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# WATER QUALITY MANAGEMENT PLAN FOR REJUVENATION OF SAGAR LAKE

**Final report**
**(2005-08)**

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# PREFACE

Lakes have always been playing an important role to mankind since ancient times. Lakes provide water for domestic, industrial and irrigation purposes besides providing a place for sanctuary for migrating birds, development of flora and fauna and an excellent spot for habitation of aquatic biota, which are important for maintaining ecological and environmental balance. Degradation of lake water quality and its consequent affect may cause a serious problem to the area to which the lake provides a socio-economic and socio-ecological support.

The Sagar lake located in the Sagar town in M.P., which is considered to be the lifeline and is the main source of drinking water supply to the town, has been reported to be under the grim of deterioration in many folds; such as, water quality and sedimentation on the lake's bed. Increasing population and the rising demand of water call upon for a comprehensive study covering water quality management and restoration of health of the lake.

With that in view, the Ganga Plains South Regional Centre of the Institute located at Sagar has carried out the study of water quality of the Sagar lake including evolving an appropriate water quality management plan under its in house work programme. The report entitled "Water Quality Management Plan for Rejuvenation of Sagar Lake" prepared by Dr. Surjeet Singh, Sc-C; Sh. R.V. Galkate, Sc-C; Sh. T. Thomas, Sc-B and Sh. R.K. Jaiswal, Sc-B under the guidance of Dr. N. C. Ghosh, Sc-F is the outcome of the study carried out during the period 2005-08.

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# ABSTRACT

The Sagar lake situated in the Sagar town of Madhya Pradesh state is famous for its historical importance. It is considered to be the lifeline of the Sagar town, in terms of providing drinking water supply and in maintaining the town risk free from environmental hazards. The health of the lake since last two-three decades has severely been deteriorated and is under threat of further deterioration because of uncontrolled and unabated human interventions on it and its catchment. The quality of lake water is primarily being deteriorated because of flora and fauna farming, accelerated developmental activities in the lake catchment, disposal of city wastewater as well as sewage through a number of septic tanks in the surroundings, and considerable silt inflow through the Kanera canal which feeds to the lake during the monsoon season.

The lake has a periphery of 5230 m with a maximum length of 1247 m and width of 1207 m. Mean depth of the lake is 2.69 m with a maximum depth of 5.3 m at full-capacity level. The lake is divided into two parts, the main lake with water spread area of 107.7 ha at full-capacity level and the other part of the lake with water spread area of 37.03 ha. The volume of the lake is 389 ha-m at full-capacity level. The catchment area of the lake is 1817 ha, out of which the water spread area is 145 ha.

In order to assess the physico-chemical constituents of the lake water, twelve parameters, viz. temperature, transparency, pH, dissolved oxygen (DO), alkalinity, hardness, nitrate, chloride, phosphate, iron, total dissolved solids and fecal coliform have been analyzed from the samples collected bimonthly during the period 2006 to 2008 from twenty-one locations, at three different depths in each location, of the lake. The lake water has been found yellowish green and has high algal activity. The transparency and dissolved oxygen of the lake water have been found extremely low. DO, BOD, iron contents have been found beyond the permissible limits in respect to the Class A categorization of IS:10500 standards and hence the lake water has been found unfit to use for drinking water purpose. A comparison of the present status of lake water with the status of the water quality of the lake in the year 1990 showed that the pollution level of the Sagar lake has increased considerably over the past eighteen years. The high

concentrations of nitrogen and phosphorous has put the lake into the hyper-eutrophic state. The analysis of seasonal variation indicated that the concentration of chloride, nitrate and iron have increased during summer and decreased during monsoon season due to dilution of lake water. The analysis of annual variation of water quality constituents indicated that transparency and dissolved oxygen followed the decreasing trend while alkalinity, nitrate, phosphate and iron contents followed increasing trend. An overall water quality index has been developed based on the water quality standards set by various agencies to categorize the water quality status of the lake. It has been found that the lake water is of poor quality suggesting unfit for drinking water purpose. The lake water quality has been found to reach the alarming stage and thus needs urgent attention for its restoration. For rejuvenation of the Sagar lake, a water quality management plan has been suggested.

## 1.0 INTRODUCTION

There are about three million lakes on the earth and more than 70% of the world's fresh water occurs on three continents - North America, Africa and Asia. Generally, lakes receive water as precipitation on the surface, through runoff to sea and from the groundwater entering as springs. The total area of all the lakes on the earth is 2.7 X $10^6$ $km^2$ and their total volume is 1,66,000 $km^3$. A lake is an inland body of water filled or partially filled by water whose surface dimensions are sufficiently large enough to sustain waves capable of producing a barren, wave- swept shore. Lakes are either manmade or natural reservoirs which store water during its passage to sea. Lakes are formed by some geological processes like subsidence, large scale faulting, damming valleys by rock falls, gorging action of glaciers, etc. As a summary, a water body should fulfill the following requirements to be a lake:

(i) It should fill or partially fill a basin or several connected basins.

(ii) It should have essentially the same water level in all parts with the exception of relatively short occasions caused by wind, thick ice cover, large inflows, etc.

(iii) It should have so small an inflow to volume ratio that a considerable portion of suspended sediment is captured.

(iv) It should have a size exceeding a specified area, e.g. 0.01 $km^2$, at mean water level.

Being the valuable natural resource, lakes have always been of great importance to mankind. From ancient times they have been providing water for domestic purposes. Since long, lake water is being used for industrial and irrigation purposes. Lake is also one of the means of transport and has always attracted the attention of human beings from the recreational point of view. Lake is also a place for sanctuary for migrating birds, development of flora and fauna and an excellent spot for habitation of aquatic biota, which are important for maintaining the ecological and environmental balance and the hydrological cycle. Some of the saline lakes are also useful sources of important minerals. In short, a lake is a sort of catalyst in the development of a city, region or a country as a whole. Where natural lakes are absent, man has constructed artificial reservoirs for water storage, flood control, hydroelectric power generation and other purposes.

In a global prospective, the most important problems concerned with lakes are:

(i) Lowering of lake level due to excessive use of water.

(ii) Rapid siltation caused by accelerated soil erosion in the catchment.

(iii) Acidification of lake water due to acid precipitation.

(iv) Concentration with toxic chemicals.

(v) Eutrophication.

(vi) Disintegration of aquatic system is a possible end result of any of the above.

Knowledge of the hydrology of lakes is essential for their proper use and conservation. Water quality is also closely linked to water and energy budgets, mixing, stratification and other physical aspects of lakes. The quantitative estimation of the thermal and biological processes is impossible without a morphometric description of a lake.

Hydrologic characteristics of lakes vary because of variation in depth, width, surface area, basin material, surrounding ground cover, reservoir, prevailing winds, climate, surface inflows and outflows and other factors. Therefore, each lake requires its own hydrological models and these models need to be characterized by different degree of variance from a generalized conceptual model.

The physico-chemical characteristics of a lake provide first hand information about the state of the quality of lake water. These characteristics include the measurement of pH, conductance, temperature, dissolved oxygen, turbidity, transparency, alkalinity, hardness, chloride, sulphate, nitrate, etc. The water quality of lake depends upon a number of parameters and is influenced by a wide range of natural and man-made operations. Each lake develops its own response to these combined factors causing major variations of water quality in both space and time.

## 1.1 Threats to the Sagar Lake

The Sagar lake is suffering from various problems:

- Siltation in the lake

- Deterioration of lake water quality
- Diminishing lake life
- Spreading of water borne diseases in the surroundings
- Encroachment of the lake area
- All the inflow pollutants and silt trapped into the lake

### 1.2 Need and Scope of the Study

The quality of lake water has severely deteriorated and reached to the alarming stage. The causes of deterioration of the lake are manifold. The quality of water is deteriorating because of trapa and lotus farming in the lake water, more and more developmental activities in the lake catchment, entry of city waste water as well as sewage through a number of channels, and heavy silt inflow through Kanera canal during the monsoon season. On the other hand, the need of water is increasing day by day. Therefore, there is a strong need for the study on the aspects related to the quality of lake water for better management and restore the health of the Sagar lake.

Keeping in view the above aspects, the water quality study on the Sagar lake is undertaken. Since the study involves a variety of data on various aspects such as geographical, geological, meteorological, hydrological, etc, and their processing, analysis and interpretation in various forms, the complied data and outcome of the study will be very much helpful to cope up with manifold problems of the lake and its proper management. The outcome of the study will help in

(i) Proper management of the lake water quality
(ii) Conservation of the valuable lake water
(iii) Favourable ecosystem and recreation
(iv) Recharging of surrounding wells with good quality water
(v) Providing valuable information base
(vi) Development of a comprehensive water quality management plan for the lake conservation

### 1.3 Objective of the Study

The present work was undertaken to see the suitability of water for various designated uses and conservation of lake and will be aimed:

- to prepare a database information
- assessment of water quality parameters of the lake and nalahs
- to assess the extent of contamination
- to identify the point and non-point sources of pollution
- to study seasonal and annual variation in the lake water quality
- development of overall water quality index
- to suggest a comprehensive water quality management plan for lake conservation

## 2.0 STUDY AREA

Sagar lake is situated in the middle of Sagar city. Sagar city falls a few kilometers to the North of Tropic of Cancer at an altitude of 517 m above MSL in the Bundelkhand region and at the latitude of 23° 50' N and longitude of 78° 45' E. The rocky and hilly terrain of the district is having north-west drainage (Krishnan, 1967). The climate of this region can be distinguished broadly into three seasons viz. summer (March to June), Monsoon (July to October) and Winter (November to February). The monsoon rainfall starts normally in the last week of June and continues up to October. The Sagar lake is divided into two parts, the main lake and small lake. Both the lakes are mutually connected by a bridge. The lake has a number of small inflowing channels carrying city wastewater and has single outflow section as Mogha weir. The northern, western and eastern shores of the lake are well guarded against encroachment and erosion due to the presence of buildings and fences. But the southern, south-eastern and part of south - eastern shores are open. Thereby large quantity of silt from the uphills is being washed into the lake during the rainy season.

There are numerous major drainage inlets apart from innumerous small inlets from housing colonies, hospitals, workshops, beedi factories, agricultural fields and runnels from the roads. Large number of temples along the shore indicates the extent of religious sentiments attached to the lake. Occasionally it can be seen that urns containing ashes are being deposited in the lake. Apart from religious ablutions, large number of people is daily taking bath as well as washing clothes. The southern and south-eastern part of the lake is being used for washing cattle and the cattle are allowed to wallow at the shallow regions of the lake. Laundry men are using huge quantity of bleaching powder for washing along with other detergents. This is a common phenomenon throughout the year. In the cultivating areas of the lake, people are using pesticides indiscriminately besides the addition of fertilizers (Yatheesh, 1990).

Climatically, the area falls under semi-arid to sub-tropical region. Monsoon rains are received from June to September and the winter rains during December to February. The vegetation of the Sagar district can be included under Northern tropical dry deciduous forest (Krishnan, 1967). The average annual rainfall is nearly 110 cm. Air temperature varies between 5 °C (minimum) in winter to 43 °C (maximum) during peak summer.

## 2.1 Origin of the Lake

The lake under investigation is two hundred years old. Historical records assign an artificial origin whereas geological evidences are in favour of natural origin (Mishra, S.K., 1969). Geological evidences also say that originally the lake had an area of 580 hectares as against the present 145 hectares and the maximum depth was about 60 feet as against the present depth of about 16 feet (Yatheesh, 1990).

## 2.2 Geology

The geological formation of the lakebed mainly comprises of quartzite sandstone of Vindhyan age and Deccan traps. The Deccan traps are basaltic in nature having vertical, polygonal and columnar joints. The Vindhyan quartzite sandstone is hard and compact with nearly vertical joints. These joints behave like channels for water infiltration. The ground water recharge is very poor, i.e., only 10 to 15 % of the total rainfall is percolated to the ground water (Krishnan, 1967).

### 2.3 Soils

The soils of this area are of two types - the red or reddish brown lateritic soil on hilltops and the black soil at the foothills.

### 2.4 Morphometric Characteristics

The lake under investigation has a periphery of 5230 m with maximum length 1247 m and width 1207 m. Mean depth of the lake is 2.69 m with maximum depth of 5.3 m at full tank level. The lake is divided into two parts, the main lake with water spread area of 107.7 ha at full tank level and the small lake with water spread area of 37.03 ha. The volume of the lake is 389 ha-m at full tank level (Table 1). The catchment area of the lake is 1817 ha, out of which the total water spread area is 145 ha. at full tank level. The lake has north-west drainage pattern in concordant with that of the district (Krishnan, 1967). The land use pattern of the lake basin is 40.9 % barren land, 20.9 % agriculture, 18.7 % settlement, 11.5 % open forest and 8.1 % water body. The index map and contour map of the Sagar lake are shown in Figure 1 and 2.

## 3.0 RESUME OF PREVIOUS WORK

Most of the scientific studies carried out on the Sagar lake have concentrated on the physico-chemical properties of the lake water and the possible inter-relationship and interactions between their properties and biological factors like plankton, macrophytes, macrofuna, etc. The first study of this kind on the micro-biological aspects was published in the year 1975 (Adoni, 1975). Thereafter a number of studies on the lake water were published in the year 1980 (Awatramani, 1980), 1986 (Yadav, 1986) and 1990 (Yatheesh, 1990). Among these studies, most of them are Ph.D. thesis available in the university library and some are state govt. publications.

Among the studies on the Sagar lake, diurnal variations have been studied by Saxena and Adoni (1973), Thakur and Bais (1986) and Joshi (1987). Studies related to Macrophytes have been done by Singhal (1980) and Yadav (1986) and Yatheesh (1990) has studied the trophic status with special reference to macro-benthic-invertebrates. Awatramani (1980) and Ghosh (1986) have done limnological studies of some aquatic ecosystems of Sagar lake. Some ecological studies on and surrounding the lake have been done by Saran (1980), Babu and Tamrakar (1987) and Gupta (1987). Thakur and Bais (1986 & 1987) has conducted chemical analysis of lake water. Awarwal and Bais (1991) have done the hydro-biological study on the lake. The general observations of these studies show a high trophic status and a high organic pollution level in the Sagar lake. Recently one status report has been prepared by Sinha and Thakural (1998). In this report, efforts are made to compile all possible published work on the Sagar lake. This includes brief description of the histrological and the geographical background of the lake, details of water quality analysis carried out in various years, present status of the lake and various schemes proposed and implemented for the improvement of pathetic condition of the lake. These studies done on the Sagar lake have focused on biological, chemical and ecological aspects.

Singh and Thakural (2005) have conducted a water balance study on the lake and estimated various inputs, outputs and storage of the lake. Singh et al. (2008a) have estimated the sedimentation into the lake at the rate of 0.58±0.028 cm/year and 467 years life of Sagar lake using the radiometric dating techniques. Singh et al. (2008b) have also conducted a comprehensive study on various hydrological aspects including the water quality aspects and concluded that the pollution level of the Sagar lake is increasing at an alarming rate. Singh et al. (2008c) have done a preliminary water quality study on the Sagar lake and concluded that the trophic status of the lake has greatly increased since 1990 and the lake water has become unsuitable for drinking, bathing as well as fish culture and urgent attention is required for its restoration.

Gupta et al. (2008) have suggested sustainable conservation and management of lakes in Rajasthan. Implementation of conservation measures will result in increased lake storage capacity, improvement of water quality, increase in avi-fauna and bio-diversity, increase in tourist in-flux and increase in revenue of local bodies. Khobragade et al. (2008) have reviewed the history and status of lake related research in India with particular emphasis on hydrological aspects. Trends in the lake research in India have been described along with the various issues and challenges. Specific suggestions for directing the future research activities have also been made. Lanjewar and Harkare

(2008) have discussed about the analysis of the water quality of the lake and suggested the means to improve the water quality through eco-remediation measures. Ladwani and Ladwani (2008) have suggested various management practices and control measures to improve the water quality for the lakes suffering phosphorus and have highlighted the sources, impacts and control measures of phosphorus in the lake water. Pokale et al. (2008) have shown the impact on water quality due to human interference on Saleem Ali lake at Aurangabad and have highlighted to create awareness regarding water quality in and around the Lake and become important reference material for administrative and educational institutions. Joshi and Arora (2008) have discussed the Sukhna lake rejuvenation through watershed management. Joshi, et al. (2008) have highlighted the management strategies being adopted to conserve Sukhniwas lake at Indore.

***Table 1. Area and volume of Sagar lake at different depths***

| **R.L.** | **Area** | **Volume** |
|---|---|---|
| (MSL) | (1000 $m^2$) | (1000 $m^3$) |
| 520.385 | 23.2 | 7.7 |
| 521.385 | 34.6 | 19.3 |
| 522.385 | 248.1 | 144.3 |
| 523.385 | 447.2 | 487.1 |
| 524.385 | 889.4 | 1,139.9 |
| 525.385 | 1,193.5 | 2,168.4 |
| 526.385 | 1,370.3 | 3,446.5 |
| 526.700 (FTL) | 1,449.1 | 3,890.5 |

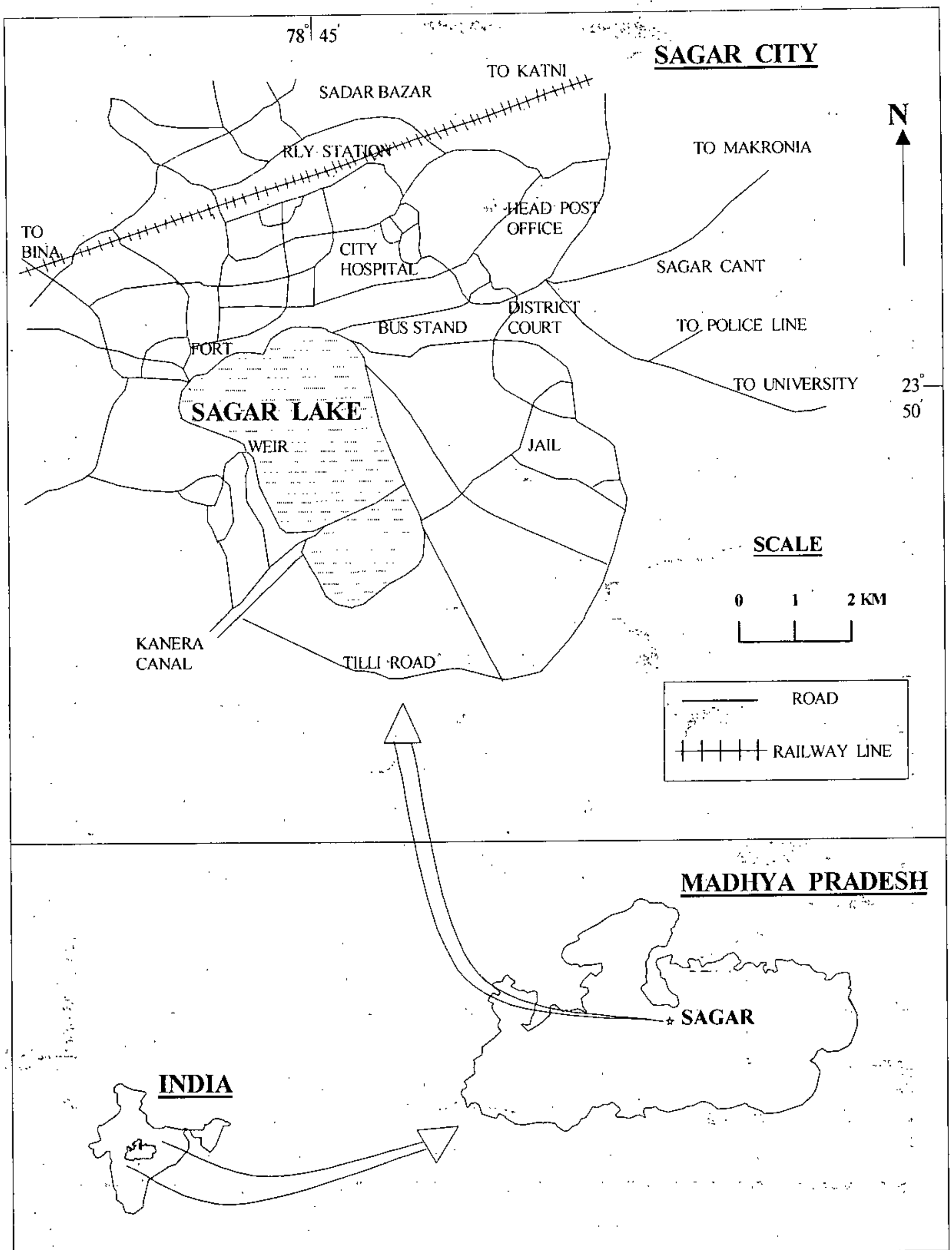



**Figure 1. Index map of the Sagar lake**

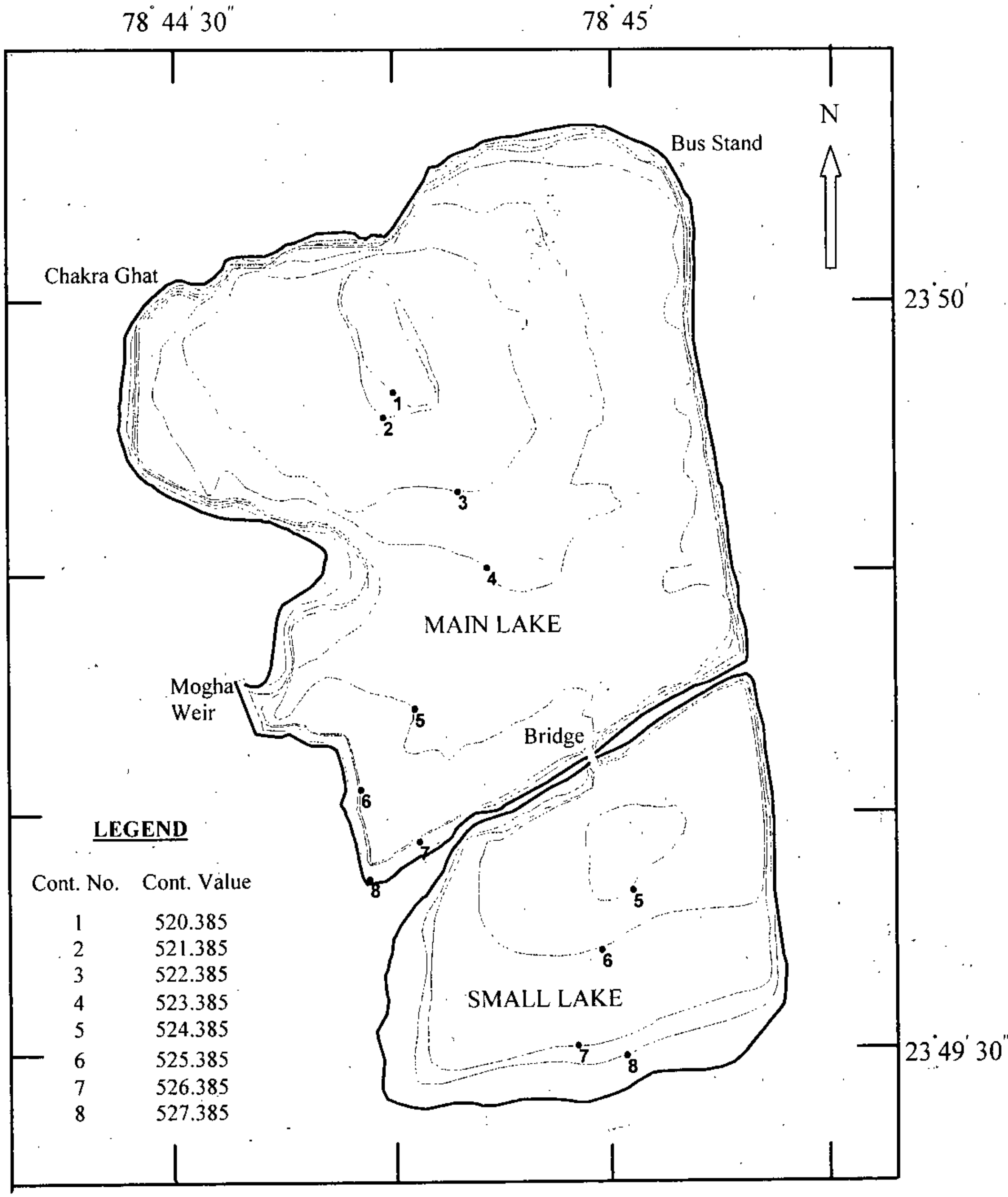



**Figure 2: Contour map of the Sagar lake**

# 4.0 MATERIALS AND METHODS

## 4.1 Sampling and Preservation

Sampling is one of the most important and foremost steps in collection of representative water samples for water quality studies. Moreover, the integrity of the sample must be maintained from the time of collection to the time of analysis. The hydrologist must also be aware of the locations of point and non-point sources of pollution such as industrial complexes, sewage outfalls, agricultural wastes, etc. Sampling from lakes is not an easy task because thermal stratification and associated hydrodynamics result into much variation in lake water quality. The physical and chemical parameters of the lake water are also affected by a large number of factors like climatological, geochemical and biological processes along with the human activities. In order to overcome this problem, lake may be divided into different zones and series of samples may be taken from each zone. Many factors are also involved in the proper selection of sampling sites, which include objectives of the study, accessibility, flow mixing and other physical characteristics of the water body.

