter (Ranga 1995). The study was carried out for a period form September 2007 to August 2008 at monthly intervals. Water samples were collected from a selected station during morning time (7 to 9 am), in the first week of every month. Physico-chemical parameters such as temperature, transparency, pH, dissolved oxygen (DO), biological oxygen demand (BOD), alkalinity, chloride, turbidity, total dissolved solids (TDS), total hardness (TH), nitrate and

phosphate were analyzed, using standard methods (APHA, 2005; Trivedy and Goel, 1986). TDS, pH and water temperature were recorded on the spot. Water temperature was calculated using thermometer and pH with the digital pH meter. DO was fixed during the sampling and measured in the laboratory within 24 hour with other parameters.

Productivity was calculated on the assumption that one atom is assimilated for each molecule of oxygen (32g) released for each molecule of carbon (12g) fixed (APHA, 1989). The light and dark bottle method (Trivedy and Goel, 1986) was used for measuring the primary productivity (GPP, NPP and Community respiration). Experiments were conducted for 6 h from 9.00 am to 3.00 pm. To convert the DO (ppm) values to gC/m3/h, the factor 0.375 (12/32) is used. Per hour values are multiplied by 12 to derive the productivity values per day (Michael, 1984). Pearson Product Moment correlation (*r*) was used to assess relationship among physico-chemical parameters. Statistical analysis was calculated using statistical software Graph Pad, Prism (version 3.02).

3.0 Result and Discussion:

Monthly variation of Primary productivity (GPP, NPP and Community respiration) are present in Table 1. The GPP ranged from 1.93 to 6.24 gram Carbon/m^2/day, whereas the NPP ranged from 0.72 to 4.99 gC/m^2/day. Three peaks were observed for GPP in October 2007, April 2008 and June 2008. Peaks for NPP were observed in March 2008, April 2008 and June 2008. The lower values of GPP were recorded in the months of September 2007, January 2008 and August 2008 and NPP in September 2007, November 2007, December 2007, May 2008 and August 2008. GPP gradually increased from December 2007 to April 2008 and declined after June 2008 to August 2008. NPP increased from November 2007 to April 2008 and declined from June 2008. The Community respiration ranged from 0.26 to 3.6 gC/m^2/day. This value decreased from September 2007 to December 2007. It increased after December 2007 to March 2008 but again it falls till August 2008. Highest value of productivity found in June 2008 during summer season. Shukla and Pawar (2001) and Sultan *et al.,* (2003) also found same result. Probably, during summer the temperature raised, which enhances the release of nutrients from sediments through bacterial decomposition. The excessive amount of nutrients along with higher temperature favors the maximum growth of aquatic flora, which ultimately favors the primary productivity. Sultan *et al.,* (2003) reported that temperature, solar radiation and available nutrients may be important limiting factors for primary production and contributing to seasonal variation in any aquatic ecosystem.

Mean values of physico-chemical parameters are given in Table 2 and correlation co-efficient values are shown in Table 3. Water temperature varied (16.4°C to 31.2°C) with changing climate condition (Fig.a). Higher temperature during summer was due to greater heating. Sharma *et al.,* (2000) observed that water temperature fluctuate between 21°C to 29°C, during limnological studies of Udaipur Lakes. During present study water transparency values ranged from 34 to 65 cm (Fig.b), which indicating productive nature of this water on the basis of clarity values as proposed by Sharma and Durve (1991). Colder months exhibited higher values. These values declined as summer approached. In the month of June 2008, evaporation was highest due to high air temperature and reduced relative humidity, which subsequently decreased transparency of water. This observation supported by Ranu (2001), Meena (2001) and Chisty (2002). Some workers believed that wind action and organic matter influence transparency (Edmondson, 1961; Ganapati, 1962), while others (Bais *et al.,* 1997; Sharma, 2001) have considered plankton as an important factor.

The pH values were found alkaline (6.7 to 10.2) throughout the study period, except July 2008 (Fig.c). This range found out of the limit prescribed by WHO 1973. The high values may be due to attributed sewage discharged by surrounding city population. pH value is very important for plankton growth (Chisty, 2002). According to Umavathi *et al.,* (2007), pH in ranged of 5 to 8.5 is best for plankton growth but harmful when more than 8.8. Dissolve oxygen (DO) is regarded as one of the best indicator to assess the health of a water body (Edmondson 1961). It varied from 6.7 to 10.7 mg/l (Fig.d). DO concentration was above 5 mg/l through out the year, hence according to Banerjea (1967) and Tarzwell (1957) the lake is productive for fish culture. Lowest value of DO found in July 2008. Rani *et al.,* (2004) also reported lower values of dissolved oxygen in summer months due to higher rate of decomposition of organic matter and limited flow of water in low oxygen holding environment due to high temperature. High temperature also decreases oxygen holding capacity of water. Low temperature in winter contributed rise in DO.

