Assessment of Water Quality of Lake Ana Sagar: A Threatened Water Body of Rajasthan, India

Jakir Hussain
National River Water Quality Laboratory, Central Water Commission, New Delhi,-110016 India
drjakirhussain@gmail.com

Ikbal Husain
Public Health Engineering Department, Laboratory, Bhilwara – 311001, Rajasthan, India

Mohammad Arif
Banasthali Vidyapeeth University, Banasthali, Rajasthan India

KEYWORDS
Ana Sagar lake, Water Quality, DO, BOD, Trace & Toxic metals, Domestic waste, Rajasthan

ABSTRACT
The lake Anasagar is a perennial shallow fresh water body situated in the center of Ajmer city (25°38' and 26°58' North latitude and 73°52' and 75°22' East latitude). The lake was made during 1135- 1150 AD by the then ruler Anaji Chouhan by constructing a dam across the river Luni and was named as Anasagar after his name. Around 35% population of Ajmer resides in the catchment area of the lake. It is degraded because of anthropogenic activities including input of detergents, agricultural activities, sewage disposal and human settlement around the lake. A study of Ana Sagar Lake in the Central Aravalli region was conducted for determination of physico-chemical, biological and microbiological characteristics relevant for eco-dynamic and hydro-biological processes. Domestic and agricultural wastes are major sources to contribute heavy organic loadings to Ana Sagar Lake. The Lake is organic, chemically affected by both domestic and agricultural having high degree of pollutant with high COD and BOD. Other pollutants include a variety of metals and other inorganic compounds, organochlorine residues and plant nutrients. The lake area is being encroached for housing which has reduced water spread. Besides use of chemical fertilizers (Nitrate and phosphate) in the lake corridor, pesticides are used by farmers for aquaculture and cultivation of other crops. This study has shown that the water of this lake are alkaline and that electrical conductivity, total dissolved solid and bicarbonate (HCO_3) are much higher than other fresh water lakes in Rajasthan. The high concentration of nutrients like phosphate, ammonia, nitrate and nitrite has observed in the Lake. Dissolved Oxygen (DO) is required to maintain the health of aquatic ecosystems. The dissolved oxygen level in Lake is less, which indicates reducing conditions in the lake due to discharge of sewage effluent resulting in the growth of anaerobic bacteria which may lead to fish mortality in the lake. Bacteriological investigations were also study by determining the MPN of coliform bacteria. The lake water was found to have a significantly higher coliform count with great fluctuations site to site. The trace & toxic metals (Cr, Cu, Pb, Zn, Fe and Ni) are present in greater amounts in the water of Lake Ana Sagar.

1. INTRODUCTION

Water is the most abundant and most useful compound in the world and hence it is called "Jeevan" in Sanskrit. Life is not possible without water and hence health is directly related with the quality of water. The contamination and pollution of water is of great concern in the world for the developing countries like India. Wetlands are vital water bodies, as crucial in a natural ecosystem as a kidney in a human body. Their role is complex and varied. Apart from being highly productive as the habitat of birds, fishes and a variety of other aquatic life forms, including microorganisms, wetlands provide other ecosystem services, from maintaining the natural balance to sustaining human livelihoods. Unfortunately, there has been much neglect of wetlands in recent times through lack of appreciation of their role and the pressures of growing human needs (agriculture, urbanization) and sheer mismanagement of land resources. There is also a misconception that wetlands are only wastelands. As a result, many precious wetlands have been sacrificed and converted to other uses throughout India and elsewhere in the world. This trend has to be checked and reversed for the greater good.

This problem assumes added significance, especially in a water stressed region such as Rajasthan, where it is vitally important to conserve every drop of rain. Rajasthan State is endowed with rich wetland resources that are also facing degradation by the aforementioned threats. The degradation in the water quality affects the floral and faunal population along with the people dependent on these ecosystems. Hence, the conservation of wetlands deserves the utmost attention.

