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Studies of Physicochemical and Bacteriological Characteristics of Jaisamand Lake, Alwar (RAJ.)

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Abstract: *The piece of investigation is carried out to study the water quality and suitability of Jaisamand Lake, Alwar for irrigation and drinking purpose. This study is done during 2015-16 to assess seasonal variations in the water of the lake by observing different physicochemical and microbiological parameters viz. temperature, pH, total hardness, total dissolved solids, dissolved oxygen, biological oxygen demand, free CO_2, alkalinity, chloride, nitrate, SPC, TCC, and FCC in different seasons of the year. Out of them DO, BOD, Free CO2, SPC, TCC and FCC were found to be very much greater than the amount recommended by WHO and ISI for drinking water. Some parameters viz. temperature, pH, Total hardness, and total dissolved solids were found within the optimal range. Hence, it can concluded that Jaisamand Lake is gradually tending towards eutrophication which leads to the lake water very unsafe for drinking, irrigation and fishery purposes and must use only after suitable treatment processes.*

Keywords: *Jaisamand Lake, physicochemical, microbiological parameters*

I. Introduction

Jaisamand Lake or Jai Samudra Lake is one of the largest fresh water lakes in India (88 sq kms) located 6-km from Alwar in south east. Jaisamand Lake is a popular spot for outings and picnics. It is believed that this lake was constructed for the purpose of water retention of Ruparel River for the purpose of irrigation. Jaisamand is acclaimed as the second largest artificial lake in Asia. Jaisamand Lake has an embankment of 1.5 kilometers. These banks house shaded pavilions and lovely towers. These monuments are erected on lotus shaped bases and are seven feet in height. A large island in the middle of the lake with lush green grassland presents eye catching spectacle to all the visitors. Monsoon is the best time to visit this place with sprawling greenery all around the Lake. Jaisamand Lake is popular for water sports as it makes a great angling site. A Game Sanctuary is located on the bank of the lake spreading across 45 square kilometers. This sanctuary houses panthers, spotted deer, sambhars and large variety of migratory birds. A recently built Sunset Point is a perfect place for a panoramic view of the lake particularly in the evening but now a days, this lake is going to be shallow due to continuous pollution and siltation and slowly converting in to a marshy island.

The limnological characteristics of water quality includes physical, chemical and biological parameters which determine its nutrient status and contamination level.

Origin of research problem

Since Jaisamand lake is the sources of irrigation and drinking water of nearby residential areas of Alwar, monitoring physicochemical and bacteriological quality of water of this lakes is of significant value in combating the problems associated with public health. Therefore, it is essential to measure and analyze all the physicochemical and bacteriological factors of the water before its use for drinking and irrigation purpose so that it can be suitable for the purpose. An estimation of bacterial production is a crucial step in understanding quantitatively the function and contribution of bacteria in material cycling within given aquatic habitats (Azam *et. al*.,1990).

Assessment of indicator bacteria namely colliform is a convenient way to evaluate sanitary condition of any water body in which fishing is being done (Pandey and Pandey, 2000). Freshwater fishes are facing a major challenge due to indiscriminate use of different types of pesticides in agriculture. Majority of studies in this line have been done in piscine, avian and mammalian system, a considerable amount is still remains to be understand regarding the impact of physicochemical and microbiological parameters on lake water. There is a growing literature about the affect of pollutants on aquatic organisms. No systematic study have been made yet on the physico-chemical and bacteriological parameters of this lake. The present study is an attempt to find out limnological and bacteriological parameters of the Jai samandh Lake. The data of present study can be used to find out the suitability of the water of this lake for drinking, pisciculture, and irrigational purpose.