To monitor the water quality of the lake, both surface and depth wise sampling have been carried out. The bi-monthly collection of water samples was started since March 2006 from 21 locations in the lake at the surface, depth wise and along the periphery of the lake (Figure 3). The sample locations marked on the lake periphery shows the sampling sites of nalahs while inside the lake periphery are the sampling from the lake. Samples were collected from three different depths to study the vertical variation in the water quality, however, at some locations only two samples could were collected because of shallowness of lake. These three different depths were 0.25 m, 1.50 m and 3.0 m. In the analysis of the results, samples of different depths are named as surface, middle and bottom. Standard water sampler (Hydro-Bios, Germany) was used for collecting the water samples from various depths. Sampling stations were fixed by putting the flag. The sampling from sites 12 and 18 was not done because at site no. 12, it was difficult to reach due to trapa farming and site no. 18 was a small seasonal nalah.

Water samples were also collected from five major nalahs, which directly discharge wastewater into the lake.

Preservation of the samples was not required as some of the parameters like temperature, transparency, pH and dissolved oxygen were determined in the field itself and rest of the parameters were analyzed in the laboratory within ten hours of the sample collection. The detailed literature on the preservation of the water samples is given in Jain and Bhatia (1987-88).

## 4.2 Methods of Analysis

Physico-chemical analysis was conducted using the following standard methods as described in the User's Manual (Jain and Bhatia, 1987-88). The physical parameters such as transparency, temperature, pH and dissolved oxygen were determined in the field at the time of sample collection using portable water testing kit.

In the present study, twelve general water quality parameters have been analyzed and other cations/anions as well as heavy metals are not included in view of the limited lab facility and staff. Chloride concentration was determined by argentometric method in the form of silver chloride. Total dissolved solids (TDS) were determined by filtration and evaporation method. Alkalinity and total hardness were determined by titrimetric method using phenolphthalein and methyl orange indicators. Phosphate, nitrate and iron concentrations were determined using UV-VIS Spectrometer. Due to limited staff and lab facility, the presence of fecal coliform bacteria was done using the qualitative analysis.

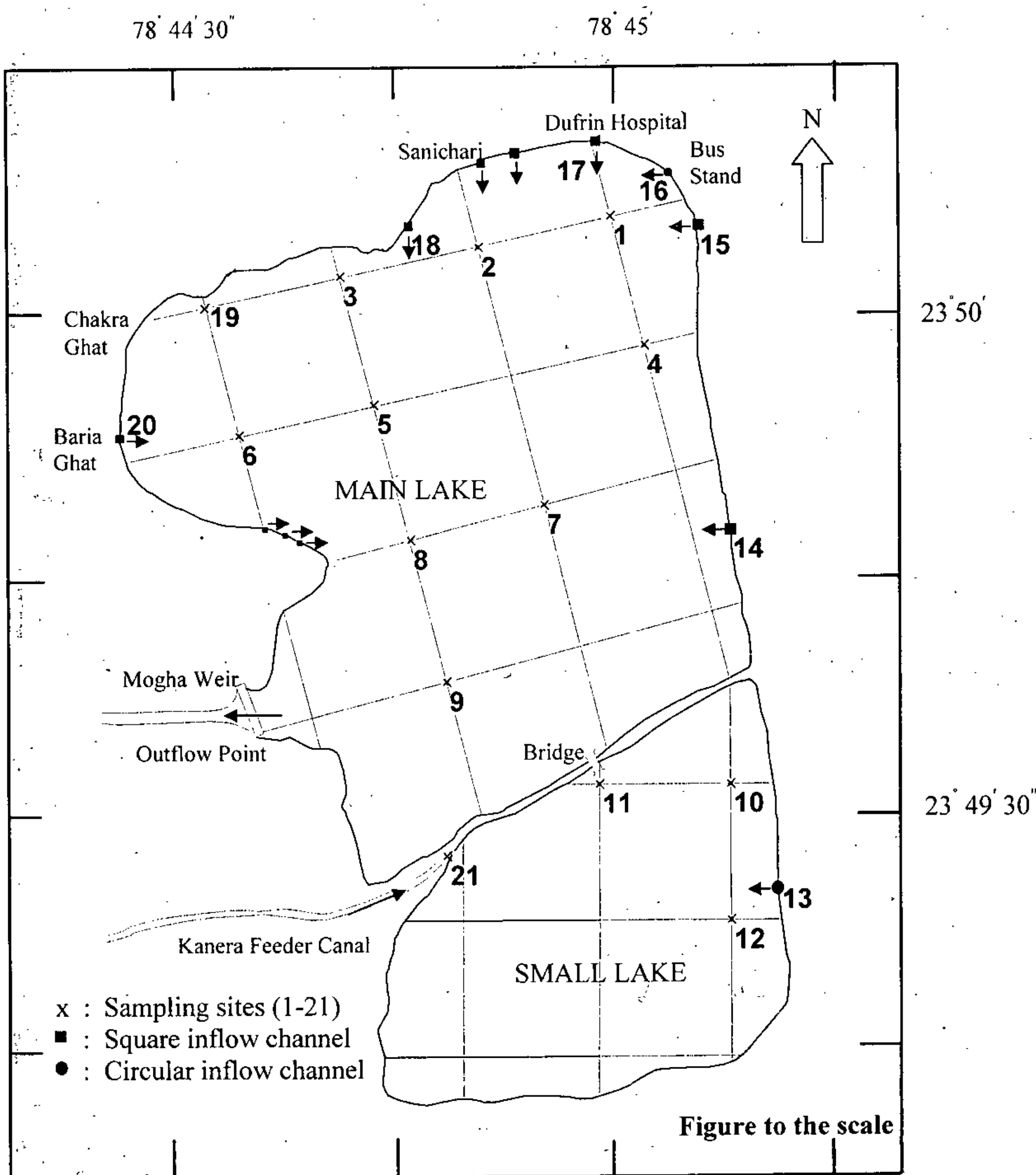



**Figure 3. Map of Sagar lake showing sampling locations**

# 5.0 RESULTS AND DISCUSSION

The chemical properties of the water samples collected during the period March 2008 to May 2008 from different locations of the Sagar lake are presented in Table 2(a-n) to 3(a-n). A discussion on the variation of the physico-chemical parameters is described below in detail.

## 5.1 Water Quality Parameter Evaluation

### 5.1.1 Temperature

The vertical temperature profile of a lake is a direct response to the penetration of the solar radiation. Temperature affects inversely the solubility of gases in water. When the temperature is more, the dissolved oxygen content of water gets reduced. An increase in temperature causes an increase in the biological activity, which, in turn, places a greater demand on the dissolved oxygen. The temperature of water can also control the survival of certain flora and fauna residing in a body of water. The type, quantity, and well being of flora and fauna will frequently change with a change in water temperature.

The lake water temperature varies seasonally from winter to summer between 17.5°C to 31.0°C with an average water temperature of 23.9 °C. The nalahs water temperature range between 16.5°C to 30.0°C with an average of 24.2°C.

### 5.1.2 Total Dissolved Solids

An aesthetic objective of *≤500 mg/L* has been established for total dissolved solids (TDS) in drinking water. At higher levels, excessive hardness, unpalatability, mineral deposition and corrosion may occur. At low levels, however, TDS contributes to the palatability of water. Total dissolved solids (TDS) comprise inorganic salts and small amounts of organic matter that are dissolved in water. The principal constituents are usually the cations calcium, magnesium, sodium and potassium and the anions carbonate, bicarbonate, chloride, sulphate and, particularly in groundwater, nitrate (from agricultural use). Total dissolved solids in water supplies originate from natural sources, sewage, urban and agricultural runoff and industrial wastewater. In Canada, salts used for road deicing can contribute significantly to the TDS loading of water supplies. Concentrations of TDS in water vary owing to different mineral solubilities in different geological regions. The concentration of TDS in water in contact with granite, siliceous sand, well-leached soil or other relatively insoluble materials is usually below 30 mg/L. In areas of Precambrian rock, TDS concentrations in water are generally less than 65 mg/L. Levels are higher in regions of Palaeozoic and Mesozoic sedimentary rock, ranging from 195 to 1100 mg/L because of the presence of carbonates, chlorides, calcium, magnesium and sulphates. Concentrations of TDS in some streams and small lakes in the arid western regions of Canada and the United States are often as high as 15 000 mg/L. Concentrations of TDS, expressed as the sum of its constituents, were below 500 mg/L in 36 of 41 rivers monitored in Canada. In a survey of the Great Lakes, TDS levels ranged from 61 to 227 mg/L. The levels of TDS in all of the Great Lakes except Lake Superior increased between 1900 and 1970. A threefold increase in chlorides and a twofold increase in sulphates, sodium and potassium in Lakes Erie and Ontario (GLWQB-1974) increased the TDS concentration in those lakes by 50 to 60 mg/L.

The TDS analysis of the water samples was started since Sept, 2007. The lake water TDS varies seasonally from winter to summer between 294 mg/L to 490 mg/L with an average 378 mg/L. The nalahs water TDS range between 282 mg/L to 796 mg/L with an average of 651 mg/L.

**5.1.3 Transparency**

The clarity of water is an indicator of water quality that relates to the ability of light to penetrate. Turbidity is an indicator of the property of water that causes light to become scattered or absorbed. Less the turbidity, more transparent the water, the greater the opportunity for photosynthesis and higher oxygen levels. Turbidity is caused by suspended clays, silts, organic matter, plankton, and other inorganic and organic particles.

The Secchi depth was measured manually. The average transparency of the lake water in terms of Secchi depth varied between 0.07 to 0.73 m with an average of 0.23 m. The transparency at site no. 10 generally shows higher value which is due to the reason that this site falls in the small lake catchment where no algae formation was observed.

## Table 2a. Water quality results of Sagar lake during March 2006

| Site No. | Level of Sampling | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 25.0 | 0.20 | 7.5 | 8.0 | 190 | 120 | 2 | 28 | 0.4 | 0.02 | Present |
| | Bottom | 23.8 | | 6.0 | 6.6 | 190 | 128 | 2 | 28 | 0.5 | 3.0 | " |
| 2 | Top | 24.0 | 0.20 | 6.5 | 5.2 | 190 | 112 | 2 | 28 | 0.5 | 0.3 | " |
| | Bottom | 23.8 | | 6.0 | 4.4 | 190 | 120 | 2 | 26 | 0.5 | 3.0 | " |
| 3 | Top | 24.2 | 0.17 | 6.5 | 5.4 | 180 | 120 | 5 | 28 | 0.5 | 0.1 | " |
| | Middle | 24.0 | | 7.0 | 4.4 | 180 | 112 | 6 | 28 | 0.5 | 0.7 | " |
| | Bottom | 23.0 | | 6.0 | 3.0 | 190 | 128 | 8 | 26 | 0.4 | 3.0 | " |
| 4 | Top | 23.8 | 0.25 | 6.5 | 9.0 | 180 | 136 | 2 | 26 | 0.4 | 0.1 | " |
| | Bottom | 23.6 | | 6.0 | 5.6 | 180 | 120 | 2 | 26 | 0.5 | 1.0 | " |
| 5 | Top | 26.0 | 0.16 | 7.5 | 5.2 | 180 | 112 | 5 | 28 | 0.5 | 0.3 | " |
| | Middle | 24.0 | | 6.5 | 5.0 | 180 | 112 | 9 | 26 | 0.6 | 0.7 | " |
| | Bottom | 23.8 | | 6.0 | 3.8 | 180 | 120 | 8 | 28 | 0.5 | 1.0 | " |
| 6 | Top | 25.2 | 0.18 | 7.5 | 5.8 | 180 | 120 | 6 | 28 | 0.5 | 0.1 | " |
| | Middle | 24.2 | | 7.0 | 4.8 | 190 | 112 | 7 | 28 | 0.5 | 0.3 | " |
| | Bottom | 23.8 | | 6.0 | 6.0 | 200 | 120 | 5 | 26 | 0.6 | 2.0 | " |
| 7 | Top | 26.2 | 0.25 | 7.0 | 6.6 | 180 | 112 | 9 | 26 | 0.5 | 0.1 | " |
| | Middle | 23.8 | | 6.5 | 7.0 | 170 | 136 | 2 | 26 | 0.5 | 0.3 | " |
| | Bottom | 24.0 | | 6.5 | 5.6 | 180 | 120 | 4 | 26 | 0.5 | 2.0 | " |
| 8 | Top | 24.5 | 0.25 | 7.0 | 7.0 | 190 | 128 | 1 | 28 | 0.5 | 0.1 | " |
| | Middle | 24.0 | | 7.0 | 5.4 | 200 | 136 | 3 | 28 | 0.5 | 0.3 | " |
| | Bottom | 23.0 | | 7.0 | 5.2 | 150 | 128 | 10 | 28 | 0.6 | 3.0 | " |
| 9 | Top | 24.8 | 0.17 | 8.0 | 6.0 | 190 | 128 | 2 | 28 | 0.5 | 0.1 | " |
| | Bottom | 24.2 | | 7.5 | 5.0 | 190 | 120 | 2 | 28 | 0.5 | 3.0 | " |
| 10 | Top | 23.8 | 0.55 | 6.0 | 3.6 | 230 | 200 | 2 | 44 | 0.6 | 3.0 | " |
| 11 | Top | 27.0 | 0.12 | 7.5 | 4.8 | 190 | 176 | 8 | 36 | 0.2 | 0.3 | " |
| 19 | Top | 25.4 | 0.14 | 8.0 | 5.0 | 200 | 176 | 8 | 44 | 0.5 | 2.0 | " |
| | Bottom | 24.4 | | 7.0 | 4.4 | 190 | 224 | 8 | 34 | 0.5 | 2.0 | " |

## Minimum, maximum and average of lake water quality results

| Parameter Extreme Value | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 23.0 | 0.12 | 6.0 | 3.0 | 150 | 112 | 1.0 | 26 | 0.2 | 0.02 | - |
| Maximum | 27.0 | 0.55 | 8.0 | 9.0 | 230 | 224 | 10.0 | 44 | 0.6 | 3.0 | - |
| Total Average | 24.3 | 0.22 | 6.8 | 5.5 | 186.7 | 132.4 | 4.8 | 29.0 | 0.5 | 1.2 | - |

**Table 2b. Water quality results of Sagar lake during May 2006**

| Site No. | Level of Sampling | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 27.0 | 0.12 | 8.0 | 4.4 | 200 | 160 | 10 | 80 | 0.5 | 0.10 | Present |
| | Bottom | 27.0 | | 7.5 | 4.0 | 200 | 160 | 1 | 80 | 0.5 | 1.0 | " |
| 2 | Top | 27.0 | 0.13 | 8.0 | 3.8 | 190 | 152 | 1 | 88 | 0.5 | 0.7 | " |
| | Bottom | 27.0 | | 7.5 | 3.6 | 190 | 152 | 5 | 84 | 0.5 | 3.0 | " |
| 3 | Top | 27.0 | 0.14 | 6.5 | 4.0 | 190 | 176 | 10 | 80 | 0.5 | 0.1 | " |
| | Middle | 27.5 | | 6.5 | 3.8 | 190 | 168 | 5 | 80 | 0.5 | 0.3 | " |
| | Bottom | 27.5 | | 6.0 | 3.4 | 190 | 168 | 0.5 | 80 | 0.5 | 0.7 | " |
| 4 | Top | 27.0 | 0.12 | 8.0 | 4.8 | 190 | 160 | 5 | 88 | 0.4 | 0.5 | " |
| | Bottom | 27.0 | | 7.0 | 4.6 | 190 | 160 | 15 | 84 | 0.4 | 2.0 | " |
| 5 | Top | 27.0 | 0.14 | 7.5 | 4.6 | 190 | 168 | 1 | 84 | 0.5 | 0.1 | " |
| | Middle | 27.0 | | 6.5 | 4.4 | 190 | 160 | 5 | 82 | 0.5 | 0.3 | " |
| | Bottom | 27.0 | | 6.5 | 3.6 | 200 | 176 | 10 | 80 | 0.4 | 1.5 | " |
| 6 | Top | 27.0 | 0.13 | 7.0 | 4.0 | 200 | 160 | 2 | 80 | 0.4 | 0.2 | " |
| | Middle | 27.0 | | 7.0 | 3.6 | 210 | 168 | 1 | 80 | 0.4 | 0.4 | " |
| | Bottom | 27.0 | | 7.0 | 3.0 | 210 | 160 | 1 | 80 | 0.5 | 0.5 | " |
| 7 | Top | 27.0 | 0.12 | 8.0 | 4.8 | 180 | 176 | 15 | 86 | 0.5 | 0.5 | " |
| | Middle | 27.0 | | 7.5 | 4.6 | 180 | 168 | 20 | 92 | 0.4 | 1.5 | " |
| | Bottom | 27.0 | | 7.0 | 4.0 | 220 | 168 | 15 | 88 | 0.6 | 3.0 | " |
| 8 | Top | 26.0 | 0.19 | 7.5 | 5.0 | 190 | 168 | 1 | 84 | 0.5 | 1.0 | " |
| | Middle | 26.0 | | 7.5 | 4.6 | 210 | 160 | 5 | 84 | 0.5 | 2.0 | " |
| | Bottom | 26.0 | | 7.0 | 3.6 | 240 | 168 | 15 | 80 | 0.6 | 3.0 | " |
| 9 | Top | 26.0 | 0.14 | 7.5 | 5.0 | 200 | 168 | 10 | 84 | 0.5 | 0.3 | " |
| | Bottom | 26.0 | | 6.5 | 4.8 | 220 | 176 | 10 | 84 | 0.5 | 2.0 | " |
| 10 | Top | 27.0 | 0.39 | 6.0 | 3.2 | 250 | 208 | 3 | 132 | 0.5 | 1.5 | " |
| 11 | Top | 27.5 | 0.12 | 7.0 | 3.6 | 180 | 160 | 0.3 | 86 | 0.5 | 1.0 | " |
| 19 | Top | 27.5 | 0.19 | 7.0 | 3.0 | 200 | 168 | 0.4 | 88 | 0.5 | 1.5 | " |
| | Bottom | 27.0 | | 7.5 | 2.8 | 180 | 168 | 0.4 | 86 | 0.7 | 3.0 | " |

**Minimum, maximum and average of lake water quality results**

| Parameter Extreme Value | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 26.0 | 0.12 | 6.0 | 2.8 | 180 | 152 | 0.3 | 80 | 0.4 | 0.1 | - |
| Maximum | 27.5 | 0.39 | 8.0 | 5.0 | 250 | 208 | 20.0 | 132 | 0.7 | 3.0 | - |
| Total Average | 26.9 | 0.16 | 7.1 | 4.0 | 199.3 | 166.8 | 6.2 | 85.3 | 0.5 | 1.2 | - |

## Table 2c. Water quality results of Sagar lake during July 2006

| Site No. | Level of Sampling | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 20.0 | 0.23 | 7.5 | 3.2 | 150 | 168 | 1.0 | 62 | 0.50 | 1.50 | Present |
| | Bottom | 20.0 | | 6.5 | 4.0 | 160 | 152 | 1.0 | 62 | 0.50 | 0.05 | " |
| 2 | Top | 20.0 | 0.26 | 7.0 | 2.8 | 160 | 160 | 1.0 | 66 | 0.40 | 0.50 | " |
| | Bottom | 20.0 | | 5.5 | 2.0 | 160 | 176 | 1.0 | 64 | 0.40 | 1.50 | " |
| 3 | Top | 19.5 | 0.28 | 7.0 | 2.4 | 170 | 176 | 0.5 | 62 | 0.40 | 0.10 | " |
| | Middle | 20.0 | | 6.5 | 1.6 | 170 | 176 | 1.0 | 62 | 0.40 | 0.40 | " |
| | Bottom | 19.0 | | 7.0 | 2.4 | 160 | 176 | 0.5 | 62 | 0.40 | 0.50 | " |
| 4 | Top | 20.0 | 0.32 | 7.0 | 5.0 | 170 | 144 | 1.0 | 66 | 0.40 | 0.10 | " |
| | Bottom | 19.0 | | 7.0 | 4.0 | 160 | 160 | 5.0 | 64 | 0.40 | 1.00 | " |
| 5 | Top | 20.0 | 0.28 | 7.0 | 2.4 | 170 | 176 | 1.0 | 64 | 0.40 | 0.10 | " |
| | Middle | 20.0 | | 6.5 | 2.0 | 170 | 184 | 1.0 | 64 | 0.40 | 0.20 | " |
| | Bottom | 19.0 | | 5.5 | 1.2 | 170 | 184 | 5.0 | 62 | 0.40 | 1.00 | " |
| 6 | Top | 20.0 | 0.33 | 7.0 | 1.8 | 170 | 176 | 1.0 | 62 | 0.30 | 0.10 | " |
| | Middle | 20.0 | | 6.0 | 1.8 | 170 | 176 | 1.0 | 62 | 0.40 | 0.30 | " |
| | Bottom | 19.0 | | 5.5 | 1.2 | 170 | 176 | 1.0 | 62 | 0.40 | 0.50 | " |
| 7 | Top | 19.5 | 0.23 | 7.0 | 4.4 | 160 | 168 | 1.0 | 64 | 0.40 | 0.05 | " |
| | Middle | 19.5 | | 6.5 | 4.6 | 160 | 160 | 5.0 | 66 | 0.40 | 1.00 | " |
| | Bottom | 19.0 | | 7.0 | 3.4 | 170 | 192 | 10.0 | 64 | 0.50 | 1.50 | " |
| 8 | Top | 20.0 | 0.31 | 7.0 | 5.0 | 150 | 176 | 1.0 | 62 | 0.40 | 0.50 | " |
| | Middle | 19.5 | | 7.5 | 4.6 | 180 | 176 | 1.0 | 64 | 0.40 | 1.00 | " |
| | Bottom | 19.0 | | 7.5 | 2.8 | 150 | 192 | 5.0 | 62 | 0.40 | 1.50 | " |
| 9 | Top | 20.0 | 0.29 | 6.5 | 5.4 | 160 | 168 | 1.0 | 62 | 0.40 | 0.05 | " |
| | Bottom | 19.0 | | 6.5 | 4.8 | 170 | 176 | 5.0 | 60 | 0.50 | 1.00 | " |
| 10 | Top | 20.0 | 0.65 | 6.0 | 2.0 | 200 | 190 | 1.0 | 64 | 0.50 | 1.50 | " |
| 11 | Top | 19.5 | 0.31 | 7.0 | 2.6 | 170 | 176 | 0.6 | 64 | 0.40 | 0.80 | " |
| 19 | Top | 20.5 | 0.27 | 7.0 | 3.0 | 190 | 144 | 0.5 | 64 | 0.40 | 1.00 | " |
| | Bottom | 20.0 | | 7.0 | 2.6 | 180 | 160 | 0.5 | 66 | 0.40 | 2.00 | " |

### Minimum, maximum and average of lake water quality results

| Parameter Extreme Value | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 19.0 | 0.23 | 5.5 | 1.2 | 150 | 144 | 0.5 | 60 | 0.30 | 0.05 | - |
| Maximum | 20.5 | 0.65 | 7.5 | 5.4 | 200 | 192 | 10.0 | 66 | 0.50 | 2.00 | - |
| Total Average | 19.7 | 0.31 | 6.7 | 3.1 | 167.4 | 171.8 | 2.0 | 63.3 | 0.41 | 0.73 | - |