The lake Anasagar is a perennial shallow fresh water body situated in the center of Ajmer city (25°28' and 26°58' North latitude and 73°52' and 75°22' East latitude). The lake was made during 1135- 1150 AD by the then ruler Anaji Chouhan by constructing a dam across the river Luni and was named as Anasagar after his name. Around 35% population of Ajmer resides in the catchment area of the lake. It is degraded because of anthropogenic activities including input of detergents, agricultural activities, sewage disposal and human settlement around the lake. A study of Ana Sagar Lake in the Central Aravalli region was conducted for determination of physico-chemical, biological and microbiological characteristics relevant for eco-dynamic and hydro-biological processes.

2. STUDY AREA

Ajmer region is ecologically significant as it forms a zone of confluence between North West and South East comparatively humid region. The catchments of Ana Sagar were built with the help of local populace. The Baradari pavilions were built by Shahjahan in 1637 and Daulat Bagh Gardens by Jehangir. The lake is spread over 1.3 Kilometres. The lake when full has an area of 384ha with max depth of 6 mts. The lake gets dry every summer. The Rajasthan High Court has banned construction in the catchments areas of the lake basins. This is one of the beautiful lakes in India. (Rajasthan Tourism 2007). The lake is severely affected by sewage disposal, washing of clothes and fertilizers used for agriculture activities in the adjacent lands. (Sharma & Sharma, 1992). Besides use of chemical fertilizers (NO_3 and PO_4) in the lake corridor, pesticides are used by farmers for Aquaculture and Cultivation of other crops. Trapa bispinosa is being cultivated as a cash crop which comprises about half of the area of littoral zone. A large area of catchments is being use for agriculture particularly for vegetables crop such as cauliflower, tomato, cabbage, brinjal, okra etc. Such activities lead to input of agrochemicals particularly pesticides, which are transported into the lake by run of water (Charan, et al., 2008)

3. EXPERIMENTAL METHODOLOGY

The water quality of the Ana Sagar lake is monitored by collecting the water samples from 10 locations. The sampling sites are selected in a grid pattern keeping in view the path of water flow in the lake from inflow channels to the outflow point. The list of sampling points with their abbreviation is shown in Table 1.

Various water quality tests were conducted in the field as well as in the laboratory to determine the physico-chemical, biological and heavy metal properties of the lake water using the standard methods (APHA 2012). The physical parameters temperature and chemical parameters such as pH and dissolved oxygen (DO) were determined in the field at the time of sample collection using portable water testing kit. Chloride concentration was determined by argentometric method in the form of silver chloride. Alkalinity was determined by the titrimetric method with the aid of phenolphthalein and methyl orange indicators. Calcium and magnesium were analysed by commplexometric titration. Fluoride, nitrate and ammonia concentration were determined by using Ion meter. Phosphate, boron, nitrite concentrations were determined using UV– VIS Spectrophotometer.

500ml of water samples were collected and immediately acidified with 2ml ultra pure nitric acid (1:1 or 50ml Con HNO_3 + 50 ml DW) and 2ml HCL for arsenic to bring down the pH to <2.0. The samples thus preserved were stored at 4^0C in sampling kits and brought to the laboratory for metal analysis. In the laboratory water samples were filtered through 0.45 µm membrane filter.

All the chemicals and reagents used were of analytical grade and were procured from Merck, India. The standard solutions of metals were obtained from Merck, Germany. Deionized water was used throughout the study. All glass wares and other containers were thoroughly cleaned and finally rinsed with deionized water several times prior to use. Trace metal analysis was carried out using Agilent 240 FS Atomic Absorption Spectrometer (AAS) following the standard methods given in APHA, 2012.