II. Review of literature

The last few years have witnessed about two fold increases in the use of pesticide chemicals, polythenes, drainage of water and industrial effluents in the water bodies. Much of the waste materials released in to the environment never find their target organisms and drains in to the homes of fishes (Pimental and Edwards, 1982). Effluents from pesticide industry have result a marked increase in the incidences of mass mortality, growth retardation and tissue damage in fish (Kumarguru, 1995; Sarkar, 1997; Lal and Pandey, 1999; Pandey 2000). Estimation of bacterial production, a crucial step in quantitatively the function and contribution of bacteria in material cycling within aquatic habitat (Azam *et al*.,1990). In a study of Pichhola lake, Udaipur during annual cycles of 2005-06 and 2006-07 the water remained moderately alkaline (pH 7.5) while electrical conductance (0.3958 ms/cm), TDS (237.5mg/l), chloride (176mg/l), hardness (174.33mg/l) and alkalinity (207.16mg/l) showed low mean values. Average dissolved oxygen levels were at 5.75mg/l while average nitrate and phosphate levels were 3.70mg/l and 2.79mg/l respectively. On the basis of water quality parameters in general, lake Pichhola was found to be eutrophic. A high rate of primary production (302.085 mgc/m2/hr), diversity of phytoplankton (58 forms), zooplankton (104 forms) and fish (15 species) were also observed during the study period. Therefore, lake Pichhola has rich number of species and biodiversity of aquatic animals (Sharma *et.al.* 2010). A limnological study of Ramgarh Lake of eastern Uttarpradesh showed significant seasonal and spatial variation in four species of zooplankton Cladocera 41%, Copepoda 24%, Rotifera 27% and Protozoa 18% as a result lake is undergoing eutrophication. Shrivastava, S. K. and Gupta, V. K. *et. al.* (2008) statistically analysed to determine the correlation between physico-chemical water quality parameters in pond water in Bilaspur, Chattisgarh. Sankhya Sagar Lake, Shivpuri, M.P. is a polluted fresh water body due to continuous discharge of municipal sewage and run off. The pollution of lake becomes noticeable in the form of visible changes of the lake environment as well as water quality tests (Mishra and Mathur *et.al*., 2007). Patra and Santra, *et.al* (2010) revealed the poor water quality due to contamination of water from sewage effluents in Santragachi jheel and the Joypur jheel in West Bengal, India. In other physical, chemical and microbiological comparative study of Ganga, Alaknanda, Bhagirathi, Yamuna, and Mandakini , water sample analyzed from 9 monitoring stations: Devprayag, Gangotri, Haridwar, Rudraprayag, Dakpather and Yamunotri showed positive for *E. Coli* which indicates fecal pollution in water and Brahamkund in Haridwar a famous tourist place found most polluted (Ashok and Bisht (2010).

A study on physico-chemical analysis of surface and ground water of Bargarh district, Orissa, India has showed that the parameters which were taken for the study of water quality were below the pollution level for ground water which satisfy the requirement for the use of domestic, industrial and agriculture but in case of surface water the water quality of small community pond are above the permissible limit (Mahananda., *et.al.,* 2010). Changes in nutritive value with pollution of *Channa punctatus* has also been reported (Srivastava and Srivastava, 2008). Sachidanandmurthy and Yajurvedi (2006) found physico-chemical factors were higher than the desirable limits in Bilikere lake, Mysore city, Karnataka due to the entry of runoff and occasional flow of sewage in to the lake therefore it is suggested that control of nutrient load that enters in lake occasionally, might help lake to continue its mesotrophic status. Fertilizer industry effluent induced some biochemical changes in freshwater teleost (Yadav *et al.,* 2007). Garg, (2007) found the effect of oral administration of l-thyroxine as growth performance digestibility and nutrient retention in *Channa punctatus* (Bloch) and *Heteropneustes fossilis*.

Studies on bacteriological aspects of the water bodies have been performed by Sharma and Mall (1988), Ramasubramanian *et al.,* (1992), Shuangjiang *et.al*.,(1993), Hodgkiss (1994), Khatavkar and Trivedy (1994), Thomas *et.al.* (2001), Parihar *et.al.* (2007). The coliform bacterium is the primary bacterial indicator for fecal population in water. A comparative limnological and microbiological study has been made by Sharma and Sharma (2008) in lake Pichhola, Swaroop sagar, Udaisagar and Fatehsagar in which all the parameters were found to fall in a far higher range than laid for fresh water by Central pollution control board (CPCB).