## Table 2d. Water quality results of Sagar lake during September 2006

| Site No. | Level of Sampling | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 29.0 | 0.34 | 7.5 | 4.0 | 110 | 176 | 0.4 | 44 | 0.50 | 3.00 | Present |
| | Bottom | 28.5 | | 6.5 | 6.0 | 130 | 144 | 0.5 | 44 | 0.40 | 0.01 | " |
| 2 | Top | 28.0 | 0.39 | 7.5 | 4.0 | 130 | 168 | 0.5 | 44 | 0.30 | 0.10 | " |
| | Bottom | 27.0 | | 5.5 | 2.4 | 130 | 192 | 0.5 | 44 | 0.30 | 0.50 | " |
| 3 | Top | 28.0 | 0.42 | 7.0 | 3.0 | 150 | 184 | 0.4 | 44 | 0.30 | 0.10 | " |
| | Middle | 27.0 | | 6.0 | 1.8 | 150 | 184 | 0.5 | 44 | 0.30 | 0.40 | " |
| | Bottom | 27.0 | | 6.0 | 3.6 | 130 | 192 | 0.5 | 44 | 0.30 | 0.60 | " |
| 4 | Top | 29.0 | 0.38 | 7.5 | 7.0 | 140 | 136 | 0.5 | 44 | 0.40 | 0.50 | " |
| | Bottom | 28.5 | | 8.0 | 5.6 | 130 | 160 | 0.5 | 44 | 0.40 | 0.60 | " |
| 5 | Top | 28.0 | 0.42 | 7.0 | 2.8 | 140 | 184 | 0.4 | 44 | 0.30 | 0.05 | " |
| | Middle | 26.5 | | 6.0 | 2.6 | 160 | 192 | 0.5 | 44 | 0.30 | 0.10 | " |
| | Bottom | 25.5 | | 5.5 | 6.0 | 150 | 192 | 0.5 | 44 | 0.30 | 0.10 | " |
| 6 | Top | 27.0 | 0.49 | 6.5 | 1.8 | 140 | 184 | 0.4 | 44 | 0.30 | 0.10 | " |
| | Middle | 26.5 | | 6.0 | 1.8 | 140 | 184 | 0.5 | 44 | 0.30 | 0.50 | " |
| | Bottom | 26.0 | | 5.5 | 1.6 | 140 | 184 | 0.5 | 44 | 0.30 | 0.60 | " |
| 7 | Top | 28.5 | 0.34 | 7.5 | 6.2 | 130 | 160 | 0.5 | 44 | 0.40 | 0.01 | " |
| | Middle | 28.5 | | 7.0 | 6.6 | 130 | 160 | 0.5 | 44 | 0.40 | 0.50 | " |
| | Bottom | 28.0 | | 6.5 | 5.0 | 130 | 224 | 0.5 | 38 | 0.40 | 0.60 | " |
| 8 | Top | 28.0 | 0.43 | 7.5 | 7.0 | 110 | 184 | 0.5 | 40 | 0.40 | 0.60 | " |
| | Middle | 28.0 | | 7.5 | 6.6 | 150 | 200 | 0.5 | 44 | 0.30 | 0.60 | " |
| | Bottom | 28.0 | | 7.0 | 4.2 | 70 | 216 | 0.4 | 44 | 0.30 | 0.60 | " |
| 9 | Top | 28.0 | 0.43 | 7.0 | 8.0 | 120 | 176 | 0.5 | 40 | 0.40 | 0.01 | " |
| | Bottom | 28.0 | | 7.0 | 6.8 | 120 | 176 | 0.5 | 38 | 0.40 | 0.50 | " |
| 10 | Top | 26.0 | 0.73 | 5.5 | 2.0 | 200 | 200 | 0.4 | 46 | 0.50 | 2.00 | " |
| 11 | Top | 28.0 | 0.5 | 6.0 | 3.6 | 160 | 200 | 0.8 | 42 | 0.20 | 0.50 | " |
| 19 | Top | 30.5 | 0.34 | 7.5 | 5.0 | 200 | 136 | 1.0 | 46 | 0.10 | 1.00 | " |
| | Bottom | 30.0 | | 7.0 | 4.4 | 190 | 160 | 1.0 | 46 | 0.10 | 1.50 | " |

## Minimum, maximum and average of lake water quality results

| Parameter Extreme Value | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 25.5 | 0.3 | 5.5 | 1.6 | 70 | 136 | 0.4 | 38 | 0.10 | 0.01 | - |
| Maximum | 30.5 | 0.7 | 8.0 | 8.0 | 200 | 224 | 1.0 | 46 | 0.50 | 3.00 | - |
| Total Average | 27.8 | 0.43 | 6.7 | 4.4 | 140.0 | 179.6 | 0.5 | 43.4 | 0.33 | 0.58 | - |

## Table 2e. Water quality results of Sagar lake during November 2006

| Site No. | Level of Sampling | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 24.3 | 0.3 | 7.3 | 5.0 | 115.0 | 228.0 | 0.4 | 54.0 | 0.4 | 1.6 | Present |
| | Bottom | 23.8 | | 6.5 | 5.2 | 125.0 | 208.0 | 0.5 | 54.0 | 0.3 | 1.5 | " |
| 2 | Top | 23.5 | 0.4 | 7.3 | 5.1 | 125.0 | 224.0 | 0.4 | 56.0 | 0.3 | 0.2 | " |
| | Bottom | 22.5 | | 6.0 | 3.5 | 125.0 | 228.0 | 0.5 | 50.0 | 0.5 | 2.0 | " |
| 3 | Top | 23.5 | 0.4 | 6.8 | 4.5 | 135.0 | 216.0 | 0.4 | 52.0 | 0.2 | 0.1 | " |
| | Middle | 22.5 | | 6.3 | 3.1 | 135.0 | 220.0 | 0.5 | 52.0 | 0.3 | 0.3 | " |
| | Bottom | 22.5 | | 6.0 | 3.6 | 125.0 | 236.0 | 0.5 | 50.0 | 0.4 | 1.8 | " |
| 4 | Top | 24.3 | 0.3 | 7.3 | 6.0 | 130.0 | 196.0 | 0.4 | 53.0 | 0.3 | 0.7 | " |
| | Bottom | 23.5 | | 7.3 | 5.1 | 120.0 | 220.0 | 0.4 | 59.0 | 0.5 | 1.3 | " |
| 5 | Top | 23.3 | 0.4 | 6.8 | 4.0 | 130.0 | 232.0 | 0.4 | 57.0 | 0.3 | 0.1 | " |
| | Middle | 22.0 | | 6.3 | 4.0 | 140.0 | 228.0 | 0.5 | 54.0 | 0.3 | 0.1 | " |
| | Bottom | 21.5 | | 5.8 | 5.1 | 135.0 | 224.0 | 0.4 | 52.0 | 0.4 | 1.6 | " |
| 6 | Top | 22.8 | 0.4 | 6.8 | 3.1 | 125.0 | 228.0 | 0.4 | 57.0 | 0.3 | 0.1 | " |
| | Middle | 22.0 | | 6.3 | 3.2 | 125.0 | 220.0 | 0.5 | 57.0 | 0.4 | 0.3 | " |
| | Bottom | 22.0 | | 6.0 | 3.2 | 125.0 | 220.0 | 0.5 | 56.0 | 0.2 | 1.3 | " |
| 7 | Top | 23.8 | 0.3 | 7.0 | 5.3 | 120.0 | 200.0 | 0.4 | 57.0 | 0.4 | 0.1 | " |
| | Middle | 23.5 | | 6.8 | 5.3 | 120.0 | 200.0 | 0.5 | 57.0 | 0.4 | 0.4 | " |
| | Bottom | 23.0 | | 6.3 | 4.3 | 120.0 | 240.0 | 0.5 | 54.0 | 0.4 | 2.1 | " |
| 8 | Top | 23.5 | 0.4 | 7.0 | 6.0 | 120.0 | 228.0 | 0.5 | 52.0 | 0.3 | 0.4 | " |
| | Middle | 23.3 | | 7.0 | 5.9 | 140.0 | 228.0 | 0.5 | 54.0 | 0.3 | 0.4 | " |
| | Bottom | 23.0 | | 6.5 | 4.8 | 100.0 | 228.0 | 0.4 | 54.0 | 0.3 | 2.1 | " |
| 9 | Top | 23.5 | 0.4 | 6.8 | 6.6 | 120.0 | 208.0 | 0.5 | 53.0 | 0.3 | 0.1 | " |
| | Bottom | 23.0 | | 6.5 | 5.1 | 125.0 | 236.0 | 0.5 | 52.0 | 0.5 | 2.0 | " |
| 10 | Top | 22.0 | 0.5 | 5.8 | 3.4 | 190.0 | 240.0 | 7.7 | 61.0 | 0.4 | 2.0 | " |
| 11 | Top | 23.5 | 0.4 | 6.0 | 4.9 | 160.0 | 228.0 | 0.6 | 56.0 | 0.5 | 0.8 | " |
| 19 | Top | 24.8 | 0.34 | 7.0 | 5.2 | 185.0 | 200.0 | 3.0 | 58.0 | 0.2 | 0.6 | " |
| | Bottom | 24.3 | | 6.8 | 4.6 | 180.0 | 216.0 | 4.5 | 59.0 | 0.3 | 2.0 | " |

## Minimum, maximum and average of lake water quality results

| Parameter Extreme Value | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 21.5 | 0.3 | 5.8 | 3.1 | 100.0 | 196 | 0.4 | 50.0 | 0.15 | 0.06 | - |
| Maximum | 24.8 | 0.5 | 7.3 | 6.6 | 190.0 | 240 | 7.7 | 61.0 | 0.50 | 2.05 | - |
| Total Average | 23.1 | 0.38 | 6.6 | 4.6 | 133.1 | 221.5 | 1.0 | 54.8 | 0.32 | 0.94 | - |

**Table 2f. Water quality results of Sagar lake during January 2007**

| Site No. | Level of Sampling | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 19.5 | 0.31 | 7.0 | 6.0 | 120 | 280 | 0.4 | 64 | 0.2 | 0.1 | Present |
| | Bottom | 19.0 | | 6.5 | 4.4 | 120 | 272 | 0.4 | 64 | 0.2 | 3.0 | " |
| 2 | Top | 19.0 | 0.35 | 7.0 | 6.2 | 120 | 280 | 0.3 | 68 | 0.2 | 0.2 | " |
| | Bottom | 18.0 | | 6.5 | 4.6 | 120 | 264 | 0.4 | 56 | 0.6 | 3.5 | " |
| 3 | Top | 19.0 | 0.35 | 6.5 | 6.0 | 120 | 248 | 0.4 | 60 | 0.1 | 0.1 | " |
| | Middle | 18.0 | | 6.5 | 4.4 | 120 | 256 | 0.4 | 60 | 0.3 | 0.2 | " |
| | Bottom | 18.0 | | 6.0 | 3.6 | 120 | 280 | 0.5 | 56 | 0.4 | 3.0 | " |
| 4 | Top | 19.5 | 0.31 | 7.0 | 5.0 | 120 | 256 | 0.2 | 62 | 0.1 | 0.8 | " |
| | Bottom | 18.5 | | 6.5 | 4.6 | 110 | 280 | 0.3 | 74 | 0.5 | 2.0 | " |
| 5 | Top | 18.5 | 0.34 | 6.5 | 5.2 | 120 | 280 | 0.3 | 70 | 0.2 | 0.1 | " |
| | Middle | 17.5 | | 6.5 | 5.4 | 120 | 264 | 0.4 | 64 | 0.2 | 0.1 | " |
| | Bottom | 17.5 | | 6.0 | 4.2 | 120 | 256 | 0.3 | 60 | 0.4 | 3.0 | " |
| 6 | Top | 18.5 | 0.32 | 7.0 | 4.4 | 110 | 272 | 0.4 | 70 | 0.3 | 0.1 | " |
| | Middle | 17.5 | | 6.5 | 4.6 | 110 | 256 | 0.5 | 70 | 0.4 | 0.1 | " |
| | Bottom | 18.0 | | 6.5 | 4.8 | 110 | 256 | 0.5 | 68 | 0.1 | 2.0 | " |
| 7 | Top | 19.0 | 0.35 | 6.5 | 4.4 | 110 | 240 | 0.3 | 70 | 0.4 | 0.1 | " |
| | Middle | 18.5 | | 6.5 | 4.0 | 110 | 240 | 0.4 | 70 | 0.4 | 0.3 | " |
| | Bottom | 18.0 | | 6.0 | 3.6 | 110 | 256 | 0.4 | 70 | 0.4 | 3.5 | " |
| 8 | Top | 19.0 | 0.28 | 6.5 | 5.0 | 130 | 272 | 0.4 | 64 | 0.1 | 0.1 | " |
| | Middle | 18.5 | | 6.5 | 5.2 | 130 | 256 | 0.4 | 64 | 0.3 | 0.2 | " |
| | Bottom | 18.0 | | 6.0 | 5.4 | 130 | 240 | 0.4 | 64 | 0.3 | 3.5 | " |
| 9 | Top | 19.0 | 0.33 | 6.5 | 5.2 | 120 | 240 | 0.4 | 66 | 0.1 | 0.1 | " |
| | Bottom | 18.0 | | 6.0 | 3.4 | 130 | 296 | 0.4 | 66 | 0.5 | 3.5 | " |
| 10 | Top | 18.0 | 0.28 | 6.0 | 4.8 | 180 | 280 | 15.0 | 76 | 0.2 | 2.0 | " |
| 11 | Top | 19.0 | 0.26 | 6.0 | 6.2 | 160 | 256 | 0.4 | 70 | 0.8 | 1.0 | " |
| 19 | Top | 19.0 | 0.24 | 6.5 | 5.4 | 170 | 264 | 5.0 | 70 | 0.2 | 0.1 | " |
| | Bottom | 18.5 | | 6.5 | 4.8 | 170 | 272 | 8.0 | 72 | 0.5 | 2.5 | " |

**Minimum, maximum and average of lake water quality results**

| Parameter Extreme Value | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 17.5 | 0.24 | 6.0 | 3.4 | 110.0 | 240.0 | 0.20 | 56.0 | 0.10 | 0.1 | - |
| Maximum | 19.5 | 0.35 | 7.0 | 6.2 | 180.0 | 296.0 | 15.00 | 76.0 | 0.80 | 3.5 | - |
| Total Average | 18.5 | 0.31 | 6.4 | 4.8 | 126.3 | 263.4 | 1.38 | 66.2 | 0.31 | 1.3 | - |

**Table 2g. Water quality results of Sagar lake during March 2007**

| Site No. | Level of Sampling | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 23.0 | 0.22 | 7.5 | 5.0 | 140.00 | 220.0 | 3.00 | 66.0 | 0.35 | 1.00 | Present |
| | Bottom | 23.0 | | 6.5 | 4.0 | 140.00 | 212.0 | 5.00 | 65.0 | 0.35 | 3.00 | " |
| 2 | Top | 24.0 | 0.23 | 7.0 | 5.9 | 135.00 | 224.0 | 5.00 | 66.0 | 0.20 | 1.00 | " |
| | Bottom | 24.0 | | 7.0 | 4.0 | 130.00 | 216.0 | 0.50 | 65.0 | 0.45 | 3.00 | " |
| 3 | Top | 24.0 | 0.24 | 7.0 | 5.1 | 140.00 | 204.0 | 5.00 | 65.0 | 0.20 | 1.50 | " |
| | Middle | 24.0 | | 7.0 | 3.9 | 130.00 | 212.0 | 3.00 | 65.0 | 0.25 | 1.50 | " |
| | Bottom | 24.0 | | 6.5 | 3.5 | 145.00 | 228.0 | 3.00 | 65.0 | 0.40 | 3.00 | " |
| 4 | Top | 23.0 | 0.22 | 7.0 | 5.0 | 150.00 | 208.0 | 3.00 | 65.0 | 0.20 | 1.50 | " |
| | Bottom | 23.0 | | 7.0 | 4.0 | 135.00 | 216.0 | 5.00 | 65.0 | 0.45 | 2.50 | " |
| 5 | Top | 24.0 | 0.25 | 6.5 | 5.0 | 135.00 | 224.0 | 1.00 | 65.0 | 0.20 | 1.00 | " |
| | Middle | 24.0 | | 6.5 | 4.5 | 135.00 | 216.0 | 5.00 | 65.0 | 0.20 | 1.00 | " |
| | Bottom | 24.0 | | 6.5 | 4.0 | 135.00 | 216.0 | 7.00 | 65.0 | 0.35 | 3.00 | " |
| 6 | Top | 24.0 | 0.23 | 7.0 | 4.2 | 135.00 | 216.0 | 0.50 | 65.0 | 0.30 | 1.00 | " |
| | Middle | 24.0 | | 6.5 | 4.5 | 125.00 | 208.0 | 6.00 | 65.0 | 0.30 | 1.50 | " |
| | Bottom | 24.0 | | 6.5 | 4.1 | 135.00 | 220.0 | 10.00 | 66.0 | 0.20 | 2.50 | " |
| 7 | Top | 22.0 | 0.24 | 7.0 | 4.0 | 130.00 | 192.0 | 2.00 | 65.0 | 0.25 | 1.50 | " |
| | Middle | 22.0 | | 6.5 | 4.4 | 130.00 | 196.0 | 5.00 | 65.0 | 0.25 | 1.50 | " |
| | Bottom | 22.0 | | 6.0 | 3.6 | 130.00 | 208.0 | 3.00 | 65.0 | 0.30 | 3.00 | " |
| 8 | Top | 21.0 | 0.19 | 7.0 | 4.9 | 145.00 | 224.0 | 1.00 | 65.0 | 0.10 | 1.50 | " |
| | Middle | 21.5 | | 6.5 | 4.5 | 145.00 | 212.0 | 3.00 | 65.0 | 0.35 | 1.50 | " |
| | Bottom | 22.0 | | 6.0 | 3.7 | 145.00 | 200.0 | 3.00 | 65.0 | 0.35 | 3.50 | " |
| 9 | Top | 22.0 | 0.23 | 7.0 | 4.9 | 130.00 | 204.0 | 3.00 | 65.0 | 0.15 | 1.00 | " |
| | Bottom | 21.5 | | 6.5 | 3.6 | 140.00 | 228.0 | 4.00 | 65.0 | 0.40 | 3.50 | " |
| 10 | Top | 22.0 | 0.32 | 6.5 | 4.4 | 175.00 | 224.0 | 10.00 | 66.0 | 0.20 | 2.00 | " |
| 11 | Top | 23.0 | 0.17 | 6.5 | 4.9 | 155.00 | 200.0 | 3.00 | 65.0 | 0.45 | 2.00 | " |
| 19 | Top | 23.0 | 0.17 | 6.5 | 4.3 | 170.00 | 212.0 | 5.00 | 65.0 | 0.30 | 0.50 | " |
| | Bottom | 22.0 | | 6.5 | 3.8 | 160.00 | 216.0 | 10.00 | 65.0 | 0.50 | 2.00 | " |

**Minimum, maximum and average of lake water quality results**

| Parameter Extreme Value | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 21.0 | 0.17 | 6.0 | 3.5 | 125.0 | 192 | 0.50 | 65.0 | 0.10 | 0.50 | - |
| Maximum | 24.0 | 0.32 | 7.5 | 5.9 | 175.0 | 228 | 10.00 | 66.0 | 0.50 | 3.50 | - |
| Total Average | 23.0 | 0.22 | 6.7 | 4.4 | 140.7 | 213.2 | 4.22 | 65.1 | 0.30 | 1.91 | - |

## Table 2h. Water quality results of Sagar lake during May 2007

| Site No. | Level of Sampling | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 25.0 | 0.12 | 6.5 | 4.0 | 160.0 | 160.0 | 5.00 | 66.0 | 0.50 | 2.00 | Present |
| | Bottom | 25.0 | | 6.0 | 3.6 | 160.0 | 152.0 | 10.00 | 66.0 | 0.50 | 4.00 | " |
| 2 | Top | 26.0 | 0.11 | 6.0 | 5.6 | 150.0 | 168.0 | 10.00 | 66.0 | 0.20 | 2.50 | " |
| | Bottom | 26.0 | - | 6.0 | 3.4 | 140.0 | 168.0 | 0.50 | 66.0 | 0.30 | 2.50 | " |
| 3 | Top | 26.0 | 0.13 | 6.5 | 4.2 | 160.0 | 160.0 | 10.00 | 66.0 | 0.30 | 2.50 | " |
| | Middle | 26.0 | | 6.0 | 3.4 | 140.0 | 168.0 | 5.00 | 66.0 | 0.20 | 2.50 | " |
| | Bottom | 26.0 | | 6.0 | 3.4 | 170.0 | 176.0 | 5.00 | 66.0 | 0.35 | 3.50 | " |
| 4 | Top | 25.0 | 0.12 | 6.0 | 5.0 | 180.0 | 160.0 | 6.00 | 66.0 | 0.30 | 2.00 | " |
| | Bottom | 25.0 | | 6.0 | 3.4 | 160.0 | 152.0 | 10.00 | 66.0 | 0.40 | 3.50 | " |
| 5 | Top | 26.0 | 0.11 | 6.5 | 4.8 | 150.0 | 168.0 | 1.00 | 64.0 | 0.25 | 2.50 | " |
| | Middle | 26.0 | | 6.5 | 3.6 | 150.0 | 168.0 | 0.50 | 66.0 | 0.20 | 2.00 | " |
| | Bottom | 26.0 | | 6.0 | 3.8 | 150.0 | 176.0 | 15.00 | 66.0 | 0.30 | 3.50 | " |
| 6 | Top | 26.0 | 0.15 | 6.0 | 4.0 | 160.0 | 160.0 | 0.25 | 66.0 | 0.30 | 2.00 | " |
| | Middle | 26.0 | | 6.0 | 4.4 | 140.0 | 160.0 | 12.00 | 66.0 | 0.20 | 2.50 | " |
| | Bottom | 26.0 | | 6.0 | 3.4 | 160.0 | 184.0 | 20.00 | 66.0 | 0.35 | 3.50 | " |
| 7 | Top | 24.0 | 0.12 | 6.5 | 3.6 | 150.0 | 144.0 | 3.00 | 66.0 | 0.10 | 2.50 | " |
| | Middle | 24.0 | | 6.0 | 4.8 | 150.0 | 152.0 | 9.00 | 66.0 | 0.10 | 2.50 | " |
| | Bottom | 24.0 | | 6.0 | 3.6 | 150.0 | 160.0 | 5.00 | 66.0 | 0.20 | 3.00 | " |
| 8 | Top | 22.0 | 0.11 | 6.5 | 4.8 | 160.0 | 176.0 | 5.00 | 66.0 | 0.10 | 2.50 | " |
| | Middle | 23.0 | | 6.5 | 3.8 | 160.0 | 168.0 | 5.00 | 66.0 | 0.40 | 2.50 | " |
| | Bottom | 24.0 | | 6.5 | 2.0 | 160.0 | 160.0 | 7.00 | 66.0 | 0.40 | 3.50 | " |
| 9 | Top | 24.0 | 0.13 | 6.5 | 4.6 | 140.0 | 168.0 | 8.00 | 66.0 | 0.20 | 2.00 | " |
| | Bottom | 23.0 | | 7.0 | 3.8 | 150.0 | 160.0 | 5.00 | 64.0 | 0.35 | 4.00 | " |
| 10 | Top | 24.0 | 0.18 | 6.5 | 3.4 | 180.0 | 176.0 | 5.00 | 68.0 | 0.50 | 3.00 | " |
| 11 | Top | 25.0 | 0.07 | 7.0 | 3.6 | 150.0 | 144.0 | 5.00 | 66.0 | 0.10 | 2.50 | " |
| 19 | Top | 25.0 | 0.11 | 6.0 | 3.2 | 170.0 | 160.0 | 5.00 | 66.0 | 0.40 | 1.00 | " |
| | Bottom | 24.0 | | 6.5 | 2.8 | 150.0 | 160.0 | 12.00 | 66.0 | 0.50 | 2.00 | " |

## Minimum, maximum and average of lake water quality results

| Parameter / Extreme Value | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 22.0 | 0.07 | 6.0 | 2.0 | 140.0 | 144 | 0.25 | 64.0 | 0.10 | 1.00 | - |
| Maximum | 26.0 | 0.18 | 7.0 | 5.6 | 180.0 | 184 | 20.00 | 68.0 | 0.50 | 4.00 | - |
| Total Average | 24.9 | 0.12 | 6.3 | 3.9 | 155.6 | 163.3 | 6.82 | 65.9 | 0.30 | 2.67 | - |