Table: 1- Location of Sampling Points

Sampling point	Location	Abbreviation
Ana Sagar 01	Behind NCC (Cloth washing)	S1
Ana Sagar 02	Mid of Lake (Rest)	S2
Ana Sagar 03	200 mt from Baradari	S3
Ana Sagar 04	Agriculture Activity	S4
Ana Sagar 05	Cultativation Activities	S5
Ana Sagar 06	Near Ram Nagar	S6
Ana Sagar 07	Nallah Near Baradari	S7
Ana Sagar 08	Baradari	S8
Ana Sagar 09	Ghat	S9
Ana Sagar 10	Near Nalah Vaishali Nagar	S10

4. QUALITY CRITERIA

As it is a well-known fact that the sources of usable water on the earth are limited, any kind of pollution in them will further reduce its availability. Polluted water cannot be utilized for drinking because of its inherent health risk. Water with high salt contents is not suitable for agriculture and most industries. The quality of water also interferes with the aesthetic and economic pursuits of water bodies by affecting marine and fresh water life. However, the water, which is not suitable for irrigation, may be quite suitable for industrial cooling. Every use of water requires a certain minimum quality standards with regards to the presence of dissolved and suspended materials of both chemical and biological nature. The desirable quality of water ensures no harm to the user.

To maintain the minimum quality standard for diverse user has led to the formulation of water quality criteria, and water quality standards. Water quality criteria can be considered as specific requirements on which a decision or judgment to support a particular use will be based. The criteria for the various uses are developed based on the experimental data, and our current knowledge of the health, ecology and other issues and assessing its overall economical effect these are not a set of fixed values, but subject to modification as the scientific data get updated and more and more knowledge is gathered. The term standard applies to any definite principle or measure established by an authority by limiting concentration of different constituents in water to ensure the safe use of water and safeguard the environment.

Drinking Water Standards

In view of the direct consumption of water by human beings, the domestic water supply is considered to be most important use of water and drinking use has been given first priority on utilization of water resource in the National Water Policy. In India, agencies like the Bureau of Indian Standards (BIS) and Indian Council of Medical Research (ICMR) have formulated drinking water standards. The World Health Organization (WHO) has also laid down drinking water standards, which are considered international standards. Values of the trace and toxic metals covered in this research paper and given in table 2 are according to BIS 10500, 2012 as given below.

Table 2: Drinking Water Standards for Trace & Toxic metals (BIS:10500;2012)

S. No	Toxic metal	Unit	Requirement (Acceptable Limit)	Permissible Limit in the Absence of Alternative Source
1	**pH**		6.5-8.5	No relaxation
2	**Total Dissolved Solid**		500	2000
3	**Ammonia**		0.5	No relaxation
4	**Boron**	mg/l	0.5	1.0
5	**Calcium**		75	200
6	**Chloride**		250	1000
7	**Fluoride**		1.0	1.5
8	**Magnesium**		30	100

S. No	Toxic metal		Requirement (Acceptable Limit)	Permissible Limit in the Absence of Alternative Source
9	**Nitrate**		45	No relaxation
10	**Sulphate**		200	400
11	**Total Hardness**		200	600
12	**Total arsenic as As**		0.01	No relaxation
13	**Cadmium as Cd**		0.003	No relaxation
14	**Total Chromium as Cr**		0.05	No relaxation
15	**Copper as Cu**		0.05	1.5
16	**Iron as Fe**		0.3	No relaxation
17	**Lead as Pb**		0.01	No relaxation
18	**Mercury as Hg**		0.001	No relaxation
19	**Nickel as Ni**		0.02	No relaxation
20	**Zinc as Zn**		5	15

5. RESULT AND DISCUSSION

The characteristics of water which has been accepted as sufficient to determine its suitability for different purposes are different and also they vary to a large extent. The concentration of hydrogen is measured on pH scale to determine the nature of solution i.e. acidic or alkaline. pH regulates most of the biological process sand biochemical reactions. During study pH value ranges from 9.21 to 9.65. pH value of all the sites are alkaline due to carbonate and bicarbonate. The maximum pH was recorded from source S7 whereas minimum was recorded from source S1. It is clear that pH values of Ana Sagar Lake are crossing the maximum desirable limits (8.5).