Significance of the study

An attempt will be made to study the physicochemical and bacteriological parameters in Jaisamand Lake in Alwar (Raj.). The lake is enough to combat the needs of drinking water supply and irrigation purpose for the people of nearby areas in Alwar. Accumulation of chemicals in aquatic flora and fauna is increasing alarmingly which ultimate affect human health too through ecological cycling and biological magnification. The aquatic ecosystem of Jaisamand Lake is habitat to a variety of migratory and resident birds. Water provides sustainable living to countless species of the aquatic ecosystem like fish, birds, insects, bacteria, micro and macro invertebrates and aquatic vegetation towards which migratory birds are drawn. Jaisamand Lake is a famous tourist place. It is visited every year by thousands of tourists because of Jaisamand dam is made at the bank of the lake. Domestic waste water and human activities by the main local inhabitants and tourists is the contributor to deteriorate the water quality of this reservoir. The untreated waste when discharged in to the lake water and silt deposition greatly alters the normal physicochemical characteristics of water and benthic soil

sediments, which in turn adversely affects the aquatic life and the lake ecosystem. Hence the present hydro-biological and microbiological study is undertaken which serves as good index in providing a complete and reliable picture of the conditions prevailing in the water body. The study of physico-chemical and microbiological parameters of the water of this lake may be useful in improving the quality of water for drinking and irrigation purpose and ultimately to human health.

Objectives

The objectives of the present study are:-

1. To measure physical parameters as temperature, pH, total hardness, TDS in the water of Jaisamand Lake.
2. To determine chemical parameters as dissolved Oxygen, BOD, COD, Alkalinity, Chloride, Fluoride etc in the water of Jaisamand Lake.
3. To find out microbiological parameters such as coliform bacteria in the water of the lakes.
4. To ascertain the application and significance of limnological and bacteriological parameters in drinking water, Irrigation and fishery purpose.

III. Methodology

The proposed research work will be carried out in 2015-16 with the help of following methodologies:

During the study, water samples will be collected at seasonal interval from 4 different places in the lake and mix them to make a composite sample. Water temperature shall be recorded in the lake with the help of mercury thermometer. The pH will be recorded with PH meter in the laboratory. Salinity and total dissolved solids (TDS) will be measured with the titration method in laboratory. Total hardness of carbonate and bicarbonate, Chloride, and Alkalinity will be determined by titration with EDTA, Silver nitrate and hydrochloric acid in the laboratory. For fecal coliform bacteria examination, samples will be collected in 125 ml pre sterilized (at 121ºc) borosil bottle and will be analyzed with multiple tube fermentation technique using Mc-Conkey broth media within 6 hours of sample collection. A standard plot will be made for counting and assessing the bacterial load by pure plate technique. Various statistical analyses like tabulation, Graph, correlation etc. will be performed with help of computer in order to ascertain the level of significance.

IV. Results and Discussions

Table 1: Physicochemical parameters of Jaisamand Lake during 2015-16.

parameters	Winter	Summer	Monsoon
Temp. (˚C)	17.5	32.1	22.8
pH	7.0	7.4	6.8
TH (mg/L)	237	250	195
TDS (mg/L)	1030	1440	793
DO (mg/L)	5.0	10.6	8.2
BOD (mg/L)	9.6	35.7	18.4
Free CO_2 (mg/L)	15.7	30.2	10.5
Alkalinity (mg/L)	445.1	848	580.3
Chloride (mg/L)	294.5	259	460
Nitrate (mg/L)	4.85	9.07	4.35
SPC	32000	52000	58000
TCC	748	1506	2455
FCC	340	446	2294