## Table 2i. Water quality results of Sagar lake during July 2007

| Site No. | Level of Sampling | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 24.6 | 0.22 | 7.3 | 4.9 | 143.9 | 182.2 | 5.2 | 58.0 | 0.40 | 1.31 | Present |
| | Bottom | 24.3 | | 6.5 | 4.8 | 148.3 | 172.9 | 3.9 | 57.9 | 0.37 | 2.06 | " |
| 2 | Top | 24.4 | 0.25 | 7.0 | 5.0 | 146.7 | 180.4 | 4.5 | 59.8 | 0.31 | 0.77 | " |
| | Bottom | 24.0 | | 6.3 | 3.6 | 145.0 | 184.4 | 3.9 | 56.8 | 0.41 | 2.33 | " |
| 3 | Top | 24.3 | 0.26 | 6.8 | 4.4 | 151.7 | 180.9 | 5.7 | 57.0 | 0.30 | 0.57 | " |
| | Middle | 24.0 | | 6.5 | 3.5 | 148.9 | 182.4 | 5.2 | 57.0 | 0.33 | 0.76 | " |
| | Bottom | 23.8 | | 6.2 | 3.4 | 151.1 | 192.9 | 5.4 | 56.1 | 0.37 | 1.87 | " |
| 4 | Top | 24.4 | 0.25 | 7.0 | 5.8 | 151.1 | 171.1 | 3.7 | 58.4 | 0.28 | 0.91 | " |
| | Bottom | 24.0 | | 6.8 | 4.6 | 143.9 | 176.4 | 5.5 | 59.8 | 0.40 | 1.82 | " |
| 5 | Top | 24.5 | 0.26 | 6.9 | 4.5 | 148.3 | 187.6 | 3.3 | 59.1 | 0.31 | 0.56 | " |
| | Middle | 23.8 | | 6.5 | 4.2 | 151.7 | 185.3 | 4.7 | 57.9 | 0.32 | 0.59 | " |
| | Bottom | 23.5 | | 6.0 | 4.2 | 151.1 | 187.6 | 7.4 | 57.0 | 0.36 | 1.72 | " |
| 6 | Top | 24.2 | 0.28 | 6.8 | 3.8 | 151.1 | 184.4 | 3.4 | 58.9 | 0.31 | 0.50 | " |
| | Middle | 23.9 | | 6.4 | 3.7 | 150.0 | 180.9 | 5.4 | 58.9 | 0.33 | 0.74 | " |
| | Bottom | 23.6 | | 6.2 | 3.5 | 154.4 | 184.9 | 6.5 | 58.4 | 0.31 | 1.52 | " |
| 7 | Top | 24.2 | 0.24 | 7.1 | 5.0 | 140.0 | 170.7 | 4.8 | 59.3 | 0.34 | 0.76 | " |
| | Middle | 23.8 | | 6.6 | 5.2 | 141.1 | 172.9 | 6.0 | 60.2 | 0.34 | 1.17 | " |
| | Bottom | 23.6 | | 6.4 | 4.3 | 150.0 | 190.2 | 5.6 | 58.6 | 0.41 | 2.46 | " |
| 8 | Top | 23.5 | 0.27 | 6.9 | 5.7 | 146.1 | 189.8 | 2.4 | 57.4 | 0.31 | 0.82 | " |
| | Middle | 23.5 | | 6.9 | 5.2 | 160.0 | 187.6 | 4.4 | 58.3 | 0.36 | 1.02 | " |
| | Bottom | 23.4 | | 6.7 | 4.1 | 141.7 | 187.1 | 8.5 | 57.7 | 0.37 | 2.38 | " |
| 9 | Top | 23.8 | 0.26 | 6.9 | 5.7 | 146.7 | 179.1 | 4.2 | 57.6 | 0.32 | 0.62 | " |
| | Bottom | 23.3 | | 6.7 | 4.7 | 153.9 | 191.1 | 4.7 | 56.8 | 0.44 | 2.61 | " |
| 10 | Top | 23.3 | 0.43 | 6.0 | 3.5 | 191.7 | 207.8 | 6.0 | 68.1 | 0.41 | 2.11 | " |
| 11 | Top | 24.4 | 0.23 | 6.6 | 4.2 | 165.0 | 187.1 | 4.9 | 60.1 | 0.36 | 1.09 | " |
| 19 | Top | 25.2 | 0.22 | 7.1 | 4.3 | 176.1 | 178.2 | 5.9 | 62.3 | 0.29 | 1.07 | " |
| | Bottom | 24.5 | | 7.0 | 3.8 | 166.7 | 191.1 | 8.3 | 61.6 | 0.41 | 2.17 | " |

### Minimum, maximum and average of lake water quality results

| Parameter Extreme Value | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 23.3 | 0.22 | 6.0 | 3.4 | 140.0 | 171 | 2.37 | 56.1 | 0.28 | 0.50 | - |
| Maximum | 25.2 | 0.43 | 7.3 | 5.8 | 191.7 | 208 | 8.47 | 68.1 | 0.44 | 2.61 | - |
| Total Average | 24.0 | 0.26 | 6.7 | 4.4 | 152.4 | 184.0 | 5.15 | 58.9 | 0.35 | 1.34 | - |

**Table 2j. Water quality results of Sagar lake during September 2007**

| Site No. | Level of Sampling | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 28.5 | 0.15 | 6.5 | 4.8 | 110.0 | 128.0 | 25.00 | 58.0 | 0.30 | 2.50 | Present | 320 |
| | Bottom | 28.5 | | 6.5 | 5.0 | 110.0 | 128.0 | 15.00 | 58.0 | 0.10 | 3.00 | " | 340 |
| 2 | Top | 28.0 | 0.22 | 7.0 | 6.4 | 120.0 | 136.0 | 20.00 | 56.0 | 0.20 | 1.50 | " | 294 |
| | Bottom | 27.5 | | 6.5 | 4.2 | 120.0 | 144.0 | 25.00 | 56.0 | 0.20 | 2.00 | " | 318 |
| 3 | Top | 27.5 | 0.23 | 7.0 | 5.2 | 120.0 | 144.0 | 20.00 | 56.0 | 0.20 | 0.50 | " | 300 |
| | Middle | 27.0 | | 6.5 | 5.0 | 125.0 | 146.0 | 25.00 | 56.0 | 0.20 | 0.50 | " | 300 |
| | Bottom | 27.0 | | 6.5 | 4.4 | 130.0 | 152.0 | 30.00 | 56.0 | 0.20 | 0.70 | " | 340 |
| 4 | Top | 28.0 | 0.16 | 6.5 | 5.2 | 100.0 | 144.0 | 15.00 | 56.0 | 0.10 | 2.00 | " | 336 |
| | Bottom | 28.0 | | 6.5 | 4.6 | 110.0 | 120.0 | 11.00 | 56.0 | 0.10 | 2.50 | " | 316 |
| 5 | Top | 28.0 | 0.23 | 7.0 | 6.2 | 120.0 | 144.0 | 20.00 | 56.0 | 0.20 | 0.80 | " | 314 |
| | Middle | 27.5 | | 7.0 | 6.0 | 120.0 | 144.0 | 20.00 | 56.0 | 0.20 | 0.80 | " | 320 |
| | Bottom | 27.5 | | 6.5 | 6.0 | 120.0 | 144.0 | 20.00 | 56.0 | 0.20 | 0.80 | " | 310 |
| 6 | Top | 27.5 | 0.25 | 6.5 | 5.4 | 140.0 | 144.0 | 20.00 | 58.0 | 0.10 | 0.80 | " | 314 |
| | Middle | 27.5 | | 6.5 | 4.8 | 140.0 | 144.0 | 20.00 | 58.0 | 0.10 | 0.80 | " | 320 |
| | Bottom | 27.0 | | 6.5 | 4.2 | 140.0 | 144.0 | 20.00 | 58.0 | 0.10 | 0.80 | " | 334 |
| 7 | Top | 28.0 | 0.17 | 7.0 | 5.6 | 100.0 | 144.0 | 12.00 | 56.0 | 0.10 | 2.00 | " | 306 |
| | Middle | 27.5 | | 6.5 | 5.4 | 120.0 | 144.0 | 12.00 | 56.0 | 0.20 | 2.50 | " | 300 |
| | Bottom | 27.5 | | 6.5 | 5.4 | 140.0 | 144.0 | 12.00 | 56.0 | 0.40 | 3.50 | " | 340 |
| 8 | Top | 27.5 | 0.29 | 6.5 | 6.6 | 120.0 | 152.0 | 11.00 | 56.0 | 0.40 | 0.70 | " | 326 |
| | Middle | 27.5 | | 6.5 | 5.8 | 125.0 | 152.0 | 21.00 | 56.0 | 0.20 | 0.70 | " | 340 |
| | Bottom | 27.5 | | 6.5 | 5.4 | 130.0 | 152.0 | 35.00 | 56.0 | 0.05 | 0.80 | " | 350 |
| 9 | Top | 27.0 | 0.21 | 6.5 | 5.8 | 140.0 | 152.0 | 12.00 | 54.0 | 0.40 | 2.00 | " | 342 |
| | Bottom | 27.0 | | 6.5 | 5.4 | 140.0 | 152.0 | 15.00 | 54.0 | 0.40 | 4.00 | " | 320 |
| 10 | Top | 27.0 | 0.24 | 6.0 | 4.4 | 120.0 | 152.0 | 10.00 | 56.0 | 0.30 | 2.00 | " | 320 |
| 11 | Top | 27.5 | 0.16 | 6.0 | 3.4 | 160.0 | 144.0 | 25.00 | 56.0 | 0.05 | 1.00 | " | 312 |
| 19 | Top | 31.0 | 0.16 | 8.0 | 4.6 | 100.0 | 144.0 | 25.00 | 60.0 | 0.10 | 2.00 | " | 326 |
| | Bottom | 30.5 | | 8.0 | 4.0 | 100.0 | 144.0 | 30.00 | 60.0 | 0.20 | 2.50 | " | 360 |

**Minimum, maximum and average of lake water quality results**

| Parameter Extreme Value | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 27.0 | 0.1 | 6.0 | 3.4 | 100.0 | 120.0 | 10.0 | 54.0 | 0.1 | 0.5 | - | 294 |
| Maximum | 31.0 | 0.3 | 8.0 | 6.6 | 160.0 | 152.0 | 35.0 | 60.0 | 0.4 | 4.0 | - | 360 |
| Total Average | 27.8 | 0.2 | 6.7 | 5.2 | 123.0 | 143.8 | 19.5 | 56.5 | 0.2 | 1.6 | - | 323 |

## Table 2k. Water quality results of Sagar lake during November 2007

| Site No. | Level of Sampling | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 24.3 | 0.13 | 6.5 | 4.6 | 132.5 | 138.0 | 24.3 | 65.0 | 0.48 | 2.63 | Present | 344.0 |
| | Bottom | 24.0 | | 6.5 | 4.8 | 132.5 | 138.0 | 16.8 | 65.0 | 0.33 | 3.06 | " | 368.0 |
| 2 | Top | 23.8 | 0.19 | 6.9 | 5.9 | 140.0 | 142.0 | 20.5 | 63.0 | 0.40 | 1.94 | " | 320.0 |
| | Bottom | 23.0 | | 6.5 | 4.1 | 140.0 | 148.0 | 24.3 | 63.0 | 0.40 | 2.38 | " | 352.0 |
| 3 | Top | 23.5 | 0.19 | 6.9 | 4.7 | 140.0 | 154.0 | 20.5 | 63.0 | 0.40 | 1.13 | " | 332.9 |
| | Middle | 22.8 | | 6.6 | 4.7 | 143.8 | 153.5 | 24.3 | 63.5 | 0.40 | 1.13 | " | 332.9 |
| | Bottom | 22.8 | | 6.5 | 4.4 | 147.5 | 158.0 | 28.0 | 63.5 | 0.40 | 1.28 | " | 360.6 |
| 4 | Top | 24.0 | 0.14 | 6.4 | 4.6 | 125.0 | 150.0 | 16.8 | 63.5 | 0.33 | 2.31 | " | 357.5 |
| | Bottom | 23.5 | | 6.5 | 4.1 | 132.5 | 132.0 | 13.8 | 63.5 | 0.33 | 2.63 | " | 342.6 |
| 5 | Top | 23.5 | 0.21 | 6.9 | 5.3 | 140.0 | 152.0 | 20.5 | 63.5 | 0.40 | 1.35 | " | 344.2 |
| | Middle | 22.8 | | 6.9 | 5.5 | 140.0 | 150.0 | 20.5 | 63.5 | 0.40 | 1.41 | " | 339.3 |
| | Bottom | 22.8 | | 6.5 | 5.1 | 140.0 | 154.0 | 20.5 | 63.5 | 0.40 | 1.35 | " | 329.7 |
| 6 | Top | 23.3 | 0.22 | 6.5 | 4.8 | 155.0 | 150.0 | 20.5 | 65.0 | 0.33 | 1.35 | " | 338.9 |
| | Middle | 22.8 | | 6.4 | 4.3 | 155.0 | 152.0 | 20.5 | 65.0 | 0.33 | 1.35 | " | 346.1 |
| | Bottom | 22.8 | | 6.4 | 3.8 | 155.0 | 150.0 | 20.5 | 65.0 | 0.33 | 1.41 | " | 356.6 |
| 7 | Top | 23.8 | 0.15 | 6.9 | 5.3 | 125.0 | 154.0 | 14.8 | 63.0 | 0.33 | 2.31 | " | 340.8 |
| | Middle | 23.3 | | 6.4 | 5.1 | 140.0 | 152.0 | 15.3 | 63.0 | 0.40 | 2.75 | " | 340.5 |
| | Bottom | 23.0 | | 6.4 | 5.0 | 155.0 | 152.0 | 15.3 | 63.0 | 0.55 | 3.63 | " | 375.8 |
| 8 | Top | 23.5 | 0.25 | 6.4 | 6.2 | 137.5 | 158.0 | 13.8 | 63.0 | 0.55 | 1.34 | " | 350.5 |
| | Middle | 23.3 | | 6.5 | 5.7 | 136.3 | 156.0 | 21.3 | 63.0 | 0.40 | 1.34 | " | 369.5 |
| | Bottom | 23.0 | | 6.5 | 5.4 | 137.5 | 158.0 | 31.8 | 62.0 | 0.29 | 1.41 | " | 366.9 |
| 9 | Top | 23.3 | 0.17 | 6.5 | 5.5 | 157.5 | 158.0 | 14.5 | 61.5 | 0.55 | 2.31 | " | 367.3 |
| | Bottom | 22.8 | | 6.6 | 5.2 | 155.0 | 160.0 | 16.8 | 61.5 | 0.55 | 3.88 | " | 350.8 |
| 10 | Top | 22.8 | 0.22 | 6.0 | 4.4 | 135.0 | 166.0 | 12.5 | 63.0 | 0.40 | 2.00 | " | 334.5 |
| 11 | Top | 23.5 | 0.14 | 6.1 | 3.4 | 170.0 | 152.0 | 24.3 | 66.0 | 0.14 | 1.56 | " | 356.5 |
| 19 | Top | 25.3 | 0.14 | 7.7 | 4.3 | 125.0 | 152.0 | 24.8 | 67.0 | 0.28 | 2.38 | " | 359.0 |
| | Bottom | 24.8 | | 7.6 | 3.8 | 125.0 | 154.0 | 28.5 | 66.5 | 0.35 | 2.75 | " | 384.5 |

## Minimum, maximum and average of lake water quality results

| Parameter Extreme Value | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 22.8 | 0.1 | 6.0 | 3.4 | 125.0 | 132.0 | 12.5 | 61.5 | 0.1 | 1.1 | - | 320 |
| Maximum | 25.3 | 0.2 | 7.7 | 6.2 | 170.0 | 166.0 | 31.8 | 67.0 | 0.6 | 3.9 | - | 385 |
| Total Average | 23.4 | 0.2 | 6.6 | 4.8 | 141.4 | 151.6 | 20.2 | 63.7 | 0.4 | 2.0 | - | 350 |

## Table 2I. Water quality results of Sagar lake during January 2008

| Site No. | Level of Sampling | Temp. (C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 20.0 | 0.12 | 6.5 | 4.3 | 155.0 | 148.0 | 23.5 | 72.0 | 0.65 | 2.75 | Present | 368.1 |
| | Bottom | 19.5 | | 6.5 | 4.6 | 155.0 | 148.0 | 18.5 | 72.0 | 0.55 | 3.13 | " | 396.0 |
| 2 | Top | 19.5 | 0.16 | 6.8 | 5.3 | 160.0 | 148.0 | 21.0 | 70.0 | 0.60 | 2.38 | " | 346.0 |
| | Bottom | 18.5 | | 6.5 | 3.9 | 160.0 | 152.0 | 23.5 | 70.0 | 0.60 | 2.75 | " | 386.0 |
| 3 | Top | 19.5 | 0.16 | 6.8 | 4.2 | 160.0 | 164.0 | 21.0 | 70.0 | 0.60 | 1.75 | " | 365.8 |
| | Middle | 18.5 | | 6.8 | 4.3 | 162.5 | 161.0 | 23.5 | 71.0 | 0.60 | 1.75 | " | 365.8 |
| | Bottom | 18.5 | | 6.5 | 4.4 | 165.0 | 164.0 | 26.0 | 71.0 | 0.60 | 1.85 | " | 381.1 |
| 4 | Top | 20.0 | 0.12 | 6.3 | 3.9 | 150.0 | 156.0 | 18.5 | 71.0 | 0.55 | 2.63 | " | 379.1 |
| | Bottom | 19.0 | | 6.5 | 3.5 | 155.0 | 144.0 | 16.5 | 71.0 | 0.55 | 2.75 | " | 369.1 |
| 5 | Top | 19.0 | 0.18 | 6.8 | 4.3 | 160.0 | 160.0 | 21.0 | 71.0 | 0.60 | 1.90 | " | 374.4 |
| | Middle | 18.0 | | 6.8 | 5.0 | 160.0 | 156.0 | 21.0 | 71.0 | 0.60 | 2.03 | " | 358.6 |
| | Bottom | 18.0 | | 6.5 | 4.1 | 160.0 | 164.0 | 21.0 | 71.0 | 0.60 | 1.90 | " | 349.4 |
| 6 | Top | 19.0 | 0.18 | 6.5 | 4.1 | 170.0 | 156.0 | 21.0 | 72.0 | 0.55 | 1.90 | " | 363.8 |
| | Middle | 18.0 | | 6.4 | 3.8 | 170.0 | 160.0 | 21.0 | 72.0 | 0.55 | 1.90 | " | 372.1 |
| | Bottom | 18.5 | | 6.4 | 3.4 | 170.0 | 156.0 | 21.0 | 72.0 | 0.55 | 2.03 | " | 379.1 |
| 7 | Top | 19.5 | 0.13 | 6.8 | 4.9 | 150.0 | 164.0 | 17.5 | 70.0 | 0.55 | 2.63 | " | 375.6 |
| | Middle | 19.0 | | 6.3 | 4.7 | 160.0 | 160.0 | 18.5 | 70.0 | 0.60 | 3.00 | " | 381.0 |
| | Bottom | 18.5 | | 6.3 | 4.6 | 170.0 | 160.0 | 18.5 | 70.0 | 0.70 | 3.75 | " | 411.5 |
| 8 | Top | 19.5 | 0.21 | 6.3 | 5.8 | 155.0 | 164.0 | 16.5 | 70.0 | 0.70 | 1.98 | " | 375.1 |
| | Middle | 19.0 | | 6.5 | 5.5 | 147.5 | 160.0 | 21.5 | 70.0 | 0.60 | 1.98 | " | 399.1 |
| | Bottom | 18.5 | | 6.5 | 5.4 | 145.0 | 164.0 | 28.5 | 68.0 | 0.53 | 2.03 | " | 383.7 |
| 9 | Top | 19.5 | 0.14 | 6.5 | 5.1 | 175.0 | 164.0 | 17.0 | 69.0 | 0.70 | 2.63 | " | 392.5 |
| | Bottom | 18.5 | | 6.8 | 5.0 | 170.0 | 168.0 | 18.5 | 69.0 | 0.70 | 3.75 | " | 381.6 |
| 10 | Top | 18.5 | 0.20 | 6.0 | 4.4 | 150.0 | 180.0 | 15.0 | 70.0 | 0.50 | 2.00 | " | 349.0 |
| 11 | Top | 19.5 | 0.12 | 6.3 | 3.3 | 180.0 | 160.0 | 23.5 | 76.0 | 0.23 | 2.13 | " | 401.0 |
| 19 | Top | 19.5 | 0.12 | 7.4 | 4.0 | 150.0 | 160.0 | 24.5 | 74.0 | 0.45 | 2.75 | " | 392.1 |
| | Bottom | 19.0 | | 7.3 | 3.6 | 150.0 | 164.0 | 27.0 | 73.0 | 0.50 | 3.00 | " | 409.1 |

## Minimum, maximum and average of lake water quality results

| Parameter Extreme Value | Temp. (C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 18.0 | 0.1 | 6.0 | 3.3 | 145.0 | 144.0 | 15.0 | 68.0 | 0.2 | 1.8 | - | 346 |
| Maximum | 20.0 | 0.2 | 7.4 | 5.8 | 180.0 | 180.0 | 28.5 | 76.0 | 0.7 | 3.8 | - | 412 |
| Total Average | 19.0 | 0.2 | 6.6 | 4.4 | 159.8 | 159.4 | 20.9 | 71.0 | 0.6 | 2.4 | - | 378 |

## Table 2m. Water quality results of Sagar lake during March 2008

| Site No. | Level of Sampling | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 24.0 | 0.10 | 6.5 | 4.1 | 177.5 | 158.0 | 22.8 | 79.0 | 0.83 | 2.88 | Present | 392.1 |
| | Bottom | 23.8 | | 6.5 | 4.4 | 177.5 | 158.0 | 20.3 | 79.0 | 0.78 | 3.19 | " | 424.0 |
| 2 | Top | 24.0 | 0.14 | 6.6 | 4.8 | 180.0 | 154.0 | 21.5 | 77.0 | 0.80 | 2.81 | " | 372.1 |
| | Bottom | 23.5 | | 6.5 | 3.8 | 180.0 | 156.0 | 22.8 | 77.0 | 0.80 | 3.13 | " | 420.0 |
| 3 | Top | 24.0 | 0.12 | 6.6 | 3.7 | 180.0 | 174.0 | 21.5 | 77.0 | 0.80 | 2.38 | " | 398.8 |
| | Middle | 23.5 | | 6.9 | 4.0 | 181.3 | 168.5 | 22.8 | 78.5 | 0.80 | 2.38 | " | 398.8 |
| | Bottom | 23.3 | | 6.5 | 4.4 | 182.5 | 170.0 | 24.0 | 78.5 | 0.80 | 2.43 | " | 401.7 |
| 4 | Top | 24.0 | 0.10 | 6.1 | 3.3 | 175.0 | 162.0 | 20.3 | 78.5 | 0.78 | 2.94 | " | 400.6 |
| | Bottom | 23.5 | | 6.5 | 3.0 | 177.5 | 156.0 | 19.3 | 78.5 | 0.78 | 2.88 | " | 395.7 |
| 5 | Top | 23.8 | 0.16 | 6.6 | 3.4 | 180.0 | 168.0 | 21.5 | 78.5 | 0.80 | 2.45 | " | 404.5 |
| | Middle | 23.0 | | 6.6 | 4.5 | 180.0 | 162.0 | 21.5 | 78.5 | 0.80 | 2.64 | " | 378.0 |
| | Bottom | 23.0 | | 6.5 | 3.2 | 180.0 | 174.0 | 21.5 | 78.5 | 0.80 | 2.45 | " | 369.1 |
| 6 | Top | 23.8 | 0.15 | 6.5 | 3.5 | 185.0 | 162.0 | 21.5 | 79.0 | 0.78 | 2.45 | " | 388.8 |
| | Middle | 23.3 | | 6.3 | 3.3 | 185.0 | 168.0 | 21.5 | 79.0 | 0.78 | 2.45 | " | 398.2 |
| | Bottom | 23.3 | | 6.3 | 3.0 | 185.0 | 162.0 | 21.5 | 79.0 | 0.78 | 2.64 | " | 401.7 |
| 7 | Top | 23.8 | 0.11 | 6.6 | 4.6 | 175.0 | 174.0 | 20.3 | 77.0 | 0.78 | 2.94 | " | 410.4 |
| | Middle | 23.5 | | 6.1 | 4.4 | 180.0 | 168.0 | 21.8 | 77.0 | 0.80 | 3.25 | " | 421.5 |
| | Bottom | 23.3 | | 6.1 | 4.2 | 185.0 | 168.0 | 21.8 | 77.0 | 0.85 | 3.88 | " | 447.3 |
| 8 | Top | 23.8 | 0.16 | 6.1 | 5.4 | 172.5 | 170.0 | 19.3 | 77.0 | 0.85 | 2.61 | " | 399.6 |
| | Middle | 23.5 | | 6.5 | 5.4 | 158.8 | 164.0 | 21.8 | 77.0 | 0.80 | 2.61 | " | 428.6 |
| | Bottom | 23.3 | | 6.5 | 5.4 | 152.5 | 170.0 | 25.3 | 74.0 | 0.76 | 2.64 | " | 400.6 |
| 9 | Top | 23.8 | 0.11 | 6.5 | 4.8 | 192.5 | 170.0 | 19.5 | 76.5 | 0.85 | 2.94 | " | 417.8 |
| | Bottom | 23.3 | | 6.9 | 4.8 | 185.0 | 176.0 | 20.3 | 76.5 | 0.85 | 3.63 | " | 412.3 |
| 10 | Top | 23.3 | 0.18 | 6.0 | 4.4 | 165.0 | 194.0 | 17.5 | 77.0 | 0.60 | 2.00 | " | 363.5 |
| 11 | Top | 23.8 | 0.10 | 6.4 | 3.3 | 190.0 | 168.0 | 22.8 | 86.0 | 0.31 | 2.69 | " | 445.5 |
| 19 | Top | 24.3 | 0.10 | 7.1 | 3.7 | 175.0 | 168.0 | 24.3 | 81.0 | 0.63 | 3.13 | " | 425.1 |
| | Bottom | 23.5 | | 6.9 | 3.4 | 175.0 | 174.0 | 25.5 | 79.5 | 0.65 | 3.25 | " | 433.6 |