Table 1: Monthly variations of Primary Productivity in Ana Sagar Lake, September 2007- August 2008

Month	NPP, mg/l/h	GPP, mg/l/h	Community respiration mg/l/h	NPP, $gC/m^2/h$	GPP, $gC/m^2/h$	Community respiration $gC/m^2/h$	NPP, $gC/m^2/day$	GPP, $gC/m^2/day$	Community respiration $gC/m^2/day$
Sept.	0.16	0.96	0.8	0.06	0.27	0.30	0.72	3.24	3.60
Oct.	0.53	1.03.	0.5	0.19	0.38	0.18	2.37	4.63	2.24
Nov.	0.40	0.93	0.53	0.15	0.25	0.19	1.80	3.09	2.37
Dec.	0.36	0.43	0.06	0.13	0.16	0.02	1.60	1.93	0.26
Jan.	0.4	0.50	0.10	0.15	0.18	0.03	1.80	2.24	0.44
Feb.	0.43	0.83	0.40	0.16	0.31	0.15	1.96	3.73	1.80
Mar.	0.50	1.23	0.73	0.18	0.36	0.27	3.24	4.32	3.27
April	0.90	1.36	0.46	0.33	0.51	0.17	4.01	6.12	2.06
May	0.43	1.00	0.56	0.16	0.37	0.21	1.96	4.50	2.52
June	1.10	1.40	0.30	0.41	0.52	0.11	4.99	6.24	1.34
July	0.60	1.06	0.46	0.22	0.39	0.17	2.70	4.76	2.06
Aug.	0.40	0.57	0.16	0.15	0.21	0.06	1.80	2.55	0.72

Table 3: Correlation co-efficient (*r*) values among physico-chemical parameters in Ana Sagar Lake

	Temp	Transparency	pH	DO	BOD	Alkalinity	Chloride	TDS	TH	Nitrate	Phosphate
Temp.	-	-0.61*	-0.45	-0.55	0.29	-0.11	0.56	0.01	0.76*	0.09	0.31
Transparency		-	0.30	0.16	-0.35	0.18	-0.23	0.53	-0.55	-0.17	0.04
pH			-	0.14	-0.37	-0.07	0.09	-0.07	-0.08	-0.10	-0.22
DO				-	-0.36	0.08	-0.24	-0.25	-0.69*	0.01	-0.05
BOD					-	-0.20	0.04	-0.08	0.43	0.44	0.25
Alkalinity						-	-0.05	0.39	-0.56	0.36	0.43
Chloride							-	0.13	0.48	0.52	0.37
TDS								-	-0.20	0.11	0.09
TH									-	-0.005	0.06
Nitrate										-	0.58*
Phosphate											-

*Significant at $P < 0.05$ level

Table 2: Mean (±SD) values of physico-chemical parameters of Ana Sagar Lake, September 2007-August 2008

Parameters	Mean (±SD)
Temp. (ºC)	24.33(±4.31)
Transparency (cm)	46.42(±9.19)
pH	8.12(±0.84)
DO (mg/l)	7.81(±1.21)
BOD(mg/l)	13.59(±4.43)
Alkalinity(mg/l)	215.8(±26.05)
Chloride (mg/l)	23.23(±4.00)
TDS (mg/l)	597.8(±243.9)
TH (mg/l)	124.3(±9.24)
Nitrate (mg/l)	18.52(±4.03)
Phosphate (mg/l)	1.76(±0.88)

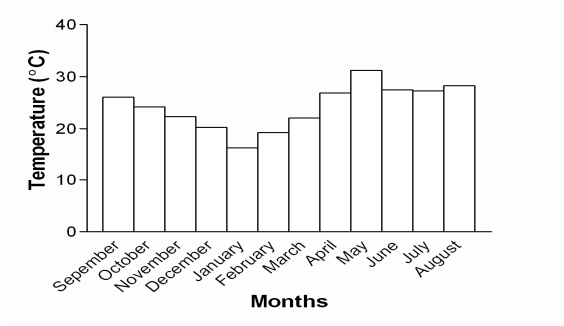

Figure a. Monthly variations in Water Temperature (°C)