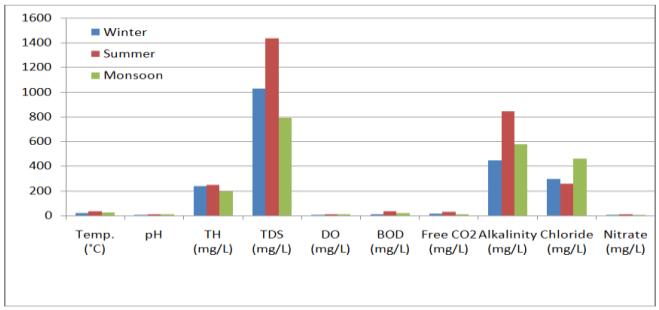

Fig1: Seasonal variations in physicochemical parameters

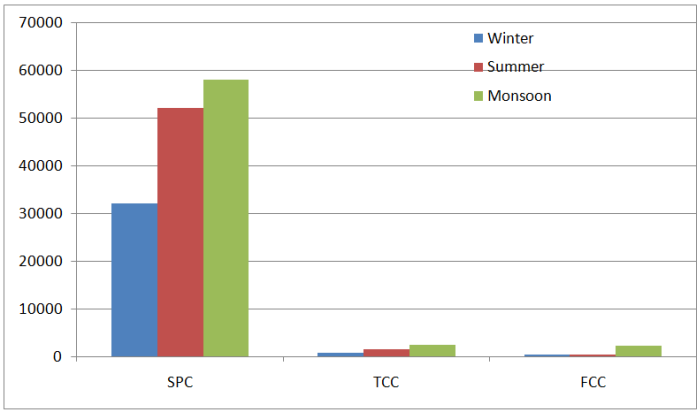

Fig2: Seasonal variations in bacteriological parameters

Table 2: Coefficient of correlation of various parameters of the lake

	Temp.	pH	TH	TDS	DO	BOD	Free CO_2	Alk.	Cl^-	NO_3^-	SPC	TCC	FCC
Temp.	1												
pH	0.76	1											
TH	0.37	0.88	1										
TDS	0.74	0.99	0.90	1									
DO	0.97	0.59	0.14	0.56	1								
BOD	0.99	0.78	0.40	0.75	0.96	1							
Free CO_2	0.81	0.99	0.84	0.99	0.64	0.82	1						
Alk.	0.99	0.78	0.40	0.76	0.96	0.99	0.82	1					
Cl^-	-0.31	-0.85	-0.99	-0.87	-0.08	-0.34	-0.81	-0.34	1				
NO_3^-	0.89	0.97	0.75	0.96	0.76	0.90	0.98	0.90	-0.70	1			
SPC	0.61	-0.03	-0.49	-0.06	0.78	0.59	0.04	0.59	0.54	0.20	1		
TCC	0.29	-0.38	-0.77	-0.42	0.51	0.26	-0.31	0.26	0.81	-0.16	0.93	1	
FCC	-0.10	-0.72	-0.96	-0.748	0.13	-0.13	-0.66	-0.13	0.97	-0.54	0.71	0.91	1

Temperature

The most common physical assessment of water quality is the measurement of temperature. Temperature impacts both the chemical and biological characteristics of surface water. All metabolic and physiological activities and life processes such as feeding, reproduction, movement and distribution of aquatic organisms are greatly influenced by water temperature (Gupta *et al.*, 2008). The temperature of Jaisamand Lake ranged from 17.5 (winter) to 32.2 ˚C (summer) throughout the period of investigation. Temperature showed positive correlation with pH, TH, TDS, DO, BOD, free CO_2,alkalinity, nitrate and negative with Chloride and FCC in the lake.