## Minimum, maximum and average of lake water quality results

| Parameter Extreme Value | Temp. (°C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 23.0 | 0.1 | 6.0 | 3.0 | 152.5 | 154.0 | 17.5 | 74.0 | 0.3 | 2.0 | - | 364 |
| Maximum | 24.3 | 0.2 | 7.1 | 5.4 | 192.5 | 194.0 | 25.5 | 86.0 | 0.9 | 3.9 | - | 447 |
| Total Average | 23.6 | 0.1 | 6.5 | 4.1 | 178.2 | 167.3 | 21.6 | 78.2 | 0.8 | 2.8 | - | 406 |

## Table 2n. Water quality results of Sagar lake during May 2008

| Site No. | Level of Sampling | Temp. (C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Top | 28.0 | 0.09 | 6.5 | 3.8 | 200.0 | 168.0 | 22.00 | 86.0 | 1.00 | 3.00 | Present | 416 |
| | Bottom | 28.0 | | 6.5 | 4.2 | 200.0 | 168.0 | 22.00 | 86.0 | 1.00 | 3.25 | " | 452 |
| 2 | Top | 28.5 | 0.11 | 6.5 | 4.2 | 200.0 | 160.0 | 22.00 | 84.0 | 1.00 | 3.25 | " | 398 |
| | Bottom | 28.5 | | 6.5 | 3.6 | 200.0 | 160.0 | 22.00 | 84.0 | 1.00 | 3.50 | " | 454 |
| 3 | Top | 28.5 | 0.08 | 6.5 | 3.2 | 200.0 | 184.0 | 22.00 | 84.0 | 1.00 | 3.00 | " | 432 |
| | Middle | 28.5 | | 7.0 | 3.6 | 200.0 | 176.0 | 22.00 | 86.0 | 1.00 | 3.00 | " | 432 |
| | Bottom | 28.0 | | 6.5 | 4.4 | 200.0 | 176.0 | 22.00 | 86.0 | 1.00 | 3.00 | " | 422 |
| 4 | Top | 28.0 | 0.08 | 6.0 | 2.6 | 200.0 | 168.0 | 22.00 | 86.0 | 1.00 | 3.25 | " | 422 |
| | Bottom | 28.0 | | 6.5 | 2.4 | 200.0 | 168.0 | 22.00 | 86.0 | 1.00 | 3.00 | " | 422 |
| 5 | Top | 28.5 | 0.13 | 6.5 | 2.4 | 200.0 | 176.0 | 22.00 | 86.0 | 1.00 | 3.00 | " | 435 |
| | Middle | 28.0 | | 6.5 | 4.0 | 200.0 | 168.0 | 22.00 | 86.0 | 1.00 | 3.25 | " | 397 |
| | Bottom | 28.0 | | 6.5 | 2.2 | 200.0 | 184.0 | 22.00 | 86.0 | 1.00 | 3.00 | " | 389 |
| 6 | Top | 28.5 | 0.12 | 6.5 | 2.8 | 200.0 | 168.0 | 22.00 | 86.0 | 1.00 | 3.00 | " | 414 |
| | Middle | 28.5 | | 6.3 | 2.8 | 200.0 | 176.0 | 22.00 | 86.0 | 1.00 | 3.00 | " | 424 |
| | Bottom | 28.0 | | 6.3 | 2.6 | 200.0 | 168.0 | 22.00 | 86.0 | 1.00 | 3.25 | " | 424 |
| 7 | Top | 28.0 | 0.09 | 6.5 | 4.2 | 200.0 | 184.0 | 23.00 | 84.0 | 1.00 | 3.25 | " | 445 |
| | Middle | 28.0 | | 6.0 | 4.0 | 200.0 | 176.0 | 25.00 | 84.0 | 1.00 | 3.50 | " | 462 |
| | Bottom | 28.0 | | 6.0 | 3.8 | 200.0 | 176.0 | 25.00 | 84.0 | 1.00 | 4.00 | " | 483 |
| 8 | Top | 28.0 | 0.12 | 6.0 | 5.0 | 190.0 | 176.0 | 22.00 | 84.0 | 1.00 | 3.25 | " | 424 |
| | Middle | 28.0 | | 6.5 | 5.2 | 170.0 | 168.0 | 22.00 | 84.0 | 1.00 | 3.25 | " | 458 |
| | Bottom | 28.0 | | 6.5 | 5.4 | 160.0 | 176.0 | 22.00 | 80.0 | 1.00 | 3.25 | " | 417 |
| 9 | Top | 28.0 | 0.08 | 6.5 | 4.4 | 210.0 | 176.0 | 22.00 | 84.0 | 1.00 | 3.25 | " | 443 |
| | Bottom | 28.0 | | 7.0 | 4.6 | 200.0 | 184.0 | 22.00 | 84.0 | 1.00 | 3.50 | " | 443 |
| 10 | Top | 28.0 | 0.16 | 6.0 | 4.4 | 180.0 | 208.0 | 20.00 | 84.0 | 0.70 | 2.00 | " | 378 |
| 11 | Top | 28.0 | 0.08 | 6.5 | 3.2 | 200.0 | 176.0 | 22.00 | 96.0 | 0.40 | 3.25 | " | 490 |
| 19 | Top | 29.0 | 0.08 | 6.8 | 3.4 | 200.0 | 176.0 | 24.00 | 88.0 | 0.80 | 3.50 | " | 458 |
| | Bottom | 28.0 | | 6.5 | 3.2 | 200.0 | 184.0 | 24.00 | 86.0 | 0.80 | 3.50 | " | 458 |

## Minimum, maximum and average of lake water quality results

| Parameter Extreme Value | Temp. (C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 28.0 | 0.1 | 6.0 | 2.2 | 160.0 | 160.0 | 20.0 | 80.0 | 0.4 | 2.0 | - | 378 |
| Maximum | 29.0 | 0.2 | 7.0 | 5.4 | 210.0 | 208.0 | 25.0 | 96.0 | 1.0 | 4.0 | - | 490 |
| Total Average | 28.2 | 0.1 | 6.4 | 3.7 | 196.7 | 175.1 | 22.3 | 85.4 | 1.0 | 3.2 | - | 433 |

## Table 3a. Water quality results of inflow and outflow channels during March 2006

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | **Nalah** | 25.0 | 8.0 | 4.8 | 190 | 168 | 5 | 34 | 0.6 | 3.0 | Present |
| 15 | **Nalah** | 26.0 | 7.0 | 0.0 | 390 | 224 | 1 | 52 | 1.0 | 3.0 | " |
| 16 | **Nalah** | 25.6 | 5.0 | 0.0 | 230 | 168 | 15 | 32 | 0.5 | 3.0 | " |
| 17 | **Nalah** | 25.8 | 6.0 | 3.0 | 240 | 144 | 2 | 24 | 1.0 | 3.0 | " |
| 20 | **Nalah** | 25.8 | 5.0 | 0.0 | 480 | 224 | 15 | 88 | 1.0 | 2.0 | " |
| 21 | **Canal** | 26.0 | 6.5 | 4.0 | 170 | 128 | 5 | 38 | 0.3 | 2.0 | " |
| Mogha | **Outflow** | 25.0 | 7.0 | 3.6 | 230 | 160 | 5 | 44 | 0.5 | 2.0 | " |

## Minimum, maximum and average of surface water quality results

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | |
| Minimum | 25.0 | 5.0 | 0.0 | 190 | 144 | 1.0 | 24 | 0.5 | 2.0 | - |
| Maximum | 26.0 | 8.0 | 4.8 | 480 | 224 | 15.0 | 88 | 1.0 | 3.0 | - |
| Total Average | 25.6 | 6.2 | 1.6 | 306.0 | 185.6 | 7.6 | 46.0 | 0.8 | 2.8 | - |
| | | | | | | | | | | |
| **Canal** | 26.0 | 6.5 | 4.0 | 170 | 128 | 5.0 | 38 | 0.3 | 2.0 | - |
| **Mogha Outflow** | 25.0 | 7.0 | 3.6 | 230 | 160 | 5.0 | 44 | 0.5 | 2.0 | - |

## Table 3b. Water quality results of inflow and outflow channels during May 2006

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | Nalah | - | - | - | - | - | - | - | - | - | - |
| 15 | Nalah | 29.0 | 6.5 | 2.2 | 320 | 168 | 0.5 | 80 | 2.0 | 3.0 | Present |
| 16 | Nalah | 29.0 | 5.5 | 2.4 | 260 | 184 | 10 | 84 | 0.7 | 3.0 | " |
| 17 | Nalah | 27.5 | 5.5 | 4.4 | 170 | 128 | 0.3 | 50 | 0.8 | 0.7 | " |
| 20 | Nalah | 28.0 | 6.0 | 2.2 | 380 | 160 | 15 | 106 | 2.0 | 0.5 | " |
| 21 | Canal | 27.5 | 6.5 | 3.4 | 190 | 176 | 0.5 | 104 | 0.4 | 1.0 | " |
| Mogha | Outflow | 26.0 | 7.0 | 3.8 | 200 | 168 | 0.4 | 86 | 0.5 | 2.0 | " |

## Minimum, maximum and average of surface water quality results

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | |
| Minimum | 27.5 | 5.5 | 2.2 | 170 | 128 | 0.3 | 50 | 0.7 | 0.5 | - |
| Maximum | 29.0 | 6.5 | 4.4 | 380 | 184 | 15.0 | 106 | 2.0 | 3.0 | - |
| Total Average | 28.4 | 5.9 | 2.8 | 282.5 | 160.0 | 6.5 | 80.0 | 1.4 | 1.8 | - |
| | | | | | | | | | | |
| **Canal** | 27.5 | 6.5 | 3.4 | 190 | 176 | 0.5 | 104 | 0.4 | 1.0 | - |
| **Mogha Outflow** | 26.0 | 7.0 | 3.8 | 200 | 168 | 0.4 | 86 | 0.5 | 2.0 | - |

**Table 3c. Water quality results of inflow and outflow channels during July 2006**

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | **Nalah** | 20.0 | 6.0 | 1.8 | 250 | 216 | 0.6 | 94 | 0.5 | 3.0 | Present |
| 14 | **Nalah** | 19.0 | 6.0 | 2.0 | 190 | 176 | 0.6 | 66 | 0.4 | 1.5 | " |
| 15 | **Nalah** | 20.0 | 6.5 | 0.6 | 240 | 192 | 0.5 | 66 | 1.5 | 2.0 | " |
| 16 | **Nalah** | 20.0 | 5.0 | 0.6 | 200 | 192 | 5 | 70 | 0.5 | 2.0 | " |
| 17 | **Nalah** | 20.5 | 5.0 | 2.0 | 200 | 112 | 5 | 40 | 0.7 | 2.0 | " |
| 20 | **Nalah** | 20.0 | 5.5 | 1.4 | 300 | 160 | 5 | 78 | 1.5 | 0.6 | " |
| 21 | **Canal** | 20.5 | 6.5 | 2.8 | 230 | 224 | 0.6 | 70 | 0.2 | 0.8 | " |
| Mogha | **Outflow** | 19.0 | 6.5 | 2.8 | 180 | 160 | 0.5 | 66 | 0.4 | 1.5 | " |

**Minimum, maximum and average of surface water quality results**

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | |
| Minimum | 19.0 | 5.0 | 0.6 | 190.0 | 112.0 | 0.5 | 40.0 | 0.4 | 0.6 | - |
| Maximum | 20.5 | 6.5 | 2.0 | 300.0 | 216.0 | 5.0 | 94.0 | 1.5 | 3.0 | - |
| Total Average | 19.9 | 5.7 | 1.4 | 230.0 | 174.7 | 2.8 | 69.0 | 0.9 | 1.9 | - |
| | | | | | | | | | | |
| **Canal** | 20.5 | 6.5 | 2.8 | 230 | 224 | 0.6 | 70 | 0.2 | 0.8 | - |
| **Mogha Outflow** | 19.0 | 6.5 | 2.8 | 180 | 160 | 0.5 | 66 | 0.4 | 1.5 | - |

**Table 3d. Water quality results of inflow and outflow channels during September 2006**

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | **Nalah** | 28.0 | 5.5 | 2.4 | 250 | 224 | 1 | 56 | 0.40 | 4.0 | Present |
| 14 | **Nalah** | 30.0 | 7.0 | 6.4 | 170 | 184 | 0.5 | 52 | 0.10 | 0.1 | " |
| 15 | **Nalah** | 29.0 | 6.5 | 1.0 | 160 | 224 | 0.5 | 52 | 1.00 | 1.0 | " |
| 16 | **Nalah** | 28.0 | 5.0 | 0.8 | 140 | 200 | 0.8 | 60 | 0.30 | 2.0 | " |
| 17 | **Nalah** | 28.0 | 5.0 | 1.6 | 220 | 184 | 10 | 30 | 0.70 | 3.0 | " |
| 20 | **Nalah** | 28.0 | 5.0 | 2.6 | 230 | 168 | 0.5 | 50 | 0.70 | 0.8 | " |
| 21 | **Canal** | 30.0 | 6.5 | 4.4 | 280 | 280 | 8 | 36 | 0.05 | 0.1 | " |
| Mogha | **Outflow** | 28.0 | 6.5 | 3.8 | 160 | 152 | 0.6 | 44 | 0.30 | 1.0 | " |

**Minimum, maximum and average of surface water quality results**

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | |
| Minimum | 28.0 | 5.0 | 0.8 | 140.0 | 168.0 | 0.5 | 30.0 | 0.1 | 0.1 | - |
| Maximum | 30.0 | 7.0 | 6.4 | 250.0 | 224.0 | 10.0 | 60.0 | 1.0 | 4.0 | - |
| Total Average | 28.5 | 5.7 | 2.5 | 195.0 | 197.3 | 2.2 | 50.0 | 0.5 | 1.8 | - |
| | | | | | | | | | | |
| **Canal** | 30.0 | 6.5 | 4.4 | 280 | 280 | 8.0 | 36 | 0.05 | 0.1 | - |
| **Mogha Outflow** | 28.0 | 6.5 | 3.8 | 160 | 152 | 0.6 | 44 | 0.30 | 1.0 | - |

## Table 3e. Water quality results of inflow and outflow channels during November 2006

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | **Nalah** | 23.0 | 5.8 | 3.2 | 305.0 | 266.0 | 8 | 88 | 1.0 | 3.8 | Present |
| 14 | **Nalah** | 23.8 | 6.5 | 5.1 | 245.0 | 240.0 | 5.25 | 83 | 0.6 | 0.3 | " |
| 15 | **Nalah** | 22.8 | 6.3 | 2.2 | 330.0 | 304.0 | 4.25 | 84 | 1.5 | 2.0 | " |
| 16 | **Nalah** | 23.5 | 5.5 | 2.1 | 200.0 | 272.0 | 1.4 | 86 | 0.4 | 3.0 | " |
| 17 | **Nalah** | 23.0 | 5.5 | 2.1 | 345.0 | 260.0 | 15 | 80 | 1.4 | 2.5 | " |
| 20 | **Nalah** | 22.8 | 5.8 | 2.5 | 340.0 | 212.0 | 22.75 | 95 | 1.6 | 1.7 | " |
| 21 | **Canal** | 23.8 | 6.3 | 5.1 | 230.0 | 308.0 | 4.25 | 54 | 0.4 | 2.1 | " |
| Mogha | **Outflow** | 22.8 | 6.3 | 3.9 | 155.0 | 216.0 | 0.5 | 57 | 0.7 | 1.3 | " |

## Minimum, maximum and average of surface water quality results

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | |
| Minimum | 22.8 | 5.5 | 2.1 | 200.0 | 212.0 | 1.4 | 80.0 | 0.4 | 0.3 | - |
| Maximum | 23.8 | 6.5 | 5.1 | 345.0 | 304.0 | 22.8 | 95.0 | 1.6 | 3.8 | - |
| Total Average | 23.1 | 5.9 | 2.9 | 294.2 | 259.0 | 9.4 | 86.0 | 1.1 | 2.2 | - |
| | | | | | | | | | | |
| **Canal** | 23.8 | 6.3 | 5.1 | 230.0 | 308.0 | 4.3 | 54.0 | 0.4 | 2.1 | - |
| **Mogha Outflow** | 22.8 | 6.3 | 3.9 | 155.0 | 216.0 | 0.5 | 57.0 | 0.7 | 1.3 | - |

**Table 3f. Water quality results of inflow and outflow channels during January 2007**

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | **Nalah** | 18.0 | 6.0 | 4.0 | 360 | 308 | 15 | 120 | 1.5 | 3.5 | Present |
| 14 | **Nalah** | 17.5 | 6.0 | 3.8 | 320 | 296 | 10.0 | 114 | 1.0 | 0.5 | " |
| 15 | **Nalah** | 16.5 | 6.0 | 3.4 | 500 | 384 | 8 | 116 | 2.0 | 3.0 | " |
| 16 | **Nalah** | 19.0 | 6.0 | 3.4 | 260 | 344 | 2 | 112 | 0.5 | 4.0 | " |
| 17 | **Nalah** | 18.0 | 6.0 | 2.6 | 470 | 336 | 20 | 130 | 2.0 | 2.0 | " |
| 20 | **Nalah** | 17.5 | 6.5 | 2.4 | 450 | 256 | 45 | 140 | 2.5 | 2.5 | " |
| 21 | **Canal** | 17.5 | 6.0 | 5.8 | 180 | 336 | 0.5 | 72 | 0.7 | 4.0 | " |
| Mogha | **Outflow** | 17.5 | 6.0 | 4.0 | 150 | 280 | 0.4 | 70 | 1.0 | 1.5 | " |

**Minimum, maximum and average of surface water quality results**

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | |
| Minimum | 16.5 | 6.0 | 2.4 | 260.0 | 256.0 | 2.0 | 112.0 | 0.5 | 0.5 | - |
| Maximum | 19.0 | 6.5 | 4.0 | 500.0 | 384.0 | 45.0 | 140.0 | 2.5 | 4.0 | - |
| Total Average | 17.8 | 6.1 | 3.3 | 393.3 | 320.7 | 16.7 | 122.0 | 1.6 | 2.6 | - |
| | | | | | | | | | | |
| **Canal** | 17.5 | 6.0 | 5.8 | 180.0 | 336.0 | 0.5 | 72.0 | 0.7 | 4.0 | - |
| **Mogha Outflow** | 17.5 | 6.0 | 4.0 | 150.0 | 280.0 | 0.4 | 70.0 | 1.0 | 1.5 | - |

## Table 3g. Water quality results of inflow and outflow channels during March 2007

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | **Nalah** | 19.0 | 6.5 | 3.8 | 480.0 | 462.0 | 15.0 | 166.0 | 1.0 | 4.0 | Present |
| 14 | **Nalah** | 20.0 | 6.5 | 3.6 | 300.0 | 252.0 | 10.0 | 114.0 | 1.0 | 0.5 | " |
| 15 | **Nalah** | 20.0 | 6.0 | 3.2 | 410.0 | 284.0 | 30.0 | 86.0 | 1.5 | 3.0 | " |
| 16 | **Nalah** | 22.0 | 6.0 | 2.8 | 320.0 | 276.0 | 25.0 | 95.0 | 0.5 | 4.0 | " |
| 17 | **Nalah** | 21.0 | 6.0 | 3.0 | 330.0 | 228.0 | 15.0 | 81.0 | 1.5 | 2.0 | " |
| 20 | **Nalah** | 21.0 | 6.5 | 2.5 | 390.0 | 208.0 | 35.0 | 113.0 | 1.5 | 2.5 | " |
| 21 | **Canal** | 20.0 | 6.5 | 4.6 | 170.0 | 268.0 | 5.0 | 72.0 | 1.0 | 4.0 | " |
| Mogha | **Outflow** | 20.0 | 6.5 | 3.6 | 155.0 | 216.0 | 20.0 | 70.0 | 1.0 | 2.0 | " |

## Minimum, maximum and average of surface water quality results

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | |
| Minimum | 19.0 | 6.0 | 2.5 | 300.0 | 208.0 | 10.0 | 81.0 | 0.5 | 0.5 | - |
| Maximum | 22.0 | 6.5 | 3.8 | 480.0 | 462.0 | 35.0 | 166.0 | 1.5 | 4.0 | - |
| Total Average | 20.5 | 6.3 | 3.2 | 371.7 | 285.0 | 21.7 | 109.2 | 1.2 | 2.7 | - |
| | | | | | | | | | | |
| **Canal** | 20.0 | 6.5 | 4.6 | 170.0 | 268.0 | 5.0 | 72.0 | 1.0 | 4.0 | - |
| **Mogha Outflow** | 20.0 | 6.5 | 3.6 | 155.0 | 216.0 | 20.0 | 70.0 | 1.0 | 2.0 | - |

## Table 3h. Water quality results of inflow and outflow channels during May 2007

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | **Nalah** | 20.0 | 6.5 | 3.6 | 610.0 | 616.0 | 15 | 212 | 0.4 | 4.0 | Present |
| 14 | **Nalah** | - | - | - | - | - | - | - | - | - | - |
| 15 | **Nalah** | 23.0 | 6.0 | 3.0 | 370.0 | 184.0 | 55 | 56 | 0.7 | 3.0 | " |
| 16 | **Nalah** | 24.0 | 5.5 | 2.2 | 370.0 | 208.0 | 50 | 78 | 0.6 | 4.0 | " |
| 17 | **Nalah** | 24.0 | 6.0 | 3.4 | 190.0 | 120.0 | 12 | 32 | 0.6 | 1.5 | " |
| 20 | **Nalah** | 25.0 | 6.0 | 2.6 | 330.0 | 160.0 | 25 | 86 | 0.5 | 2.0 | " |
| 21 | **Canal** | - | - | - | - | - | - | - | - | - | - |
| Mogha | **Outflow** | 22.0 | 6.5 | 3.0 | 160.0 | 152.0 | 35 | 70 | 0.4 | 2.5 | " |

## Minimum, maximum and average of surface water quality results

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | |
| Minimum | 20.0 | 5.5 | 2.2 | 190.0 | 120.0 | 12.0 | 32.0 | 0.4 | 1.5 | - |
| Maximum | 25.0 | 6.5 | 3.6 | 610.0 | 616.0 | 55.0 | 212.0 | 0.7 | 4.0 | - |
| Total Average | 23.2 | 6.0 | 3.0 | 374.0 | 257.6 | 31.4 | 92.8 | 0.6 | 2.9 | - |
| | | | | | | | | | | |
| **Canal** | - | - | - | - | - | - | - | - | - | - |
| **Mogha Outflow** | 22.0 | 6.5 | 3.0 | 160.0 | 152.0 | 35.0 | 70.0 | 0.4 | 2.5 | - |

**Table 3i. Water quality results of inflow and outflow channels during July 2007**

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | **Nalah** | 21.0 | 6.0 | 3.1 | 375.0 | 351.4 | 10.7 | 122.3 | 0.7 | 3.3 | Present |
| 14 | **Nalah** | 20.0 | 6.6 | 4.1 | 245.0 | 233.7 | 6.6 | 84.1 | 0.5 | 1.2 | - |
| 15 | **Nalah** | 21.0 | 6.3 | 2.0 | 332.2 | 238.7 | 14.4 | 71.3 | 1.3 | 2.6 | " |
| 16 | **Nalah** | 21.0 | 5.5 | 1.8 | 243.3 | 227.1 | 16.0 | 77.4 | 0.5 | 3.0 | " |
| 17 | **Nalah** | 21.0 | 5.7 | 2.9 | 258.3 | 182.2 | 10.5 | 55.4 | 1.0 | 2.0 | " |
| 20 | **Nalah** | 20.5 | 5.8 | 2.1 | 368.9 | 192.4 | 22.0 | 95.6 | 1.3 | 1.6 | " |
| 21 | **Canal** | 20.0 | 6.3 | 4.3 | 218.8 | 247.5 | 4.2 | 60.8 | 0.4 | 1.8 | - |
| Mogha | **Outflow** | 19.0 | 6.5 | 3.7 | 171.1 | 183.1 | 8.6 | 62.1 | 0.5 | 1.6 | " |

**Minimum, maximum and average of surface water quality results**

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform |
|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | |
| Minimum | 20.0 | 5.5 | 1.8 | 243.3 | 182.2 | 6.6 | 55.4 | 0.5 | 1.2 | - |
| Maximum | 21.0 | 6.6 | 4.1 | 375.0 | 351.4 | 22.0 | 122.3 | 1.3 | 3.3 | - |
| Total Average | 20.8 | 6.0 | 2.7 | 303.8 | 237.6 | 13.4 | 84.4 | 0.9 | 2.3 | - |
| | | | | | | | | | | |
| **Canal** | 20.0 | 6.3 | 4.3 | 218.8 | 247.5 | 4.2 | 60.8 | 0.4 | 1.8 | - |
| **Mogha Outflow** | 19.0 | 6.5 | 3.7 | 171.1 | 183.1 | 8.6 | 62.1 | 0.5 | 1.6 | - |