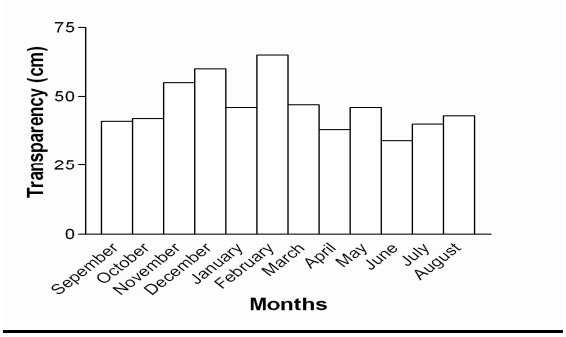

Figure b. Monthly variation in Transparency (cm)

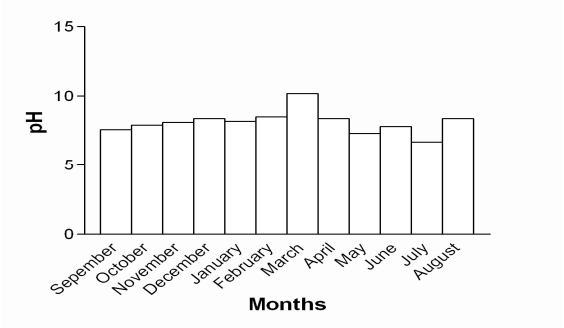

Figure c. Monthly variation in pH

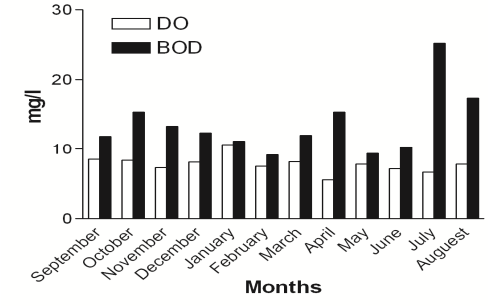

Figure d. Monthly variation in Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD) (mg/l).

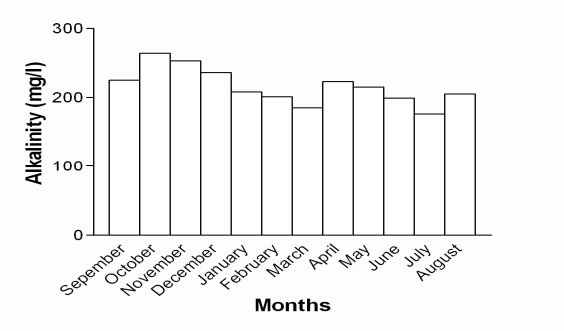

Figure e. Monthly variation in Alkalinity (mg/l)

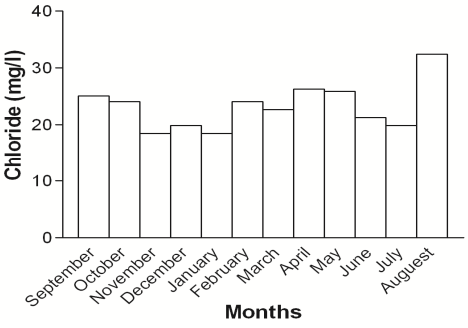

Figure f. Monthly variation in Chloride (mg/l)

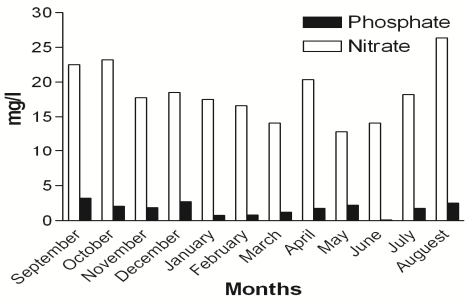

Figure g. Monthly variation in Phosphate and Nitrate (mg/l)

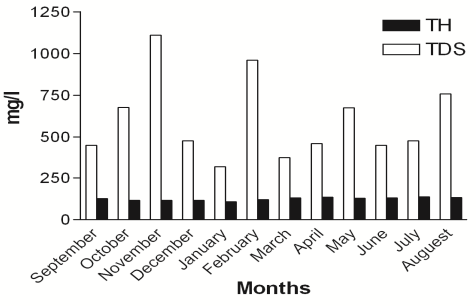

Figure h. Monthly variation in Total Hardness (TH) and Total Dissolved Solids (TDS) (mg/l)

BOD is the measurement of the amount of biologically oxidizable organic matter present in waste. Permissible limit of BOD is 5 mg/l (WHO 1984). During present study BOD ranged from 9.2 to 25.2 mg/l (Fig.d), was above the permissible limit. So, this water body is not safe for drinking purpose. The entry of sewage water, industrial effluents and the agricultural runoff might be responsible for the increased levels of BOD. Kaur *et al.,* (1996) reported increase in BOD values due to deposition of animal excretory wastes. Thomas and Abdul (2000) observed higher BOD values during summer because of higher microbial activity due to high temperature. Total alkalinity showed similar fluctuation trends and ranged between 176 to 264 mg/l (Fig.e). Natural water containing 40 mg/l or more of total alkalinity is considered as more productive (Moyle 1946). Minimum content was noted during monsoon presumably due to dilution, while maximum contents were recorded during pre monsoon presumably due to evaporation of water from the system. Chisty (2002) reported that pollution by sewage and its decomposition seems to be a possible cause for the higher values of alkalinity in the water bodies of Udaipur City. The high value of alkalinity indicates the presence of weak and strong base such as carbonates, bicarbonates and hydroxides in the water body (Jain *et al.,* 1997; Agarwal and Saxena 2011).