The electrical conductivity of the Ana Sagar lakes varies from 2260 to 3450 μmhos/cm. High electrical conductivity is found near site S_{10} near Vaishali nagar nallah. Due to the domestic waste of the Vaishali nagar nallah, it mixes with the Ana Sagar Lake near S_{10} site and electrical conductance increases. Total dissolved solids and specific conductivity of water has a high degree of correlation (>0.95) as both parameters indicate the amount of dissolved solid. Total dissolved solid of the Ana Sagar lake ranges from 1095 to 1889 mg/l. From table 3 it is clear that all the sources have the value between maximum desirable limit (500 mg/l) and maximum permissible limits (2000 mg/l). The effect of total dissolved solids on human is not studied so far as it has no individual identity. It is contributed by various dissolved ions hence it is difficult to predict the effect by total dissolved solids.

The hardness of water depends mainly on the presence of dissolved calcium and magnesium salts. The total hardness of the study area was observed in the range of 226 to 376 mg/l in source S_3 and S_1 respectively. Total hardness of seven sources (S_2, S_3, S_4, S_5, S_8, S_9 and S_{10}) found within maximum desirable limit (300 mg/l.), while remaining three sources are between maximum desirable limit and maximum permissible limit (600 mg/l.). No health are found to be associated with total hardness, however, the use of hard water may cause problems in its domestic use. It may scale in the pipes and obstruct lather with soap during washing. Sawyer classified the water on the basis of hardness as shown in table 3.

Table: 3 Classification Water for domestic purpose (Sawyer)[4]

S. No.	Class	Hardness as $CaCO_3$ (in mg/l)	No. of samples	Detail of sources
1	**Soft**	Below 75	0	
2	**Moderately Hard**	75-150	0	
3	**Hard**	150-300	7	**S_2,S_3,S_4,S_5,S_8,S_9,S_{10}**
4	**Very Hard**	Above 300	3	**S_1, S_6 and S_7**

According to this classification no source is soft and moderately hard. Seven Sources are hard and remaining three sources are very hard hence not suitable for domestic purpose. High value of hardness at Site S_6 and S_7 may be due to the domestic waste nallah. High values at site S_1 may be due to the addition of calcium and magnesium in the detergents, which are used for bathing and washing by the local people the increase in hardness may be attributed to the decrease in water volume and increase in rate of evaporation at high temperature (Kaur et al.,1996).

Calcium is the fifth most abundant natural element. It is an essential element for plant and animal life forms and is a major component of the solutes in most natural water. It is one of the major ions of water and is an absolute requirement of algae and plants. It plays an important role in affecting pH, carbonate and bicarbonate system. It regulates physiological function. In the present study calcium value ranges from 35 to 85 mg/l. All the sites were within the maximum desirable limit (75 mg/l) except site S_7**.** S_7 site has concentration between both limits (75-200 mg/l). Consumption of water containing up to 1.8 gm/l of calcium has been reported harmless. In case of suspected kidney or bladder stones high content of calcium and magnesium in drinking water should be avoided.

Magnesium is the eighth most abundant natural element. It is present in all natural waters and is a major contributor to water hardness. It is a common element and is essential in plant and animal nutrition. During the study magnesium varies from 28.4 to 53.2 mg/l. Three sources (S_6, S_7 and S_9) are within the maximum desirable limit (30 mg/l). Magnesium concentrations in remaining seven sources were found between maximum desirable limit and maximum permissible limit (100 mg/l). Magnesium has been considered as nontoxic to human at the concentration expected in water. Magnesium salt has a laxative and diuretic effect particularly for individuals not accustomed to high dosage.

Sodium and potassium are elements which harm human physiology if present in high concentration. The ratio of sodium to total cations is important for plant growth. Sodium, if present in high amounts in drinking water, may be harmful to individuals with cardiac, renal, and circulatory disease. Excess concentrations of sodium salts in drinking water can also be deleterious to animals and birds. Irrigation water with high sodium levels can bring a displacement of exchangeable cations (Ca, Mg) followed by replacement of the cations by sodium. The ratio of sodium ions to total cation contents can be used as an assessment of the suitability of water for irrigation. The ability of water to expel calcium and magnesium by sodium can be estimated by determination of Sodium Adsorption Ratio (SAR). In present study the concentration of sodium in water samples varied from 285 to 460 mg/l and high concentration of sodium is found near Baradari nallah and Vijay nagar nallah. Concentration of potassium varies from 46 to 170 mg/l.