## Table 3j. Water quality results of inflow and outflow channels during September 2007

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | **Nalah** | 30.0 | 6.0 | 3.0 | 370.0 | 368.0 | 20 | 120 | 0.1 | 1.0 | Present | 746 |
| 14 | **Nalah** | 27.0 | 6.0 | 3.0 | 300.0 | 320.0 | 15 | 126 | 0.1 | 2.5 | " | 676 |
| 15 | **Nalah** | 29.0 | 6.0 | 2.4 | 270.0 | 184.0 | 30 | 50 | 0.1 | 3.0 | " | 426 |
| 16 | **Nalah** | 28.0 | 6.0 | 2.0 | 210.0 | 200.0 | 35 | 80 | 0.2 | 2.0 | " | 700 |
| 17 | **Nalah** | 28.5 | 6.5 | 3.6 | 160.0 | 128.0 | 15 | 32 | 0.1 | 1.5 | " | 282 |
| 20 | **Nalah** | 29.0 | 6.0 | 2.8 | 420.0 | 184.0 | 35 | 104 | 0.1 | 2.0 | " | 766 |
| 21 | **Canal** | 29.0 | 6.0 | 4.0 | 300.0 | 260.0 | 10 | 40 | 0.1 | 0.1 | " | 760 |
| Mogha | **Outflow** | 28.0 | 6.0 | 5.2 | 150.0 | 144.0 | 15 | 52 | 0.1 | 1.0 | " | 346 |

### Minimum, maximum and average of surface water quality results

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | | |
| Minimum | 27.0 | 6.0 | 2.0 | 160.0 | 128.0 | 15.0 | 32.0 | 0.1 | 1.0 | - | 282 |
| Maximum | 30.0 | 6.5 | 3.6 | 420.0 | 368.0 | 35.0 | 126.0 | 0.2 | 3.0 | - | 766 |
| Total Average | 28.6 | 6.1 | 2.8 | 288.3 | 230.7 | 25.0 | 85.3 | 0.1 | 2.0 | - | 599 |
| | | | | | | | | | | | |
| **Canal** | 29.0 | 6.0 | 4.0 | 300.0 | 260.0 | 10.0 | 40.0 | 0.1 | 0.1 | - | 760 |
| **Mogha Outflow** | 28.0 | 6.0 | 5.2 | 150.0 | 144.0 | 15.0 | 52.0 | 0.1 | 1.0 | - | 346 |

## Table 3k. Water quality results of inflow and outflow channels during November 2007

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | Nalah | 25.0 | 5.5 | 2.5 | 300.0 | 176.0 | 17.0 | 72.0 | 0.7 | 3.9 | Present | 746.0 |
| 14 | Nalah | 24.0 | 6.5 | 3.0 | 235.0 | 170.0 | 11.0 | 67.5 | 0.3 | 0.2 | " | 676.0 |
| 15 | Nalah | 25.0 | 6.0 | 2.4 | 350.0 | 180.0 | 27.3 | 67.0 | 0.8 | 2.5 | " | 518.5 |
| 16 | Nalah | 25.5 | 5.8 | 2.2 | 282.5 | 196.0 | 32.0 | 91.5 | 0.3 | 1.9 | " | 710.0 |
| 17 | Nalah | 25.3 | 6.5 | 3.3 | 232.5 | 130.0 | 16.0 | 47.5 | 0.8 | 1.5 | " | 345.0 |
| 20 | Nalah | 25.5 | 6.0 | 2.7 | 459.0 | 182.0 | 33.3 | 106.0 | 0.5 | 1.8 | " | 764.5 |
| 21 | Canal | 25.0 | 6.5 | 2.6 | 235.0 | 200.0 | 5.0 | 45.0 | 0.2 | 1.1 | " | 760.0 |
| Mogha | Outflow | 24.5 | 6.5 | 3.0 | 155.0 | 168.0 | 3.0 | 50.5 | 0.5 | 1.1 | " | 346.0 |

## Minimum, maximum and average of surface water quality results

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | | |
| Minimum | 24.0 | 5.5 | 2.2 | 232.5 | 130.0 | 11.0 | 47.5 | 0.3 | 0.2 | - | 345 |
| Maximum | 25.5 | 6.5 | 3.3 | 459.0 | 196.0 | 33.3 | 106.0 | 0.8 | 3.9 | - | 764 |
| Total Average | 25.0 | 6.0 | 2.7 | 309.8 | 172.3 | 22.8 | 75.3 | 0.6 | 2.0 | - | 627 |
| | | | | | | | | | | | |
| **Canal** | 25.0 | 6.5 | 2.6 | 235.0 | 200.0 | 5.0 | 45.0 | 0.2 | 1.1 | - | 760 |
| **Mogha Outflow** | 24.5 | 6.5 | 3.0 | 155.0 | 168.0 | 3.0 | 50.5 | 0.5 | 1.1 | - | 346 |

**Table 3l. Water quality results of inflow and outflow channels during January 2008**

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | **Nalah** | 20.0 | 6.1 | 3.7 | 381.7 | 345.3 | 12.7 | 124.7 | 1.1 | 3.8 | Present | 746.0 |
| 14 | **Nalah** | 21.0 | 6.3 | 4.2 | 288.3 | 262.7 | 8.4 | 103.7 | 0.9 | 0.4 | " | 676.0 |
| 15 | **Nalah** | 21.0 | 6.0 | 2.3 | 430.0 | 176.0 | 24.5 | 84.0 | 1.5 | 2.0 | " | 611.0 |
| 16 | **Nalah** | 23.0 | 5.5 | 2.3 | 355.0 | 192.0 | 29.0 | 103.0 | 0.4 | 1.8 | " | 720.0 |
| 17 | **Nalah** | 22.0 | 6.5 | 3.0 | 305.0 | 132.0 | 17.0 | 63.0 | 1.5 | 1.5 | " | 408.0 |
| 20 | **Nalah** | 22.0 | 6.0 | 2.5 | 498.0 | 180.0 | 31.5 | 108.0 | 1.0 | 1.5 | " | 763.0 |
| 21 | **Canal** | 21.0 | 6.3 | 5.2 | 193.3 | 304.0 | 3.3 | 66.0 | 0.7 | 3.4 | " | 760.0 |
| Mogha | **Outflow** | 21.0 | 6.3 | 3.8 | 153.3 | 237.3 | 7.0 | 65.7 | 0.9 | 1.6 | " | 346.0 |

**Minimum, maximum and average of surface water quality results**

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | | |
| Minimum | 20.0 | 5.5 | 2.3 | 288.3 | 132.0 | 8.4 | 63.0 | 0.4 | 0.4 | - | 408 |
| Maximum | 23.0 | 6.5 | 4.2 | 498.0 | 345.3 | 31.5 | 124.7 | 1.5 | 3.8 | - | 763 |
| Total Average | 21.5 | 6.1 | 3.0 | 376.3 | 214.7 | 20.5 | 97.7 | 1.1 | 1.8 | - | 654 |
| | | | | | | | | | | | |
| **Canal** | 21.0 | 6.3 | 5.2 | 193.3 | 304.0 | 3.3 | 66.0 | 0.7 | 3.4 | - | 760 |
| **Mogha Outflow** | 21.0 | 6.3 | 3.8 | 153.3 | 237.3 | 7.0 | 65.7 | 0.9 | 1.6 | - | 346 |

## Table 3m. Water quality results of inflow and outflow channels during March 2008

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | **Nalah** | - | - | - | - | - | - | - | - | - | - | - |
| 14 | **Nalah** | 24.5 | 6.5 | 3.6 | 310.0 | 164.0 | 17.0 | 115.0 | 1.0 | 0.5 | Present | 676.0 |
| 15 | **Nalah** | 25.5 | 6.0 | 2.3 | 510.0 | 172.0 | 21.8 | 101.0 | 2.3 | 1.5 | " | 703.5 |
| 16 | **Nalah** | 26.5 | 5.3 | 2.5 | 427.5 | 188.0 | 26.0 | 114.5 | 0.4 | 1.6 | " | 730.0 |
| 17 | **Nalah** | 25.8 | 6.5 | 2.7 | 377.5 | 134.0 | 18.0 | 78.5 | 2.3 | 1.5 | " | 471.0 |
| 20 | **Nalah** | 25.5 | 6.0 | 2.4 | 537.0 | 178.0 | 29.8 | 110.0 | 1.5 | 1.3 | " | 761.5 |
| 21 | **Canal** | 24.0 | 6.5 | 4.6 | 175.0 | 240.0 | 8.0 | 80.0 | 1.0 | 1.5 | " | 760.0 |
| Mogha | **Outflow** | 24.0 | 6.3 | 3.5 | 155.0 | 216.0 | 18.5 | 70.0 | 0.8 | 2.0 | " | 346.0 |

## Minimum, maximum and average of surface water quality results

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | | |
| Minimum | 24.5 | 5.3 | 2.3 | 310.0 | 134.0 | 17.0 | 78.5 | 0.4 | 0.5 | - | 471 |
| Maximum | 26.5 | 6.5 | 3.6 | 537.0 | 188.0 | 29.8 | 115.0 | 2.3 | 1.6 | - | 761 |
| Total Average | 25.6 | 6.1 | 2.7 | 432.4 | 167.2 | 22.5 | 103.8 | 1.5 | 1.3 | - | 668 |
| | | | | | | | | | | | |
| **Canal** | 24.0 | 6.5 | 4.6 | 175.0 | 240.0 | 8.0 | 80.0 | 1.0 | 1.5 | - | 760 |
| **Mogha Outflow** | 24.0 | 6.3 | 3.5 | 155.0 | 216.0 | 18.5 | 70.0 | 0.8 | 2.0 | - | 346 |

**Table 3n. Water quality results of inflow and outflow channels during May 2008**

| Site No. | Level of Sampling | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform - | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | Nalah | - | - | - | - | - | - | - | - | - | - | - |
| 14 | Nalah | - | - | - | - | - | - | - | - | - | - | - |
| 15 | Nalah | 30.0 | 6.0 | 2.2 | 590.0 | 168.0 | 19 | 118 | 3.0 | 1.0 | Present | 796 |
| 16 | Nalah | 30.0 | 5.0 | 2.6 | 500.0 | 184.0 | 23 | 126 | 0.5 | 1.5 | " | 740 |
| 17 | Nalah | 29.5 | 6.5 | 2.4 | 450.0 | 136.0 | 19 | 94 | 3.0 | 1.5 | " | 534 |
| 20 | Nalah | 29.0 | 6.0 | 2.2 | 576.0 | 176.0 | 28 | 112 | 2.0 | 1.0 | " | 760 |
| 21 | Canal | - | - | - | - | - | - | - | - | - | - | - |
| Mogha | Outflow | - | - | - | - | - | - | - | - | - | - | - |

**Minimum, maximum and average of surface water quality results**

| Parameter Extreme Value | Temp. (°C) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) | Iron (mg/L) | F. Coliform | TDS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nalah** | | | | | | | | | | | |
| Minimum | 29.0 | 5.0 | 2.2 | 450.0 | 136.0 | 19.0 | 94.0 | 0.5 | 1.0 | - | 534 |
| Maximum | 30.0 | 6.5 | 2.6 | 590.0 | 184.0 | 28.0 | 126.0 | 3.0 | 1.5 | - | 796 |
| Total Average | 29.6 | 5.9 | 2.4 | 529.0 | 166.0 | 22.3 | 112.5 | 2.1 | 1.3 | - | 708 |
| | | | | | | | | | | | |
| **Canal** | - | - | - | - | - | - | - | - | - | - | - |
| **Mogha Outflow** | - | - | - | - | - | - | - | - | - | - | - |

### 5.1.4 pH

pH indicates the acidity and alkalinity of the lake water. Most natural water range pH from 4 to 9 and are often slightly basic due to the presence of carbonates and bicarbonates. A major deviation from the normal pH for given water indicates the presence of industrial wastes. Practically every phase of water supply and wastewater treatment, e.g., acid-base neutralization, water softening, precipitation, coagulation, disinfection, and corrosion control, is pH dependent.

The pH value of lake varies between 5.5 to 8.0 with an average of 6.6. The depth wise analysis indicates that pH is decreasing with depth. Rao (1991) has pointed out that low pH value occurred in bottom zone due to liberation of acids from the decomposing organic matter under low oxygen conditions resulted into the lower pH value. The pH of nalahs water range from 5.0 to 8.0 with an average of 6.0.

### 5.1.5 Dissolved Oxygen

Dissolved oxygen is an important indicator of water pollution and depends on the physical, chemical and biochemical activities in the water body. The dissolved oxygen concentration of a water body is determined by the solubility of oxygen, which is inversely related to water temperature, pressure and biological activity. Dissolved oxygen is a transient property that can fluctuate rapidly in space and time.

DO values of lake water are found to vary between 1.2 to 9.0 mg/L with an average value of 4.4 mg/L. The Nalah water contains DO values from 0.0 to 6.4 mg/L with an average of 2.6 mg/L.

### 5.1.6 Alkalinity

Alkalinity refers to the capability of water to neutralize acids. The presence of carbonates, bicarbonates and hydroxides is the most common cause of alkalinity in natural waters. Natural waters may also contain appreciable amounts of carbonates and hydroxide alkalinities, particularly surface waters blooming with algae. The algae take up carbonate for its photosynthesis activities and raise the pH.

Alkalinity of water varies between 70.0 to 250.0 mg/L with an average value of 157.0 mg/. The alkalinity of nalahs water range from 140.0 to 610.0 mg/L with an average of 334.7 mg/L.

### 5.1.7 Total Hardness

Hardness in water is due to the calcium and magnesium ions. Temporary hardness is caused by the presence of bicarbonates of calcium and magnesium and permanent hardness is mostly due to sulfates. When the total hardness has a value greater than total alkalinity, the amount of hardness equivalent to the alkalinity is called carbonate hardness and the excess amount is non-carbonate hardness. When total hardness is equal or less than the total alkalinity, there is no carbonate hardness.

The hardness of water is found to vary between 112.0 to 296.0 mg/L with an average value of 178.1 mg/. There is increase in hardness from surface to bottom. Temperature affects the variation in the value of hardness because the solution of $CaCO_3$ as bicarbonate is prompted in cold waters and solubility of $CO_2$ is enhanced (Pettijohn, 1984). The hardness of Nalah water ranges from 112.0 to 616.0 mg/L with an average of 216.3 mg/L.

### 5.1.8 Nitrate

Man's influence on the nitrogen cycle includes production and use of synthetic fertilizers such as ammonia and other nitrogen compounds. Some of this fixed nitrogen escapes to the hydrosphere. Nitrogen in reduced or organic forms is converted by soil bacteria into nitrite and nitrate. This process is commonly termed as nitrification. The nitrogen used by plants is largely in the oxidized form. Nitrate in anaerobic systems can be reduced by other strains of bacteria to nitrous oxide or nitrogen gas. Biochemists refer to this process as denitrification.

Nitrogen occurs in water as nitrite or nitrate anions ($NO_2^-$ and $NO_3^-$), in cationic form as ammonium ($NH_4^+$), and at intermediate oxidation states as a part of organic solutes. The nitrite and organic species are unstable in aerated water and are generally considered to be indicators of pollution through disposal of sewage or organic waste.

Farm animals also produce considerable amounts of nitrogenous organic waste that tends to concentrate in places where large numbers of animals are confined.

The nitrate contents in the lake water range from 0.20 to 35.0 mg/L with an average value of 9.76 mg/L. The nitrate contents of lake water increased from Sept, 2007 because the lake was not filled up completely and no overflow taken place during the 2007 monsoon. All the pollutants carried by nalahs were retained in the lake. The nitrate contents in nalahs water range from 0.30 to 55.0 mg/L with an average of 16.0 mg/L.

### 5.1.9 Chloride

Chlorides are present in all potable water supplies and in sewage, usually as a metallic salt. Chloride is essential in the diet and passes through the digestive system unchanged to become one of the major components of raw sewage. In most surface streams, chloride concentrations are lower than those of sulfate or bicarbonate. Exceptions occur where streams receive inflows of high-chloride groundwater or industrial waste. Chloride is also present in the rainwater.

The chloride contents in the lake water range from 26.0 to 132.0 mg/L with an average value of 63.4 mg/L. The chloride contents in nalahs water range from 24.0 to 212.0 mg/L with an average of 86.7 mg/L.

### 5.1.10 Phosphate

Phosphates are widely used in the municipal and private water treatment systems. Phosphates enter the water supply from agricultural fertilizer run-off, water treatment, and biological wastes and residues. Industrial effluents related to corrosion and scale control, chemical processing, and the use of detergents and surfactants also contribute phosphates significantly. Phosphorous is a component of sewage, as the element is essential in metabolism, and it is always present in the animal metabolic waste. Further, the increased use of sodium phosphate to increase the cleaning power of household detergents tends to increase the output of phosphate. Indian public is not aware of the role of phosphorous as a nutrient for aquatic biota and the implication of phosphorous is a major cause of eutrophication problem in lakes. Detergent manufacturers and consumers need to limit the use of phosphate in detergents. Domestic and industrial effluents are also important sources of phosphorous in surface waters.

The phosphate contents in lake water range from 0.0.5 to 1.0 mg/L with an average value of 0.44 mg/L. The phosphate contents of lake water increased from Sept, 2007 because the lake was not filled up completely and no overflow taken place during the 2007 monsoon. All the pollutants carried by nalahs were retained in the lake. The phosphate contents of nalah water range from 0.05 to 3.0 mg/L with an average of 1.01 mg/L. The causes of higher concentration of phosphate in the lake are mainly due to the agricultural runoff and urban wastes entering into the lake.

### 5.1.11 Iron

Natural waters contain variable but minor amounts of iron despite its universal distribution and abundance. Iron in ground water is normally present in the ferrous ($Fe^{++}$) or soluble state, which is easily oxidized to ferric ($Fe^{+++}$) or insoluble iron on exposure to air. Iron can enter a water system by leaching natural deposits, from iron-bearing industrial wastes, effluents from picking operations, or acidic mine drainage.

Iron in domestic water supply systems stains laundry and porcelain, causing more nuisance than a potential health hazard. Taste thresholds of iron in water are 0.1 mg/L ferrous iron and 0.2 mg/L ferric iron, giving a bitter or astringent taste. Domestic water supplies containing more than 0.3 mg/L total iron should be rejected due to staining and taste considerations.

The iron contents in the lake water range from 0.01 to 4.0 mg/L with an average value of 1.71 mg/L. The iron contents in the nalahs water range from 0.10 to 4.0 mg/L with an average of 2.09mg/L.

### 5.1.12 Biochemical Oxygen Demand

Biochemical Oxygen Demand (BOD) is an empirical measurement of the oxygen requirement of municipal and industrial waste and sewage. The test measures the oxygen required for the biochemical degradation of organic material and the oxygen used to oxidize inorganic material such as sulfides and ferrous ions. If sufficient oxygen is available in water, the useful aerobic bacteria will flourish and cause the aerobic biological decomposition of waste, which will continue until oxidation is completed. The amount of oxygen consumed in this process is the BOD. Polluted waters will continue to absorb oxygen for many months, and it is not practically feasible to determine this ultimate oxygen demand. Hence, the BOD of water during 5 days at 20 °C is generally taken as the standard demand, and is about 68 % of the total demand. The BOD for the lake water and nalah were analyzed for one sample each collected from the site no. 11 and 17, respectively. The 5-day BOD at 20 °C of the lake water varies from 7.4 to 24.0 mg/L with an average of 11.4 mg/L. The BOD of nalahs water range between 15.0 to 32.0 mg/L with an average of 23.7 mg/L.

### 5.1.13 Fecal Coliform Bacteria

Coliform bacteria are a common measure of biological pollution and a standard measure of microbial pollution. Bacteriological indicators are often employed to determine if water is of sufficient quality for drinking or human contact reaction (swimming, bathing, etc.). An estimate of the number of organisms is an index of bacteriological water quality. Livestock grazing near the shoreline can cause bacterial densities to rise, particularly where livestock graze in marshy areas adjacent to lake. High bacterial counts are found in the summer period of warm temperatures, and finally, counts decline in autumn.

The coliform bacteria was found to be present in all the water samples collected from various locations in the lake as well as the samples collected from the nalahs.

## 5.2 Point Sources of Pollution

The water samples from 05 Nalahs (No. 14, 15, 16, 17 and 20) were collected and tested. The values of water quality parameters of these nalahs are given in Table 2 to 3. The results of these tables are summarized in brief as below:

- low pH (5.0 – 8.0) and DO (0.0 – 6.4 mg/L).

- high nitrate (0.3 – 55.0 mg/L), phosphate (0.05 – 3.0 mg/L) and iron (0.10 – 4.0 mg/L)
- high $BOD_5$ (15.0 – 32.0 mg/L)

It is observed that the pH range between 5.0 to 8.0, which has gone down the normal limit of 6.5 to 8.5. Dissolved oxygen is also extreme low. Nitrate, phosphate, iron and BOD are found in very high concentration. Since these nalahs contribute water in sufficient amount with parameter values beyond the normal limits, all these nalahs are the sources of major pollution to the lake. Besides above, all the nalahs are the pollution sources of fecal coliform bacteria.

### 5.3 Comparison of Observed Water Quality Parameters with Yatheesh (1990)

The comparison of various water quality parameters viz. temperature, transparency, pH, dissolved oxygen, alkalinity, hardness, nitrate, chloride and phosphate for the period March 2006 to May 2008 is done with Yatheesh (1990) and is presented in Table 4. It is seen from the comparison that at present the transparency, pH, DO, total hardness and chloride contents of the lake water have significantly reduced while the alkalinity, nitrate and phosphate level of the lake water have tremendously increased. The parameters which shall be towards the lower side are highly increased and those shall be towards the higher side are greatly reduced. So there is disparity among the values of various water quality parameters. A comparison of all the parameters indicates that the pollution status of the Sagar lake has greatly increased during the past eighteen years.

### 5.4 Evaluation of Lake Water for Drinking Purpose as per IS:10500 Standards

The average values of pH, dissolved oxygen, total hardness, chloride, nitrate, fluoride and iron have been compared with the *class A* type of water (Indian Standards for Inland Surface Waters for use as Drinking Water Source without Conventional Treatment but after Disinfection). The results are summarized in Table 5 and 6.

The average pH value of the lake water at different depths varies between 5.5 to 8.0, which is partly beyond the lower limit and partly within the tolerance limit. The average dissolved oxygen level is 4.4 mg/L, which has gone down even below the minimum prescribed limit of 6.0 mg/L. The average value of total hardness, chloride and nitrate are below the maximum limit as mentioned for *class A* water. The average value iron is beyond the maximum permissible limits. Therefore, the present study indicates that the water of the Sagar lake can not be used for drinking purpose.

**Table 4. Comparison of 2006-08 results of water quality parameters with Yatheesh (1990)**

2006-08 Data

| Parameter Extreme Value | Temp. (C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hardness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| Minimum | 17.5 | 0.07 | 5.5 | 1.20 | 70.00 | 112.00 | 0.20 | 26.00 | 0.05 |
| Maximum | 30.5 | 0.73 | 8.0 | 9.00 | 250.00 | 296.00 | 35.00 | 132.00 | 1.00 |
| Average | 23.5 | 0.23 | 6.6 | 4.37 | 157.19 | 178.08 | 9.76 | 63.34 | 0.44 |

Yatheesh (1990) Data

| Parameter Extreme Value | Temp. (C) | Transpar. (m) | pH | DO (mg/L) | Alkalinity (mg/L) | Hradness (mg/L) | Nitrate (mg/L) | Chloride (mg/L) | Phosphate (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| Minimum | 17.0 | 0.07 | 7.3 | 2.02 | 100.00 | 120.00 | 0.05 | 40.04 | 0.02 |
| Maximum | 30.2 | 1.80 | 9.4 | 7.68 | 180.00 | 236.00 | 0.51 | 85.09 | 0.93 |
| Average | 23.9 | 0.55 | 8.5 | 5.45 | 137.96 | 168.58 | 0.14 | 59.98 | 0.22 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Change in Average Value | -0.4 | -0.32 | -1.9 | -1.08 | 19.23 | 9.50 | 9.62 | 3.36 | 0.22 |

**Table 5. Average water quality of Sagar lake compared with IS:10500 Standards**

| **Parameter** | **pH** | **DO** (min) | **$BOD_5$** (max) | **Hardness** (max) | **Chloride** (max) | **Nitrate** (max) | **Iron** (max) | **TDS** (max) |
|---|---|---|---|---|---|---|---|---|
| | | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) |
| Class-A | 6.5 - 8.5 | 6 | 2 | 300 | 250 | 20 | 0.3 | 500 |
| Class-C | 6.5 - 8.5 | 4 | 3 | - | 600 | 50 | 0.5 | 1500 |
| **Period** | **Average Values** | | | | | | | |
| 2006-08 | 6.6 | 4.37 | 11.4 | 178.08 | 63.34 | 9.76 | 1.71 | 378 |

Class-A: Inland Surface Waters for use as Drinking Water Source without Conventional Treatment but after Disinfection

Class-C: Inland Surface Waters for use as Drinking Water Source with Conventional Treatment followed by Disinfection

**Table 6. Average value of water quality parameters of Sagar lake and inflowing nalahs**

| Sl. No. | Parameters | Tolerance Limit of *Class A* | Average Value of Parameters | |
|---|---|---|---|---|
| | | | Sagar Lake | Inflowing Nalahs |
| 1 | **Temperature** (°C) | - | 23.9 | 24.2 |
| 2 | **Secchi Depth** (m) | - | 0.23 | - |
| 3 | **pH** | 6.5 - 8.5 | 6.6 | 6.0 |
| 4 | **DO** (mg/L) | 5 (min) | 4.37 | 2.6 |
| 5 | **Alkalinity** (mg/L) | - | 157.19 | 334.7 |
| 6 | **Hardness** (mg/L) | 300 (max) | 178.08 | 216.3 |
| 7 | **Chloride** (mg/L) | 250 (max) | 63.34 | 86.7 |
| 8 | **Nitrate** (mg/L) | 20 (max) | 9.76 | 16.0 |
| 9 | **Phosphate** (mg/L) | - | 0.44 | 1.01 |
| 10 | **Iron** (mg/L) | 0.3 (max) | 1.71 | 2.09 |
| 11 | **$BOD_5$** (mg/L) | 2 (max) | 11.4 | 23.7 |
| 12 | **TDS** (mg/L) | 500 (max) | 378 | 651 |

### 5.5 Trophic Status of the Sagar Lake

Addition of nutrients greatly accelerates the process of eutrophication while pollutants exert a deleterious effect on the aquatic biota. Eutrophication is the process where a lake accumulates essential plant nutrients principally phosphorous and nitrogen. This process occurs naturally at varying rates in every lake and along with sedimentation, it leads to the infilling and ultimate disappearance of the lake. However, in many developed areas, streams and groundwater carry high levels of these nutrients that originate from fertilizers and treated/untreated sewage effluents. The human induced over fertilization is called cultural eutrophication, and it is a form of pollution because it induces accelerated growth of algae, which die seasonally in the lake. The process of decaying consumes dissolved oxygen in water. The lack of dissolved oxygen makes a lake uninhabitable for fish and other aquatic animals. Increased level of phosphorous is usually responsible for cultural eutrophication of lakes.