Chloride found to be high during the pre-monsoon season, whereas it was low during the monsoon season (Fig.f). This may be assigned to the continuous evaporation of water during summer and pre monsoon season. According to Trivedi and Goel (1986) the most important source of chloride in the natural freshwater is the discharge of domestic sewage and the concentration of chloride serve as an indicator of sewage pollution. Umavathi *et al.,* (2007) and Vijayvergia *et al.,* (2007) also showed that higher concentration of chloride is associated with increased level of pollution. Phosphate is one of the most important nutrient and a limiting factor in the maintenance of lake fertility. During present study the phosphate concentration varied between 0.14 to 3.2 mg/l (Fig.g). The highest (3.2 mg/l) and lowest (0.14 mg/l) values of phosphate were recorded during monsoon and winter seasons, respectively. The highest value during monsoon season may be related to the weathering of rocks liberating soluble alkali phosphate and the anthropogenic inputs of super phosphate applied to the agriculture field can be other source of phosphate. This finding is in agreement with that in Udaipur lakes (Ranu, 2001; Meena, 2001; Chisty, 2002).

Nitrate is the highest oxidized form of nitrogen and in water its most important source is biological oxidation nitrogenous organic matter of both autochthonous and allochthonous origin. Nitrate fluctuated between 14.1 to 26.4 mg/l (Fig.g). These values are much higher than Chisty (2002), and Rani *et al.,* (2004). High concentration of nitrates in drinking water is toxic (Umavathi *et al.,* 2007) and indicates pollution by organic waste and domestic sewage. Sultan *et al.,* (2003) correlated high concentration of nitrate to eutrophic condition. Total hardness ranged from 108 to 136 mg/l and values were higher during summer (Fig.h). These high values may be due to the addition of calcium and magnesium salts from detergents, which were used for bathing and washing by the local people. The increase in hardness can be attributed to the decrease in water volume and increase in the rate of evaporation at high temperature (Kaur *et al.,* 1996). Water in Ana Sagar Lake can be classified into hard water on the basis of hardness (Kannan, 1991).

Water with high TDS is of inferior potability and may induce an unfavorable physiological response of the body of consumer (Basheer *et al.,* 1996). Present observation includes higher total dissolved solids value varied from 315 to 1109 mg/l (Fig.h). Chisty (2002) recorded average total dissolved solids of 963.2 and 285.9 mg/l for lake Udaisagar and Fatehsagar respectively. TDS analysis has great implications in the control of biological and physical waste water treatment processes (Birasal, 1996). In essence the physico-chemical and primary productivity values of the lake reveal that it is in eutrophic condition. the quality of water deteriorating day by day due to inflow of domestic sewage, municipal sewage, agriculture runoff and effluents of organic waste of animal and human origin into the lake. So, on the basis of above investigation Ana Sagar Lake is not safe for any type of activities especially as a source of drinking water.

4.0 Conclusions:

In the light of the above information we can conclude that Ana Sagar lake was highly productive and the primary productivity was influenced by various factors like, eutrophication, agriculture runoff, industrial effluents, sewage water and other anthropogenic activities. The nutrients of an aquatic ecosystem plays key role in the primary productivity. Phosphate and nitrate shows positive correlation with the lake productivity. Productivity was also found to be

influenced by seasonal variation and was highest in summer season, because the rate of photosynthesis was peak in summer period due to high water temperature. The result of the present investigation on the physico-chemical characteristics and tropic status of the lake indicate its eutrophic nature.

The Ana Sagar Lake is highly under pressure of city encroachment and urbanization. Water quality of the lake was deteriorating and polluted day by day mainly due to agriculture runoff, industrial effluents and sewage water concerned to the urban population. Thousands of piligrims bathing in the lake during Urs festival of Ajmer city, which were came from all over the India and also contributed in the pollution to the lake. Thus, pollution of the lake was increasing in alarming rate, which required urgent attention of regular monitoring of lake water. Sewage water should be diverting or proper treated before release into the lake. Coordination effort is required from the local people with the governmental and nongovernmental organizations to restore the lake ecosystem.

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