The chloride concentration depends on the characteristics of the sediment and pollution load. High value of chloride is indication of their degree of pollution especially of human and animal origin. Sreenivasan (1965) also stated that low chloride contents indicated absence of any substantial pollution. Chlorides are usually present in low concentration in natural waters and play metabolically active role in photolysis of water and photophosphorylation relations in autotrophs. Chloride concentration in the study area ranges from 278 mg/l (S_7) to 503 mg/l (S_{10}). All the sources are between maximum desirable limit (250 mg/l) to maximum permissible limit (1000 mg/l). Higher value of chloride were noted may be due to suspended particles, agrochemicals, fertilizers, animals dung, leaves of plants, and other organic material joining the lake water and settled in the bottom from catchment area through surface runoff.

Fluoride is considered beneficial to human health if taken in limited quantity (0.5 to 1.5 mg/l). Fluoride prevents tooth decay by enhancing the remineralization of enamel that is under attack, as well as inhibiting the production of acid by decay causing bacteria in dental plaque. Fluoride is also a normal constituent of the enamel itself, incorporated into the crystalline structure of the developing tooth and enhancing its resistance to acid dissolution. But it is also known to cause dental, skeletal fluorosis, osteosclerosis, thyroid, kidney changes and cardiovascular, gastrointestinal, endocrine, neurological, reproductive, developmental, molecular level, immunity effects, if concentration is higher than 1.5 mg/l in drinking water. Fluoride concentration in the Ana Sagar Lake varies from 0.92 to 1.10 mg/l. All the sources are within the maximum desirable limit expect S_{10} site.

Ammonia in water is an indicator of possible bacterial, sewage and animal waste pollution. In the present study value of ammonia do not vary greatly, it vary from 1.25 to 1.50 mg/l.

Nitrate and nitrite are naturally occurring ions that are part of the nitrogen cycle. Nitrate is used mainly in inorganic fertilizers, and sodium nitrite is used as a food preservative, especially in cured meats. The nitrate concentration in groundwater and Surface water is normally low but can reach high levels as a result of leaching or runoff from agricultural land or contamination from human or animal wastes as a consequence of the oxidation of ammonia and similar sources. Anaerobic conditions may result in the formation and persistence of nitrite. Chloro-amination may give rise to the formation of nitrite within the distribution system if the formation of chloramine is not sufficiently controlled. The formation of nitrite is as a consequence of microbial Activity and may be intermittent. Nitrification in distribution systems can increase Nitrite levels, usually by 0.2–1.5 mg/l. In the present study concentration of nitrite vary from 0.01- 4.28 mg/l.

During the study nitrate varies from 18 to 85 mg/l as nitrate. Only one source has been found to have nitrate concentration above maximum acceptable. Major concentration of nitrate in lake is from catchments area by rainfall, sewage effluents agro waste suspended organic matter and decomposed organic matter and also when algae and other microorganisms die and settle to the bottom. The nitrogen is released from above sources and become available for subsequent of aquatic biota (Hart, 1956). Nitrate itself does not show toxic effect but in human body when it is reduced to nitrite, it creates various serious unhealthy effects. Nitrate has been found to react with nitro stable compounds to form N - nitroso compounds. Most of these compounds have been found to be carcinogenic. United State National Research Council (USNRC) has found an association between high nitrate intake and gastric and or Oesorphageal cancer. The major biological effect of nitrite in human is its involvement in the oxidation of normal hemoglobin to methaemoglobin, which is unable to transport oxygen. When the concentration of methaemoglobin reaches 10% of that of hemoglobin; the condition called *mathaemoglobinaemia* or *blue baby syndrome*, cause cyanosis and at higher concentration asphyxia. Such reports of other health disorder namely non Hodgkin's lymphoma has increased infant mortality and hypertension have also been recorded.