Natural eutrophication usually takes many hundreds of thousands of years to occur. Lakes undergoing natural eutrophication generally have a good water quality and exhibit diverse biological community throughout much of their existence (Ryding and Rast, 1989). However, human interference in the catchment dramatically increases rates of nutrient input (cultural eutrophication) which is the main cause of concern for most lakes. It can have significant negative biological, health, social and economic impacts on man's use of lake water (Holland et al., 1989). Cultural eutrophication can render the water unsuitable for many uses, or else require that the water be treated prior to its use by humans, which is often expensive and time consuming. Eutrophication can cause problems in water supplies such as corrosion of equipment and clogging of water treatment plants. Toxins produced by cynobacteria can also be a health concern. The increased production of macrophytes causes aesthetic and recreational interference. There are also problems related to odour and taste. Eutrophication can cause death of fish due to reduced dissolved oxygen. Eutrophication has been reported to have caused deaths of birds, mammals, and amphibians also (Harper, 1982). Eutrophication can also cause gastro-intestinal problems and skin rashes in humans (Harper, 1982). A summary of intended water uses and the optimal versus minimally acceptable trophic state for such uses is given in Table 7.

Lakes are considered to undergo a process of aging which has been characterized by three qualitatively defined conditions. The initial condition of a lake is termed oligotrophic and is normally associated with deep lakes, where the waters at the bottom of the lake are cold and have relatively high levels of dissolved oxygen throughout the year. The waters and bottom sediments of the lake usually contain only small amounts of organic matter. Productivity in terms of the population levels of phytoplankton, rooted aquatic plants, zooplankton and fish is usually low. Species diversity is often quite high and chemical water quality is good.

The eutrophic condition of a lake represents the opposite end of the aging process. Eutrophic lakes may be either shallow or deep. They are characterized by high concentrations of suspended organic matter in the water column and by relatively large sediment depths with high organic contents particularly in the upper layers of the sediment. Biological productivity is high and the diversity populations may be somewhat limited. Coarse fish may predominate due to elevated bottom water temperatures and/or depressed water quality. Dissolved oxygen concentrations of bottom waters are usually depressed and in extreme cases of eutrophication may reach zero during summer periods. Generally water quality is low and can result in impairment of beneficial water usages such as water supply, contact recreation and/or boating.

The characteristics of a eutrophic lake is that it will have frequent blue-green algal blooms, coloured water (green/brown), very low or absence of dissolved oxygen in the bottom waters and fairly high fish productivity. Silt is a major source of adsorbed nutrients and organic matter in a eutrophic lake and silt loading directly contributes to reduction of lake's capacity. It is important to note that the term eutrophic does not mean bad, but it is only a descriptive of the state or condition of the lake. The problems of potable water treatment and its safety are directly related to the degree of eutrophication of the lake. Surface water with a blue-green algal bloom may be unfit for human consumption as they may contain toxins released from algae. These toxins are lethal to cattle and have been shown to produce human gastro-intestinal problems.

A third lake condition is mesotrophic which is defined as an intermediate state between oligotrophic and eutrophic. Mesotrophic lakes have intermediate levels of biological productivity and can have some reductions in bottom dissolved oxygen levels. Lakes in this category generally have water quality which is adequate for most beneficial uses but may be deteriorating toward the eutrophic state.

The boundaries between the three stages are not rigidly defined and may vary with regions of the nation and with beneficial uses of lake waters. Therefore, attempts have been made to establish a trophic state index (TSI) as a function of community measures water quality variables.

**Table 7. Intended lake and reservoir water uses as related to trophic conditions**

(Ryding and Rast, 1989)

| Desired Utilization | Trophic Status Required | Still Tolerable |
|---|---|---|
| Drinking Water Purpose | Oligotrophic | Mesotrophic |
| Fish Culture | Oligotrophic | Mesotrophic-Eutrophic |
| Bathing Purpose | Mesotrophic | Slightly Eutrophic |
| Industrial Supply | Mesotrophic | Slightly Eutrophic |
| Water Sports (without bathing) | Mesotrophic | Eutrophic |
| Irrigation | - | Strongly Eutrophic |
| Energy Production | - | Strongly Eutrophic |

Carlson (1977) has given the multivariate trophic status index for the lakes and reservoirs as given in Table 8.

**Table 8. Carlson's Trophic State Index**

| TSI | Trophic Status |
|---|---|
| 0-25 | Strongly Oligotrophic |
| 26-32 | Oligotrophic |
| 33-37 | Slightly Oligotrophic |
| 38-42 | Slightly Mesotrophic |
| 43-48 | Mesotrophic |
| 49-53 | Strongly Mesotrophic |
| 54-57 | Slightly Eutrophic |
| 58-61 | Eutrophic |
| 62-64 | Strongly Eutrophic |
| 65+ | Hypre- Eutrophic |

The Carlson TSI may be computed using the following regression equations (Reokhow and Chapra, 1983):

$$TSI(SD) = 60.0 - 14.41 * \ln(SD) \quad (1)$$

$$TSI(TP) = 14.42 * \ln(TP) + 4.15 \quad (2)$$

$$TSI(TN) = 54.45 + 14.43 * \ln(TN) \quad (3)$$

Where, SD = Secchi depth (m); TP = Total phosphorous (μg/L), and TN = Total nitrogen (mg/L). TSI for the lake can be obtained by taking average of the three or from any of the three variables. The trophic status of the Sagar lake has been computed on the basis of nitrogen, phosphorous and Secchi depth using trophic state indices (TSI) developed by Carlson (1977). The TSI values estimated on the basis of these three parameters indicate that the Sagar lake is in the hyper eutrophic state (Table 9). To compare the present trophic status of the lake, the trophic status of the lake for the 1989-99 data (Yatheesh, 1990) has been used (Table 10). Figure 4 shows a comparison of the TSI value for 1983, 1988-89 and 2006-08 data of the Sagar lake. It is seen that the trophic status of the lake has greatly increased over the past eighteen years.

Suitability of the lake water for various purposes has been evaluated by relating the trophic status of the lake to the intended use based on the criteria suggested by Ryding and Rast (1989) (Table10). The suitability of the lake water for various uses is indicated in Table11. It can be seen that the water of the Sagar lake has been unsuitable for most of the uses, viz. drinking, bathing, fish culture, industrial supply and water sports. However, the lake water can be utilized for the irrigation purpose.

Table 9. Trophic status of Sagar lake based on Carlson Bivariate Index

| Sl. No. | Parameter | 2006-08 Data | Carlson, TSI | Trophic Status |
|---|---|---|---|---|
| | | | | |
| 1 | **Total Phosphorous** (micro-gram/L) | 440 | 91.9 | Hyper Eutrophic |
| 2 | **Total Nitrogen** (mg/L) | 9.76 | 87.3 | Hyper Eutrophic |
| 3 | **Secchi Depth** (m) | 0.23 | 81.2 | Hyper Eutrophic |
| **Average** | | | **86.8** | **Hyper Eutrophic** |

Table 10. Suitability of Sagar lake water for various uses

| Desired Use of Lake Water | Suitability of Water (without treatment) |
|---|---|
| Drinking Water Purpose | Unsuitable |
| Fish Culture | Unsuitable |
| Bathing Purpose | Unsuitable |
| Industrial Supply | Unsuitable |
| Water Sports (without bathing) | Unsuitable |
| Irrigation | Can be used |

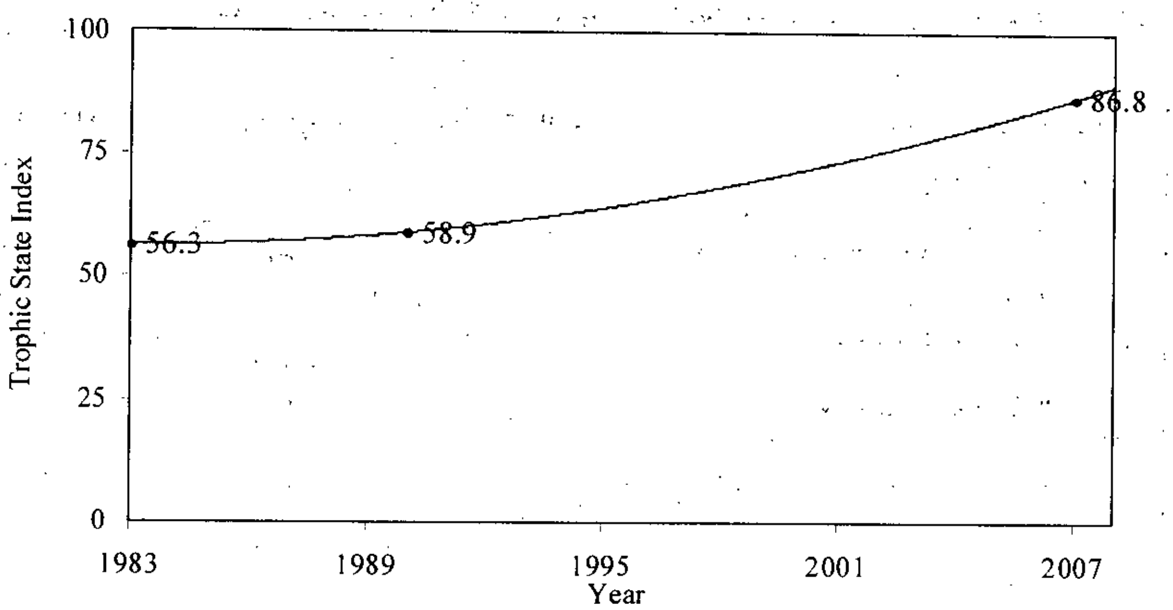



**Figure 4. Variation of trophic state index of Sagar lake**

From the observations made while visiting the surrounding of the lake, the sources of nutrients (P and N) in the lake can be summarized as below:

1. Direct addition of solid waste and sewage to rain water fed channels, which ultimately reach to the lakes.
2. Storm runoff from agricultural land, township and forest.
3. Litter from the vegetation in the catchment.
4. Randomly deposited faecal matter of animal origin.
5. Rooted aquatic plants, which can release nutrients when they die and decompose.
6. Nutrients from the atmosphere (dust, debris carried by wind) and precipitation falling on the lake.

## 5.6 Seasonal And Annual Variations In Water Quality of Sagar Lake

### 5.6.1 Seasonal Variations in the Lake Water Quality and Inflowing Nalahs

The seasonal variations in lake water quality and inflow channels are shown in Figures 5 and 6. Chloride, nitrate and iron contents of the lake water are found to be in maximum concentration during summer. The concentration of these parameters declines sharply during monsoon season because of the dilution of the lake water due to precipitation and catchment runoff and thereafter the concentration further increases during winter. DO declines during monsoon season but rises during winter to the maximum. Hardness is also found maximum during winter season. Transparency decreases greatly during summer due to high algae formation but increases after monsoon to maximum during winter season. In case of inflow channels, all the parameters contribute with maximum concentration during summer and with minimum concentration during monsoon season due to dilution of water with rainfall. The concentration of these parameters further increases as winter season starts.

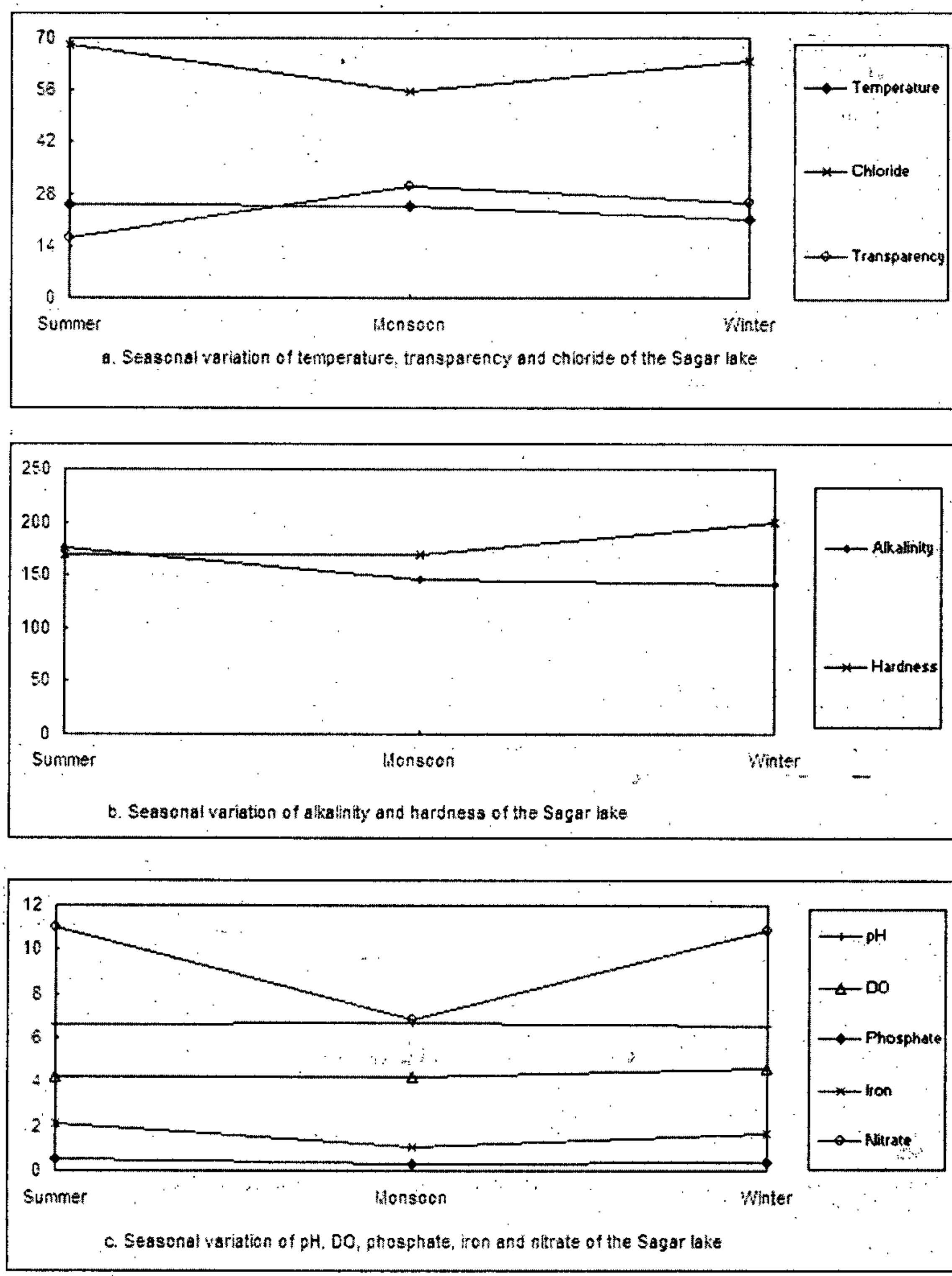
### 5.6.2 Annual Variations in the Lake Water Quality and Inflowing Nalahs

The annual variations in lake and inflow channels were studied from 2006 to 2008 and are shown in Figures 7 and 8. The average level of DO of the lake water is declined from 4.3 to 4.1mg/L with a mild change, but it is towards the lower borderline of 4.0mg/L. Alkalinity, nitrate, phosphate and iron contents of the lake water have drastically increased while chloride is slightly increased. The concentration of these parameters is significantly increased because the lake was not filled during 2007 monsoon and all the pollutants and waste concentrated the lake water, as it was not passed out of the lake through overflow. Transparency of the lake water is found to decrease sharply year by year. However, there is no appreciable change in the pH and hardness level of the lake water.

In case of inflow channels, alkalinity, hardness, chloride, nitrate and phosphate contents have been found to increase while there is found no noticeable change in pH, DO and hardness level. However, the iron contents were found to decrease slightly.

### 5.7 Development of Overall Water Quality Index for the Sagar Lake

The quality of water is defined in terms of its physical, chemical and biological parameters, and ascertaining its quality is crucial before use for various intended purposes such as potable water, agricultural, recreational and industrial water uses, etc. (Sargaonkar and Deshpande, 2003). A major objective of water quality assessment is to determine whether or not the water quality meets previously defined objectives for designated uses, to describe water quality at regional, national or international scales, and also to investigate trends in time, etc. (Boyacioglu, 2007).




a. Seasonal variation of temperature, transparency and chloride of the Sagar lake

b. Seasonal variation of alkalinity and hardness of the Sagar lake

c. Seasonal variation of pH, DO, phosphate, iron and nitrate of the Sagar lake

**Figure 5. Seasonal variation of various water quality parameters of the Sagar lake**

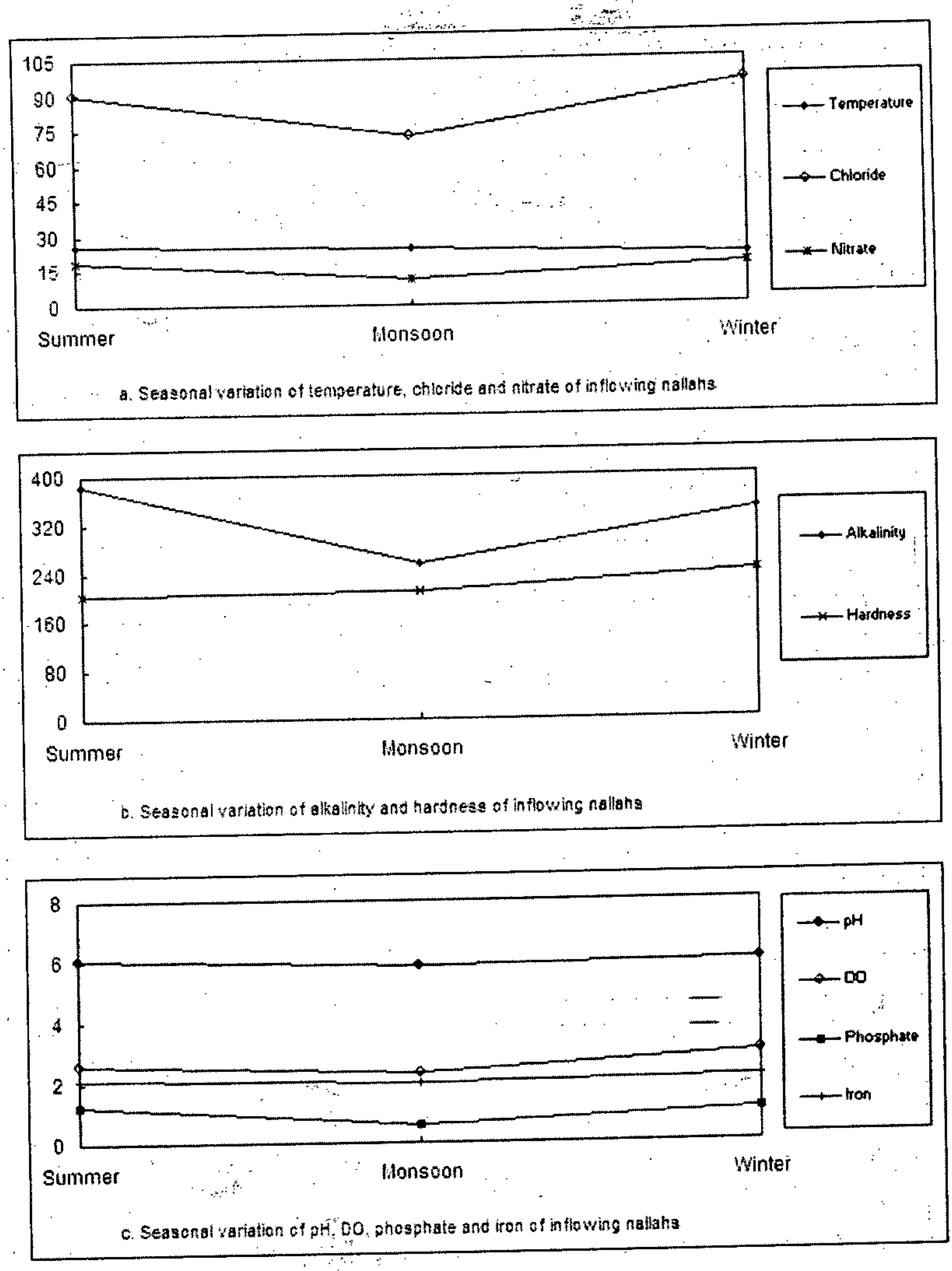
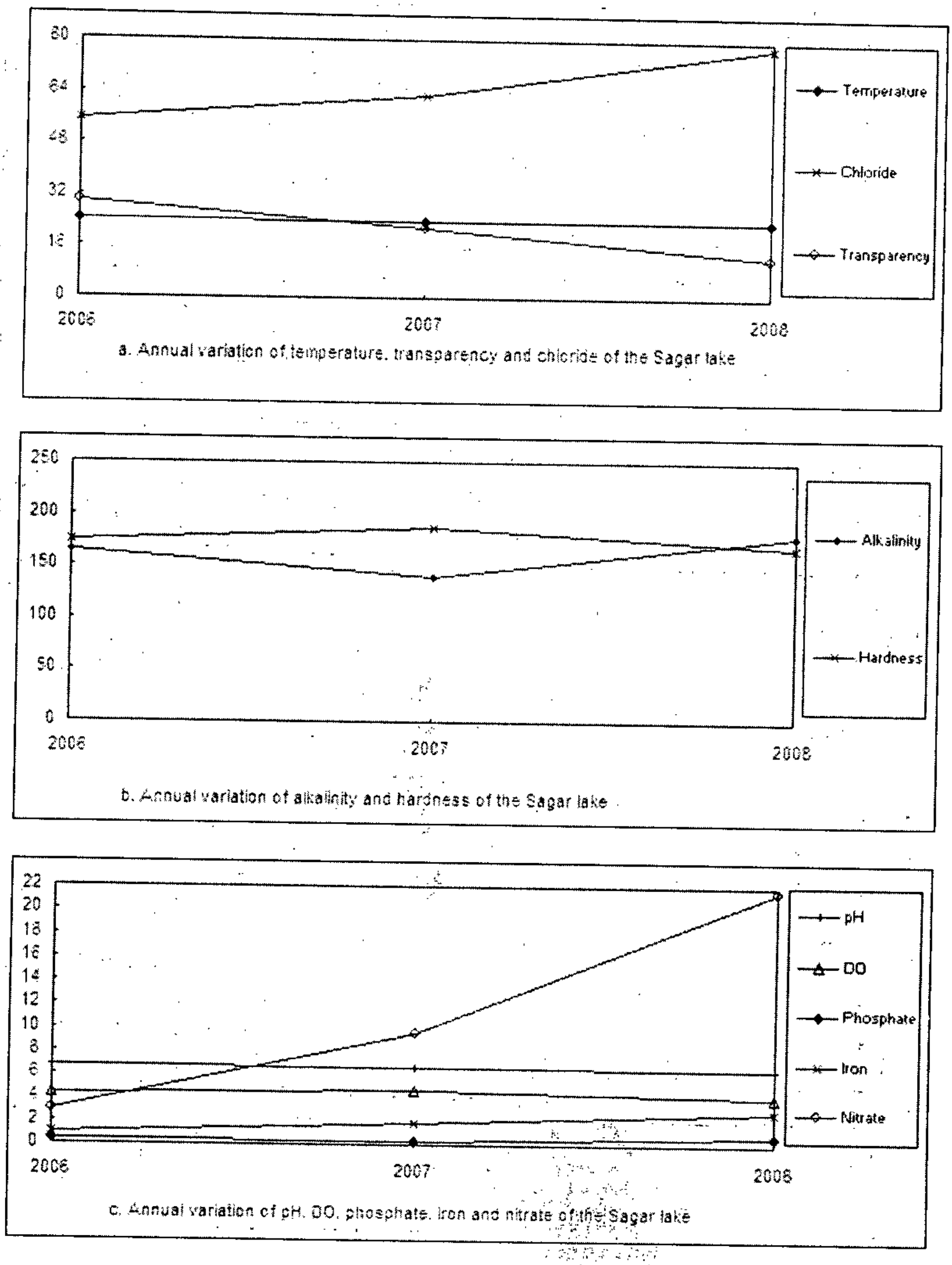