Higher temperature in the summer was probably due to greater solar radiations with scorching heat, longer day length, and clear atmosphere comparatively low water levels, increased load of suspended solids, soil particles of the lakes and decomposed organic matter in both the lakes water because suspended solids absorb more heat. Srivastava *et al.*, (2003), Ekeh and Sikoki (2003); Amakiri (2006); Banerjee and Mandal (2009) and Yadav *et al.*, (2012) have observed similar trends while working on the limnology of different water bodies.

pH

pH gives an idea of the concentration of the ionized hydrogen which in turn yields indirect information of free CO_2 content, alkalinity, dissolved oxygen, dissolved solids and thus may serves as test of several environmental conditions (Sheeja, 2005 and Yadav, 2012). pH of water is an important environmental factor that influence the metabolism of all the aquatic organisms. Generally neutral or slightly alkaline water pH (7.5) proved to be more productive and suitable for biota. A number of published data showed that there are positive relationships among the water quality parameters (Gupta and Mahrotra, 1986 and Qudri *et al.*, 1994). pH showed positive correlation with temperature, TH, TDS, DO, BOD, free CO_2, alkalinity, nitrate and negative with chloride, FCC, SPC and TCC in the lake.

The pH exhibit slightly acidic and alkaline nature of water and ranged between 6.8 (monsoon) and 7.4 (summer) in Jaisamand Lake. Minimum pH was found in rainy season and maximum in summer season in lake. Data represent a clear cut indication of alkaline nature of the Lakes. Slightly acidic nature of lake water in monsoon and winter could be attributed to reduced photosynthetic activity of phytoplankton and other higher plants and higher value of pH in summer was due to more utilization of bicarbonate and carbonate buffer system. Similar trends were reported by Ekeh and Sikoki (2003) in new Calabar River and Ansa (2005) in Adani

flats of the Niger Delta area Upadhyaya *et al.,* (2010); Yadav and Sahni, (2012) reported alkaline nature of Varanasi and Bhadohi Ponds.

Most of the biological processes and biochemical reactions are pH dependent. It is considered as an indicator of overall productivity that causes habitat diversity (Bhatnagar and Singh, 2010). pH is an important ecological factor. It is the result of the interactions of various substances in solutions and also of numerous biological phenomenons. The pH of water is very important indication of its quality and provides information in many types of geochemical equilibrium and solubility calculations (Hem, 1991). In water body's evaporation, amount of dissolved nutrients and gases, standing biomass of plants and animals, addition of organic matter from extraneous sources and influx of rain water are some of the important factors which determine pH in time and space. pH of water dependent upon the carbonates and bicarbonates. The water tends to be more alkaline if it possesses carbonates and it is much less alkaline when it possesses large quantities of bicarbonates, CO_2 and calcium.

Total hardness

The term 'hardness' is frequently used to assess the water quality and is governed principally by the concentration of calcium and magnesium and sometimes by iron and aluminum salts, which combined largely with bicarbonate and carbonate, sulphate, chloride and other anions of mineral acids. Iron and aluminum are generally present in negligible amount in water. Most of the calcium and magnesium were present in natural water as bicarbonate, sulphate and sometimes as chlorides and nitrates. Hardness producing substances react with soaps, forming insoluble compounds before lather is produced. They are thus a measure of soap consuming power of water. Temporary hardness is due to the presence of bicarbonates of calcium and magnesium which can be removed by boiling. Permanent hardness is mostly due to calcium sulphate and magnesium sulphate and that remains even after boiling. TH showed positive correlation with temperature, TDS, DO, BOD, free CO_2, alkalinity, nitrate and negative with chloride, FCC, SPC and TCC in the lake.