Ana Sagar lake phosphate concentration varies from 1.80 to 6.0 mg/l. Highest concentration was observed at Site S_7 (3.25 mg/l), S_{10} (4.0 mg/l) and S_4 (6.0 mg/l). High concentration at site S_7 and S_{10} in lake may be due to the discharge of pollutants from phosphorite sewage and domestic waste from human settlements. At Site S_4 may attribute to the main tributary which carries runoff from the agricultural fields surrounding lake using phosphate fertilizers.

Sulphate concentration of the study area was found between 149 and 387 mg/l. The maximum concentration (387mg/l.) was found in S_7 and minimum (149 mg/l) in site S_2. From table 3 it is clear that S_1 and S_2 sites are within the maximum desirable limit (200 mg/l). Remaining eight sources lies between MDL-MPL (200-600 mg/l). Dehydration has been reported by Final, 1980 as a common side effect of high sulphate consumption. Carthartic effects are also experimented on people consuming drinking water containing sulphate concentration more than 600 mg/l.

Boron is found frequently a naturally in groundwater, but its presence in surface water is consequence of the discharge of treated sewage effluent, in which it arises from use in some detergents, to surface waters.Boron is generally essential to plants, but concentrations of higher than 0.2 mg/L in irrigation waters is harmful for certain vegetation, and over 0.1 mg/ L may damage some greenhouse plants water generally contains less than 0.1 mg/L boron. In the present study boron concentration varies from 0.03 to 2.05.

Biological Parameters:

Dissolved oxygen is a basic requirement for a healthy aquatic ecosystem. Most fish and aquatic insects need DO to survive. Fish, especially larvae, will die when the DO levels get too low. Low DO is a sign of possible pollution in a water body. As DO levels in water drop < 5.0 mg/L, aquatic life is put under stress. The lower the concentration, the greater is the stress. Oxygen concentrations < 2 mg/L are considered hypoxic. In some cases, the water may lose all of its oxygen and become anoxic. Oxygen levels that remain hypoxic for a prolonged period can result in large fish kills. In present study value of dissolved oxygen is zero to 4.50 mg/l. This is probably due to high rate of decomposition of autochthonous and allochthonous organic matter in water which consumed oxygen in the process. Secondly at higher temperature the solubility of oxygen in water reduces and surplus oxygen is lost to the atmosphere.

Microorganism such as bacteria is responsible for decomposing organic waste. The presence of organic matter such as dead plants, leaves, manure, sewage or even food waste in the water initiate the process of bacteria breaking down this waste. When this happens, much of the available dissolved oxygen is consumed by the aerobic bacteria, robbing other aquatic organisms of the oxygen they need to live. BOD is an indicator of the potential for a water body to become depleted in oxygen and possibly become anaerobic because of biodegradation. During present study BOD range from 6 to 85 mg/l. The highest BOD value was at station S_{10} and the lowest was at station S_2 mg/l. The high BOD in the lake due to high decomposition activity of microorganisms acted on dead aquatic plants, sewage and organic fertilizer.

The COD is one of the most important parameters to assess the quality of water and is the most reliable also. It may serve as quite a useful pollution index of the water and is widely used as a means of measuring the organic strength of domestic and industrial wastes. COD is a measure of oxygen consumed by a strong chemical oxidant while oxidizing the available organic matter. The chemical oxygen demand value in the lake water varies from 9 to 120 mg/l. The highest concentration 120 mg/l was measured at S_{10} whereas the lowest concentration 9 mg/l at site S_2.

HEAVY METALS:

The highest concentration of Arsenic was recorded at Site S_9 (13.78 ppb) and the lowest concentration was recorded at Site S_7 (8.38 ppb). Some organic arsenic compounds are beneficial as a growth stimulant for animals. In the environment, arsenic is combined with oxygen, chlorine and sulphur to form inorganic arsenic compounds. Arsenic in plants and animals combines with carbon and hydrogen to form organic arsenic compounds. Inorganic arsenic is the toxic form of arsenic for humans. It is a known carcinogen. Inorganic arsenic is more toxic than organic arsenic is more hazardous than the pentavalent form.