The highest value of hardness was found in monsoon (250 mg/L) and lowest (195 mg/L) in summer in the lake. The permissible limit of hardness for drinking water is 600 mg/L as per Indian standard. Hardness as such, has got no adverse effect on human health. Water with hardness above 200 mg/L may cause scale deposition in the water distribution system and more soap consumption

Total dissolved Solids (TDS)

Water, the universal solvent has large number of salts dissolved in it, which is largely governed by physicochemical properties and in turn have an indirect effect on aquatic organisms. TDS are the solids that are in dissolved state in solution. Water with high dissolved solids generally is of inferior palatability and may induce an unfavorable physiological reaction in the transient consumer. The total dissolved solids fluctuated between 793 and 1440 mg/L the lake which showed hard water character. Higher concentration of TDS might also due to discharge of sewage and organic matter by interference of man. Further total hardness exhibited a low value in monsoon season and high value in summer season. This observation is supported by Sumitra *et al.,* (2007). ISI has declared 500 mg/L as the permissible limit for TDS in drinking water. The lake TDS showed positive correlation with temperature, TH, DO, BOD, free CO_2, alkalinity, nitrate and negative with chloride, FCC, SPC and TCC in the lake.

Dissolved oxygen

Dissolved oxygen refers to the level of free, non-compound oxygen present in water. It is an important parameter for assessing water quality because of its influence on the organisms living within the water of lakes. A dissolved oxygen level that is too high or too low can harm aquatic life and affect water quality. Dissolved oxygen is necessary to many forms of life including fish, invertebrates, bacteria and plants. These organisms use oxygen in respiration. Bacteria and fungi also require DO to decompose organic material at the bottom of the lakes. According to the study, the low value of DO in the lake was 5.0 mg/L in winter and the highest value was observed 10.6 mg/L in summer in Jaisamand Lake. . The low value during the winter may be due to high load of suspended particles, soil particles and decomposed organic matter which reach the water and reduce the penetration of light that in turn lowers the photosynthesis. In winter O_2 holding capacity of water increases therefore rise in O_2 content seen in the winters. DO showed positive correlation with temperature, TH, TDS, BOD, free CO_2,alkalinity,nitrate and negative with chloride only.

Biological Oxygen Demand

Biological oxygen demand (BOD) is the amount of dissolved oxygen demanded by aerobic biological organisms to break down organic material present in the water at certain temperature over a period of time. It is found to be more sensitive test for organic pollution. The BOD value is most commonly expressed in milligrams

of oxygen consumed per litre of sample during 5 days of incubation at 20 ˚C and is often as a surrogate of the degree of organic pollution of water. Most natural lake water contains small quantities of organic compounds. Aquatic microorganisms have evolved to use some of these compounds as food. Microorganisms living in oxygenated waters use dissolved oxygen to oxidatively degrade the organic compounds releasing energy which is used for growth and reproduction. Populations of these microorganisms tend to increase in proportion to the amount of food available. This microbial metabolism creates an oxygen demand proportional to the amount of organic compounds useful as food. Fish and aquatic insect may die when oxygen is depleted by microbial metabolism. The amount of oxygen require to completely oxidize the organic compounds to carbon dioxide and water through generations of microbial growth, death, decay and cannibalism is total biological oxygen demand (Total BOD). BOD values of the lakes were ranged from 9.6 to 35.7 mg/L in Jaisamand Lake. The higher values of BODs were observed in summer and low in winter in the lake.

BOD of the lake showed positive correlation with temperature, TH, TDS, DO, free CO_2, alkalinity, nitrate and negative with chloride and FCC.

Free CO2

Carbon dioxide is highly soluble in water. The source of free carbon dioxide in water is not from the air phase because CO_2 is a product of aerobic and anaerobic decomposition of organic matter and it intimately bounds in the complex carbonate-bicarbonate equilibrium. CO_2 is an important component of the buffer system that influences carbonate and bicarbonate concentration in water. It is released during the decomposition of certain substances and metabolic activity of living organisms. The mean value of free carbon dioxide varied between 10.5 (Monsoon) and 30.2 mg/L (summer) in Jaisamand Lake.

Carbon dioxide exhibited an inverse relation with dissolved oxygen. A gradual rise in dissolve oxygen and fall of free carbon dioxide level had probably disrupted the equilibrium between these two gases. Higher level of free CO_2 concentration incommitant with increasing temperature during summer season might be due to the dumping of garbage in the lake and rapid decomposition of organic matter. This is strengthened by the observation of Joshi *et al.*,(1995): Sharma (1999); Sukund and Patil (2004) and Singh *et al.*,(2009) who have observed the addition of drainage to be the main causal factor for increase in carbon dioxide in water bodies. Free CO_2 showed positive correlation with temperature, TH, TDS, DO, BOD, alkalinity, nitrate and negative with chloride, FCC, and TCC in the lake.

Alkalinity

Alkalinity of any water body is mainly due to carbonates, bicarbonates and hydroxide ions. It is an index of nutrients status in water body. The total alkalinity fluctuated between 445.1 and 580.3 mg/L with the highest value in the monsoon and lower values in winter season in Jaisamand Lake. One important environmental consequence of alkalinity is the ability of a water body to withstand acidification due to acidic precipitation and atmospheric deposition. A water body may have a fairly neutral pH, but its alkalinity is low, it will readily be acidified. A body of water with same pH but with higher alkalinity will have greater buffer capacity and consequently, a greater resistance to acidification (APHA, 2005).

High alkalinity is a function of ion exchange that is calcium ions are replaced by sodium ions and later contributed to alkalinity (Sharma and John, 2009). Alkalinity is imperative for fish and aquatic life as it buffers against rapid changes of pH (Sheeja and Ebanasar, 2006). The observation was supported by the findings of Yadav and Sahni (2012). This parameter showed negative correlation with chloride and FCC in the lake.

Chloride

Chloride value ranged 259 (summer) to 460 mg/L (monsoon) in Jaisamand Lake. The peak chloride values during the early monsoon tend to increase sharply till the post monsoon approaches. The peak chloride value can be attributed to the surface run off, rich in animal origin and organic wastes. Sahni and Solutia (2011) have also found similar results during the study on Mansagar Lake, Jaipur. Chloride can be considered as one of the basic parameter of classifying water bodies polluted by sewage in to different categories. Chloride showed negative correlation with most of the physicochemical parameters but positive with microbiological ones.

Nitrate

Total nitrogen in the sediments comprises all types of organic nitrogen along with nitrates, nitrites and ammoniacal nitrogen. All dead animal and plant tissues release nitrogen to the soil and from the soil to the sediments. Nitrate is the oxidized form of nitrogen and is usually found in combined form of inorganic nitrogen in any water body. Nitrate is also an indispensible nutrient for aquatic flora as well as phytoplankton that establishes the productivity of ponds.

Nitrate concentration in the present study ranged from 4.35 (monsoon) to 9.07 mg/L (summer) in Jaisamand Lake. Total nitrogen in the sediments comprises all types of organic nitrogen along with nitrates, nitrites and ammoniacal nitrogen. During present investigation maximum values of nitrogen were found in

summer season probably due to decaying organic matter and depletion in water level of lakes while, minimum values were observed during winter season which may be due to dilution and stagnation of water level. These findings support to the observations of several workers (Kataria *et al.,* 1996; Singh and Jha, 1997; Majumdar *et al.,* 2006; Chaurasia and Pandey, 2007; and Manjare *et al.,* 2010). Nitrate showed positive correlation with temperature, pH, TH, TDS, DO, BOD, free CO_2, alkalinity and negative with chloride, FCC and TCC in the lake.

Bacteriological parameters

Coliform are bacteria that are always present in the digestive tracts of animals, including humans, and are found in their wastes. They are also found in plant, soil and water. Water pollution caused by faecal contamination is a serious problem due to the potential for spreading diseases from pathogens (disease causing organisms). Frequently, concentrations of pathogens from faecal contamination are small, and the number of different possible pathogens is large. As a result, it is not practical to test for pathogens in every water sample collected. Instead, the presence of pathogens is determined with indirect evidence by testing for an "indicator" organism such as coliform bacteria. Coliform come from the same sources as pathogenic organisms. Coliform are relatively easy to identify, are usually present in larger numbers than more dangerous pathogens, and respond to the environment, wastewater treatment, and water treatment similarly to many pathogens. As a result, testing for coliform bacteria can be a reasonable parameter for indicating the presence of other pathogenic bacteria in the lakes. All the bacteriological observations were recorded in MPN per 100 ml. of water sample.