It is widely distributed in soil, water and biological materials. It is known to cause a painful human disease itai – itai (Agarwal et al.1976) the toxicity further increases with the increase in pH of the system. it is toxic to plants (Hunter and vergano,1953; Pratt,1966, Handa et al .1985), animals fish and carcinogenic to human. The highest concentration of Chromium was recorded at Site S_6 (3.85 ppb) the lowest concentration was recorded at Site S_7 (1.7 ppb). The concentration of serum cholesterol also correlated negatively with the chromium in drinking water. Chromium is generally toxic to algae and other aquatic plant like Lemna minor.

Although Nickel is found in two oxidations state Ni^{+2} and Ni^{+4} but according to Latimer (1925), in aqueous chemistry, nickel is concerned with Ni^{+2} oxidation state. The solubility of Nickel in water is low, hence found in low concentrated. The highest concentration of nickel was recorded at site S_3 (9.05 ppb) and the lowest concentration was recorded at site S5 (3.74 ppb). The primary acute effect of nickel exposure is dermatitis, including contact dermatitis, atrophic dermatitis, and allergic sensitization.

The free cadmium ions are highly toxic to most plants and animals. Concentration of Cadmium is very low at all sites of lake and varies from 0.335 to 0.01ppb. All the samples are within the acceptable limit.

Copper an essential element in plant and animal metabolism occurs in the earth crust as the free native metal. The Concentration of copper ranged from 4.87 to 15.31µg/L. The highest concentration of copper was recorded at site S_6 (15.31 µg/L) and the lowest concentration was recorded at site S_1 (4.87 µg/L). The Bureau of Indian Standard IS: 10500:2012 guidelines for maximum permissible limit of copper is 0.05 mg/l and permissible limit in the absence of alternative source is 1.5mg/l. All the sources have copper concentration within the acceptable limit.

Level of lead in water varied between 15.73 - 20.18 µg/l. The highest concentration of lead in lake was recorded at site S_3 (20.18 µg/l) and the lowest concentration was recorded at site S_1 (15.73 µg/l). The BIS acceptable limit is 0.10 mg/l (10µg/l). The range obtained in this study exceeds that of BIS standard hence making the water unsuitable for drinking use. The use of the lake water for drinking purpose by human and animals could lead to accumulation of the metal with resultant ill health effects. Chronic exposure to lead has been linked to growth retardation in Children (Schwartz et al., 1986).

Although Iron is the second most abundant metallic element in the earth's outer crust, concentration present in water generally is small. As far as is known, human suffer no harmful effect from drinking waters containing iron. Such water when exposed to the air, so that oxygen can enter becomes turbid and highly unacceptabale from the asthetic view point owing to the oxidation of iron to the Fe [III] which forms colloidal precipitates. The rate of oxidation are not rapid and thus reduced from can persist for some time in aerated waters. This is especially true when the pH is below 6. The rate can be increased by certain microorganisms. Presence of iron at higher level interferes with laundering operations, plumbing fixtures difficulties in distribution system by supporting growth of iron bacteria. In the present study the lowest concentration of Iron is found at Site S_7 (0.03 mg/l) and highest concentration at Site S_8 (0.14 mg/l).

6. CONCLUSION

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 pilgrims 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.