Standard plate count

Standard plate count (SPC) for bacteria ranged from 32000 (winter) to 58000 (monsoon) in Jaisamand Lake. It is observed that the trends indicate higher bacterial population with the commencement of monsoon and relatively lower bacterial density during winter. This is in conformity observation of Singh (1985), Patralek (1992), and Mohan *et al.,* (2007). The higher bacterial population was obviously due to transport of organic matter from various sources through surface run-off from hills around the lakes (Sharma *et al.,* 2008). It showed very high level from the permissible limit as suggested by ISI. SPC was positively correlated with temperature, DO, BOD, alkalinity, chloride, nitrate and negatively correlated with pH, TH and TDS in the lake.

Total coliform count

Total coliform count (TCC) ranged from 748 (winter) to 2455 (monsoon) in Jaisamand Lake. It was also showed a very high level from the permissible limit as suggested by Pandey and Sharma (1999) for drinking water. 100 MPN (most probable number) per 100 ml. presence of *E. coli* in the water indicates that it has been contaminated with faecal material that may contain disease causing microorganism such as certain bacteria, virus and other parasites. TCC was positively correlated with temperature, DO, BOD, alkalinity, chloride and negatively correlated with pH, TH , TDS and nitrates in the lake.

Faecal coliform count

Faecal coliform count (FCC) ranged 340 (winter) to 2294 (monsoon) in Jaisamand Lake. Qualities of lake water have been reported to be unsatisfactory with FCC and other bacterial count due to far exceeding level recommended by ISI and WHO for drinking water. The lake water is not suitable for drinking and irrigation purpose as most of the physicochemical parameters were not in the optimal range. FCC of the lake were negetively correlated with most of the parameters.

Table 3: Permissible limits for water as recommended by ISI and WHO.

SN	Parameters	ISI permissible limits	WHO limits
1	Temperature	---	---
2	pH	6.5 - 8.5	9.2
3	Total hardness	300 - 600 ppm	500 ppm
4	TDS	500 - 2000 ppm	1500 mg/L
5	DO	3 - 7 ppm	---
6	BOD	0 – 5.0 ppm	30 ppm
7	Free CO_2	< 10 ppm (for surface water)	10 ppm
8	Alkalinity	200 - 600 ppm	500 mg/L
9	Chloride	250 - 1000 ppm	250 mg/L
10	Nitrate	45 – 50 ppm	10 mg/L
11	Standard plate count	10 / 100 MPN per 100 ml.	100 MPN/100 ml.
12	Total bacteria	0-100 MPN	100 MPN/100 ml.
13	Coliform bacteria	0-100 MPN	100 MPN/100 ml.

Table 4: Suggested values of coliform MPN/100ml. for water (Pandey and Sharma, 1999).

SN	Quality	Grade	Bathing and swimming	Public water supply
1	Excellent	I	<10	<100
2	Good	II	4	200
3	Satisfactory	III	250	800
4	Poor	IV	1500	1000
5	Unacceptable	V	>6000	>8000

V. Conclusion

The present study of physicochemical and bacteriological parameters of Jaisamand lake reveals that DO, BOD, CO2, SPC, TCC, and FCC were found in much higher amount in the lake. Temperature, pH, Total hardness, total dissolved solids, alkalinity, chloride and nitrates were within permissible limit as suggested by ISI and WHO in the lake. Hence, it can be concluded that both the lakes have become heavily contaminated and eutrophicated which leads to the lakes very unsafe for drinking, irrigation and fishery purposes and must be used only after suitable treatment processes.

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