Table 3 . Analysis Results of Ana Sagar Lake

Parameters	Unit	S 1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH		9.21	9.3	9.21	9.49	9.57	9.59	9.65	9.55	9.59	9.61
EC	**µmhos/cm**	2585	2260	2530	2400	2550	2751	3250	2774	2849	3450
Potassium	**mg/l**	95	46	88	110	171	153	170	145	169	166
Sodium		320	300	434	285	295	342	411	340	380	460
Calcium		72	44	39	66	63	74	86	61	57	56
Magnesium		47	32	31	3	32	29	28	33	29	53
Ammonium(N)		1.50	1.20	1.10	3.25	1.50	1.50	1.50	1.25	1.50	1.20
Carbonate		37	22	36	13	19	54	48	39	48	55
Bicarbonate		316	269	323	278	375	330	450	268	438	432
Fluoride		0.97	0.96	0.97	0.99	1.00	1.00	0.92	1.00	1.00	1.10
Chloride		370	305	405	382	327	308	278	313	372	504
Sulfate		163	149	210	250	295	275	388	300	262	305
Nitrate(N)		30	30	22	85	30	18	45	32	22	40
Nitrite(N)		0.13	0.13	2.33	4.28	2.10	0.10	2.80	4.05	2.20	2.08
Phosphate		6.90	3.25	3.03	2.80	3.00	3.03	4.50	2.68	3.03	4.69
Silicate		27.39	24.99	32.27	25.54	21.09	18.16	18.91	20.22	25.49	26.42
Boron		1.63	1.40	1.05	1.93	1.38	1.83	1.75	2.05	1.68	1.00
Trace & Toxic Metals											
Arsenic	**µg/L**	11.33	11.4	11.98	8.19	10.16	12.19	8.38	10.05	13.78	12.25
Lead		15.73	17.64	20.18	16.04	16.42	15.96	16.99	15.74	16.11	13.47
Copper		4.87	14.71	10.24	10.42	7.48	15.31	9.51	9.55	9.38	10.68
Cadmium		0.01	0.02	0.02	0.149	0.335	0.211	0.02	0.108	0.17	0.17
Chromium		2.65	2.05	2.08	3.04	2.3	3.85	1.7	1.48	2.06	1.18
Nickel		6.29	7.82	9.05	6.11	3.74	5.39	4.47	7.97	6.14	6.28
Iron	**mg/l**	0.08	0.08	0.12	0.05	0.06	0.11	0.04	0.14	0.11	0.12
Biological Parameters											
Dissolved Oxygen		1.20	4.50	0.95	0.00	0.00	1.10	0.00	0.00	0.00	0.00
Biochemical Oxygen Demand		20.4	6.0	37.3	68.2	40.6	48.3	70.5	75.0	65.0	85.0
Chemical Oxygen Demand		8.1	9.0	45.0	75.0	75.0	65.0	85.0	89.0	79.0	120.0
Hardness		376	242	226	290	290	305	333	289	261	262
% Sodium		58.31	68.48	73.59	59	55	59.76	61	60	63	63

7. REFERENCES

APHA, 2013. Standard Methods for the Examination of Water and Wastewater 22nd (Edition). American Public Health Association Washington, DC.

Bureau of india Standards(BIS)10500, 2012: Specification for drinking water, Indian Standard Institution, (Bureau of Indian Standard), New Delhi, 1-5.

Sharma, K.C. and Sharma, R. 1992. Algal Diversity in the littoral zones of a polluted shallow lake at Ajmer, Rajasthan. Int. J. of Eco. and Env. Sci. . 18:139- 146.

Charan, P.D., Patni, A. and Sharma, K.C. 2008. Pesticide contamination in Lake Anasagar of Ajmer, Rajasthan, Procedding of Taal2007: The 12th World Lake Conference: 360-365.

Kaur, H., Dhillion, S.S., Bath, K.S. and Mander, G. (1996). Abiotic and biotic components of a fresh water pond of Patiala (Punjab). Poll. Res., 15(3): 253-256.

Sreenivasan, A. 1965. Limnology of tropical impoundments III. Limnology and productivity of Amaravathy reservoir (Madaras State) India. Hydrobiologia, 26:501-576.

Sharma, K.P., Goel, P.K. and Gopal, B. 1978. Limnological studies of polluted fresh water. Phydico-chemical characteristics, int. J. Ecol. Environ. Sci., 4:89-105

Kodarkar, M.S., 1995. Conservation of lakes, case study of five lakes in and around Hyderabad, Andhra Pradesh, India. *Indian Association of Aquatic Biologists (IAAB)*, Publ. 3. Hyderabad. PP : 85.

Srivastava N., M. Agrawal, and A. Tyagi. 2003. Study of physico- chemical characteristics of water bodies around Jaipur, Journal of Environmental biology 24:2, 177-180.

Rajasthan Tourism Development report, India Planning Commission,Academic Foundatrion,2007, 200- 207.