**Figure 6. Seasonal variation of various water quality parameters of inflowing nalahs**

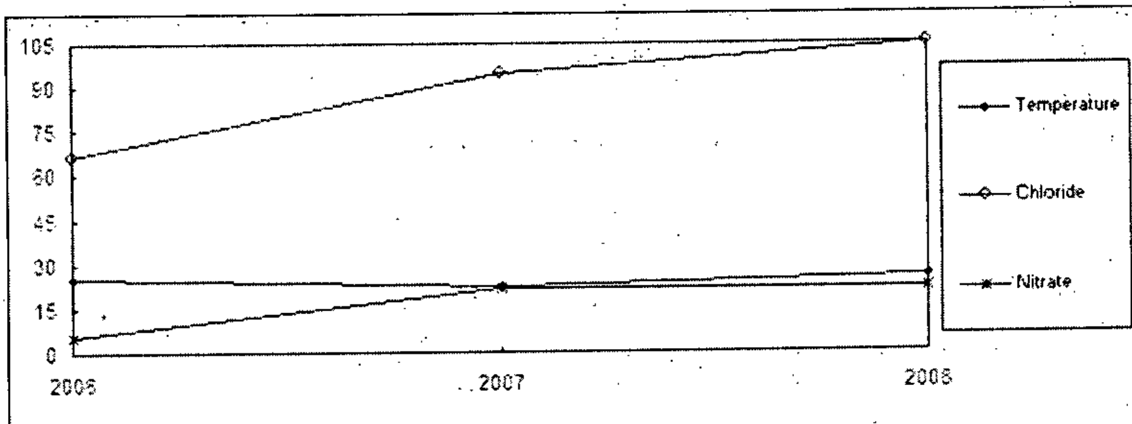



a. Annual variation of temperature, transparency and chloride of the Sagar lake

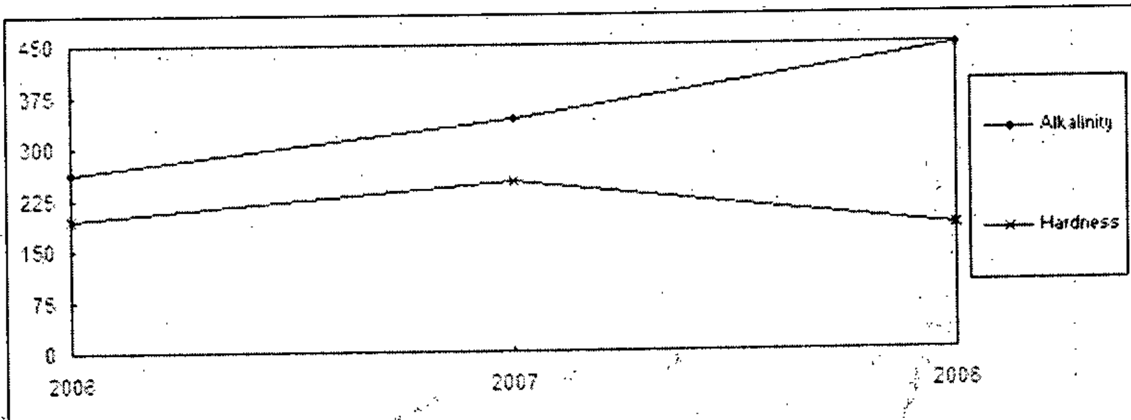
b. Annual variation of alkalinity and hardness of the Sagar lake

c. Annual variation of pH, DO, phosphate, iron and nitrate of the Sagar lake

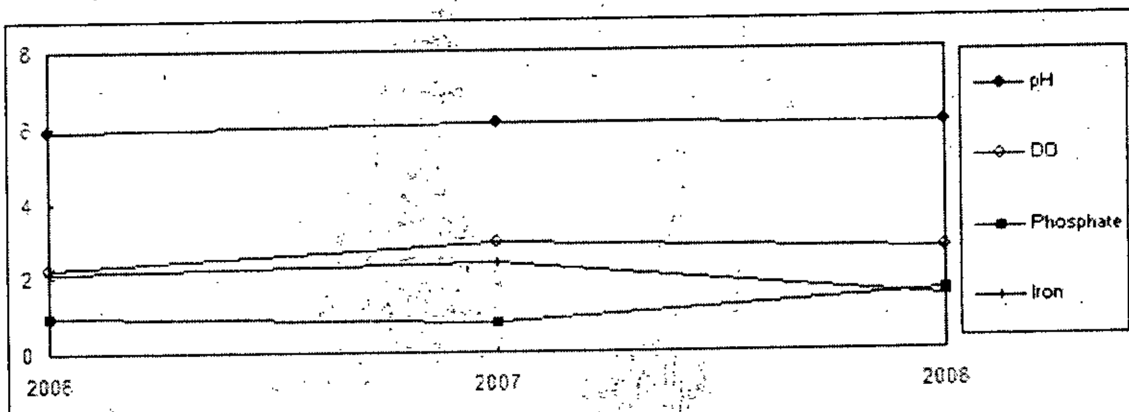
**Figure 7. Annual variation of various water quality parameters of the Sagar lake**




a. Annuall variation of temperature, chloride and nitrate of inflowing nallahs




b. Annual variation of alkalinity and hardness of inflowing nallahs




c. Annual variation of pH, DO, phosphate and iron of inflowing nallahs

**Figure 8. Annual variation of various water quality parameters of inflowing nalahs**

A number of water quality indices have been developed by various researchers. A comparison of various indices and overview of types of sub-indices, aggregation functions and flaws is presented in Table 11 (Abbasi, 1999).

**Table 11. Comparison of various water quality indices**

| Sl. No. | Index | Sub-Indices | Aggregation Function | Flaws |
|---|---|---|---|---|
| 1 | Horton (1965) | Segmented linear (step functions) | Weighted sum multiplied by 2 Dischotomous term | Eclipsing region |
| 2 | Brown et al. (1970) (NSF $WQI_a$) | Implicit non-linear | Weighted sum | Eclipsing region |
| 3 | Landwehr (1976) (NSF $WQI_m$) | Implicit non-linear | Weighted product | Non-linear |
| 4 | Prati et al. (1971) | Segmented non-linear | Weighted sum (arithmetic mean) | Eclipsing region |
| 5 | Mc Duffie & Haney (1973) | Linear | Weighted sum | Eclipsing region |
| 6 | Dinius (1972) | Non-linear | Weighted sum | Eclipsing region |
| 7 | Dee et al. (1973) | Implicit non-linear | Weighted sum | Eclipsing region |
| 8 | O'Connor's (FAWL, PWS) | Implicit non-linear | Weighted sum | Eclipsing region |
| 9 | Deininger & Landwehr (1971) (PWS) | Implicit non-linear | Weighted sum & geometric mean | Eclipsing region & non-linear |
| 10 | Walski & Parker (1974) | Non-linear | Weighted product Geometric mean | Non-linear |
| 11 | Stoner (1978) | Non-linear | Weighted sum | |
| 12 | Nemerow & Sumitomo (1970) | Segmented linear | Root mean square of max. & arithmetic mean | - ve value |
| 13 | Smith (1987) | Multiple types | Minimum operator | - ve value |
| 14 | Viet & Bhargava (1989) | Multiple types | Weighted product | - ve value |

Recently two water quality indices Sargaonkar (2003) and Boyacioglu (2007) have been published. Both these indices are developed very nicely, yet some issues are lacking. Sargaonkar (2003) have developed most of the indices functions in the exponential form while Boyacioglu (2007) have developed most of the indices functions in linear form. The coliform index of Boyacioglu (2007) gives erroneous value of index in the parameter range of 5000 to 50000 (MPN). While in case of Sargaonkar (2003), some eclipsing problem in the indices of % DO saturation, BOD, hardness, nitrate and coliform are occurring.

Therefore, in the present study a new water quality index is developed in the logarithmic form to provide a simpler tool for describing the quality of the surface water for drinking water supply. Eleven parameters are selected based on social and environmental impact and weights are assigned on their relative importance to impact the water quality (Table 12). The number of variables is kept limited to avoid making the index unwidely (Horton, 1965).

**Table 12. Assignment of weight to the concerned parameter**

| Sl. No. | Parameter | Weight Factor |
|---|---|---|
| 1 | pH | 1 |
| 2 | DO | 4 |
| 3 | BOD | 2 |
| 4 | Secchi Depth | 3 |
| 5 | Total Hardness | 1 |
| 6 | Chloride | 1 |
| 7 | Fluoride | 3 |
| 8 | Nitrate | 3 |
| 9 | Total Phosphate | 2 |
| 10 | Iron | 3 |
| 11 | Fecal Coliform | 4 |
| | **Total** | **27** |

In this index, the corresponding variation between the range of parameter and index is kept uniform and hence it is more accurate one (Table 13). For the development

**Table 13. Mathematical equations developed for various parameters**

| Sl. No. | Parameter | Range of Parameter | Sub-Index Function |
|---|---|---|---|
| 1 | pH | 6.5 - 8.5 | Y=100 |
| | | 6.0 - 6.4 & 8.6 - 9.0 | Y=50 |
| | | 5.5 - 5.9 & 9.1 - 9.5 | Y=25 |
| | | < 5.5 & > 9.0 | Y=0 |
| 2 | DO | 8 and above | Y=100 |
| | | 6 - 7.9 | Y=175.31*LN(X)-265.54 |
| | | 4 - 5.9 | Y=61.762*LN(X)-61.442 |
| | | < 4 | Y=0 |
| 3 | BOD | < 2 | Y=100 |
| | | 2 - 4.9 | Y=-55.128*LN(X)+138.15 |
| | | 5 - 6.9 | Y=-74.387*LN(X)+169.4 |
| | | 7 and above | Y=0 |
| 4 | Secchi Depth | 10 and above | Y=100 |
| | | < 10 | Y=100*LOG(0.90*X+1) |
| 5 | Total Hardness | 100 - 300 | Y=100 |
| | | 301 - 400 | Y=-173.87*LN(X)+1092.8 |
| | | 401 - 500 | Y=-113.39*LN(X)+730.02 |
| | | < 100 and > 500 | Y=0 |
| 6 | Chloride | 200 and below | Y=100 |
| | | 201 - 250 | Y=-224.12*LN(X)+1288.3 |
| | | 251 - 600 | Y=-30.275*LN(X)+219.88 |
| | | > 600 | Y=0 |
| 7 | Fluoride | 0.7 - 1.5 | Y=100 |
| | | 1.6 - 2.0 | Y=-260.8*LN(X)+205.38 |
| | | < 0.7 & > 2.0 | Y=0 |
| 8 | Nitrate | 10 and below | Y=100 |
| | | 11 - 20 | Y=-72.284*LN(X)+266.07 |
| | | 21 - 50 | Y=-26.326*LN(X)+128.59 |
| | | > 50 | Y=0 |
| 9 | Total Phosphate | 0.020 and below | Y=100 |
| | | 0.021 - 0.160 | Y=-24.33*LN(X)+4.454 |
| | | 0.161 - 0.650 | Y=-17.964*LN(X)+16.73 |
| | | > 0.650 | Y=0 |
| 10 | Iron | 0.10 and below | Y=100 |
| | | 0.11 - 0.30 | Y=-45.732*LN(X)-1.1274 |
| | | 0.31 - 0.50 | Y=-50.448*LN(X)-9.2335 |
| | | > 0.50 | Y=0 |
| 11 | Feccal Coliform | 0 - 50 | Y=-0.06*X+100 |
| | | 51 - 500 | Y=-0.1044*X+102.22 |
| | | 501 - 5000 | Y=-0.0056*X+52.775 |
| | | 5001 - 50000 | Y=-0.0005*X+27.5 |
| | | > 50000 | Y=0 |

of the sub-index functions, the range of parameters is selected based on water quality standards set by various agencies and organizations. Sub-index functions in the form of mathematical equations have been developed to transform the actual concentration values into water quality indices both in linear and non-linear form (Table 13). The weighted-sum method is employed to get the overall index based on the individual index values. Based on the status of water quality, the index value from 0 to 100 is classified into five categories: heavily polluted (0-24), poor (25-49), fair (50-74), good (75-94) and excellent (95-100). This index improves understanding of water quality issues by integrating complex data and generating a score that describes water quality status and evaluates water quality trends. The overall water quality index, considering eleven parameters, viz. pH, DO, BOD, Secchi depth, total hardness, chloride, fluoride, nitrate, total phosphate, iron and fecal coliform as investigated for the Sagar lake, comes out to be 47. Based on this index, the water of Sagar lake is of poor quality and cannot be used for the drinking purpose.

### 5.8 Problem Description

Development within the lake catchment has increased greatly in recent years and the lake has been subjected to an ever-increasing load of nutrients and sediments, resulting in decreased lake water quality. Increased nutrient loadings generally occur due to excessive use of fertilizers, malfunctioning septic systems, poor aeration system and improper waste disposal within the catchment and lake surroundings. As development continues to increase, the amount of total hard–surfaced area also increases and the volume and velocity of the water moving through the watershed into surface waters is increased. This run-off erodes soils and transports organic materials and nutrients from surface soils. Inorganic materials, in the form of sand, silt, and clay are also transported to receiving waters, resulting in decreased lake water quality.

Healthy lakes have a natural capacity to cleanse themselves. Each lake is an individual ecosystem with a food chain of organisms that assimilate the incoming nutrients. The food chain moves nutrients up from the simplest single-celled bacteria, to people catching fish. This natural system works very well without any lake aeration system to improve lake water quality, keeping the ecosystem in balance until excessive nutrient inflow overwhelms the ability of the ecosystem to assimilate the nutrients. Once this occurs, the excessive nutrient levels adversely affect the aesthetic qualities of the lake by stimulating the growth of nuisance algae and plant life. Lake algae (algae blooms) can quickly turn a lake "pea soup" green or cause the formation of "smelly" floating algae mats.

If there is oxygen present, the accumulated organic sediments begin to decompose aerobically. This organic material serves as food for bacteria and organisms that live in the substrate (bacteria, insect larvae, worms, etc.). These organisms require and consume dissolved oxygen as they digest the organic sediments. As sediments and biological activity increase, dissolved oxygen levels are depleted and become limiting. Low or no dissolved oxygen conditions can occur quickly, eliminating aerobic organisms and slowing the breakdown of the organic sediments. Then the growth of anaerobic bacteria, the bacteria that thrives in an environment of low or no dissolved oxygen, increases. Anaerobic digestion of the organic sediments begins, releasing toxic gases into the water that kill beneficial aerobic bacteria and insects.

Anaerobic digestion of lake sediments is a much slower process than with aerobic digestion. Where aerobic digestion can result in the control or reduction of organic sediment levels, anaerobic digestion almost always allows organic sediments levels to increase. During anaerobic digestion, bacterial enzymes and lack of oxygen make the nutrients in the bottom sediments soluble. Then the nutrients return to the water column and are available to support new weed and algae growth. Anaerobic conditions at the lake bottom have a damaging effect on the food chain that supports fish populations as well as reducing or eliminating fish habitat, ultimately resulting in a reduction of the fish quality, size and quantity.

Traditionally, aquatic lake weeds or lake algae problems have been addressed by using water treatment chemicals in place of lake aeration systems. Chemicals are applied at the water surface or directly to floating mats. These chemicals kill the weeds and algae and the dying vegetation sinks to the bottom of the water-body where it rots. As the vegetation rots, the plant nutrients in it that have been absorbed from the water are released back to the water column and become nutrients for the next weed growth or algae bloom. But something far worse occurs; as the vegetation decays, it uses up the oxygen at the bottom. Many studies have shown that an average of about three times as much nutrients are released from bottom sediment of lakes without oxygen, than what typically comes in from the watershed each year. The next weed or algal growth will occur when conditions of light and temperature are favorable, and the concentration of the water treatment chemical in the water column is reduced below toxic levels. The effectiveness of the water treatment chemical is quickly reduced as it settles to the bottom and is diluted by lake inflow and mixing with waters from untreated portions of the lake. The dead mass of vegetation accumulates on the bottom of the lake adding to the mass of organic sediments already there. Herbicides and algaecides do more harm to water quality than they do well. They sometimes cause fish kills and add toxic substances to the water and sediments. So it is highly recommended to use the lake aerators and proper lake aeration systems for maintaining water quality.

## 5.9 Comprehensive Water Quality Management Plan For Rejuvenation Of Sagar Lake

The comprehensive water quality management plan should comprise the following key features in the following order of priority:

i. City Wastewater Diversion, Laying Sewer Line and Treatment Plant Establishment
ii. Fencing of Shoreline
iii. Cattle Entry Control
iv. Minimizing Nutrients Input
v. Necessary Dredging
vi. Sluice Gate Operation at Mogha Weir and Construction of Silt Traps
vii. Hypo-limnetic Zone Aeration
viii. Aquatic Plant Control and Vegetation Restoration
ix. Contaminated Fish Removal, Restocking and Wildlife Habitat Enhancement

x. Catchment Treatments

xi. Development of Adequate Institutional Capability

xii. Public Awareness

### 5.9.1 City Wastewater Diversion, Laying Sewer Line and Treatment Plant Establishment

With a normal rainfall of around 1200mm, total inflow into the lake throughout the year comes around 20.146mcm through seven major drains and one canal. Out of which 58% comes into lake through various inflow channels including monsoon flow. Of this 58%, 2% is the city wastewater, which is directly discharged into the lake carrying various pollutants. Therefore, all the surrounding nalahs, which directly discharge wastewater into the lake, either need to be diverted in order to limit the nitrate, phosphate, chloride, iron, etc, or properly treated before entering into the lake.

Since the southern and western shores of the lake are directly attached to houses, there is needed to lay sewer line surrounding the lake. The sewage entering into the lake causes the enrichment of phosphate and nitrate in the lake water. Therefore, appropriate territory treatment plants have to be established. Water discharges to the lake have some form of silt and nutrient which need filtration before final discharge into the lake in an attempt to limit the infilling and nutrification of the water.

### 5.9.2 Fencing of Shoreline

The south-western shoreline of the main lake (around 1000m) is not guarded which needs to be fenced to restrict the lake encroachment by surrounding habitants. The southern and western shores of small lake cover around 1000m length, which are not guarded and are adjacent to the agricultural fields. During monsoon, the small lake receives sediment, pesticides and fertilizers from these lands. Hence these shores need to be protected to avoid the encroachment of the lake area, agricultural pollution and sedimentation.

A road needs to be constructed surrounding the lake and should be beautified with recreational activities. Presently there is no tourism around the lake. Hence, there is need to develop a hotspot for eco-tourism. As per International conservation guideline, 10-30 m strip of land along the lake shoreline and next 90 m is recommended for buffer zone and controlled development zone with horticultural/agro- forestry activities respectively (ICUN, 1956).

### 5.9.3 Cattle Entry Control

Presently there is no control over the entry of cattle into the lake water. Daily around 200 to 300 buffalos and other animals take bath in the lake and pass on their urine and excreta in the lake. This has become the main cause of pollution due to the fecal coliform as it resides in the intestine of these animals. Hence the entire boundary of the lake needs to be fenced.

The lake also contains Cyanobacteria, which is very harmful to human beings. These bacteria leave a poison compound named micosystien, which remains floating on the surface water in green colour. Due to these bacteria, many species of fish have been disappeared.

Fecal coliform bacteria are not part of the normal microbial populace of the water. Coliform bacteria usually contaminate water from some external source such as leaking septic tanks or stagnant storm sewers, and are almost invariably of fecal nature. Also fecal coliform bacteria usually do not multiply in natural waters, but are only in a transitory state. One can reduce fecal and total coliform bacteria levels in several ways:

1. Fecal coliform bacteria thrive without oxygen.
2. Coliform bacteria require an organic nutrient broth in order to survive.
3. Fecal coliform bacteria require carbon dioxide, phosphorus, nitrogen, ammonia or sulfur to live.
4. Fecal coliform bacteria require an acidic to slightly acidic environment for survival, in the pH range of 5.0 to 6.5.
5. Coliform bacteria are killed by ultraviolet light, which the sun emits. This ultraviolet does not penetrate the water deeply, so only surface water is affected under normal conditions.

Therefore, highly oxygenating the water body, creating an environment where aerobic bacteria thrive, reducing the nutrient media, raising the pH and exposing pathogenic bacteria to sunlight, coliform bacteria are weakened and killed.

### 5.9.4 Minimizing Nutrients Input

The nutrient level of the lake is very high. The lake contains an average of 9.8 mg/L nitrate and 0.44 mg/L phosphate, which has set the lake in the hyper-eutrophic state. The eutrophication results in over-abundance of phytoplankton and algae, reduced water clarity, low dissolved oxygen levels and depends on geology and stratification of lakes. The colour of lake water is yellowish green. It contains high algae content. Intensive activities of washing cloths are in practice on all surrounding ghats. The production of toxic blue green algae (Cyanobacteria) is enhanced by the presence of zebra mussel at any phosphorous levels. These algae represent a health risk for swimmers and those who may be exposed to aerosols from irrigation systems that use water containing these noxious algae. The presence of zebra mussel suggests that bloom conditions could easily be formed.

Algae control can be accomplished by reducing plant nutrients (fertilizers). These include phosphorus and nitrogen, minor nutrients such as sulfur and various micronutrients such as iron, manganese, magnesium, zinc, molybdenum, cobalt, etc. This is why algae removal using algaecides often results in weed growth and weed control with herbicides often results in heavy algal blooms. The nutrients must go somewhere. They will go either into weeds or algae. Algae shade the water so weeds cannot grow. If the problem is excessive weed growth, the weeds take up the plant nutrients in the water so the algae cannot grow. Lakes naturally shift every few years from weeds to algae or from algae to weeds. It all depends on what becomes established first in the season.

As, algaecides remove algae. Likewise, both excessive copper algaecides and alum can kill fish and other aquatic animals or interfere with reproduction in fish. Copper compounds can kill beneficial bacteria in the lakes that want to feed on bottom organic sediment. Alum can leave an aluminum hydroxide flocculent on the bottom that interferes with both fish reproduction and with beneficial bacteria and insects that feed on bottom organic sediment (muck). Copper compounds can destroy water quality. As the dead algae decompose they not only release phosphorus and nitrogen, they also consume oxygen. Lack of oxygen causes a release of massive amounts of phosphorus and nitrogen from the sediment into the water. Reducing oxygen often causes fish kills. Algaecides do nothing to improve the health and growth of fish, nothing to reduce bottom organic sediment. Copper compounds also add new toxic sediment to the bottom, copper carbonate, which also interferes with bacterial decomposition of sediments and interferes with fish reproduction. If you remove all the algae in a lake without eliminating the cause, the plant nutrients are still in the water. The algae will quickly return, unless weeds quickly take up the nutrients before the algae grow again. Then you have a lake full of weeds.

Aluminum, iron, or calcium salts can inactivate phosphorus in lake sediments. Lake projects typically use aluminum sulfate (alum) to inactivate phosphorus. Alum may also be applied in small doses for precipitation of water column phosphorus. When applied to water, alum forms a fluffy aluminum hydroxide precipitate called a floc. As the floc settles, it removes phosphorus and particulates (including algae) from the water column (precipitation). The floc settles on the sediment where it forms a layer that acts as barrier to phosphorus. Phosphorus, released from the sediments, combines with the alum and is not released into the water to fuel algae blooms (inactivation). Algal levels decline after alum treatment because phosphorus levels in the water are reduced. The length of treatment effectiveness varies with the amount of alum applied and the depth of the lake. Alum treatment in shallow lakes for phosphorus inactivation may last for eight or more years. In deeper lakes, alum treatment may last far longer. Some lake managers use alum to precipitate phosphorus from the water column by continuously injecting small amounts of alum during the summer months (micro-floc alum injection).

Aluminum sulfate (alum) is dispensed in carefully controlled amounts to the affected water body. The aluminum reacts with the soluble reactive phosphate (SRP) to form aluminum phosphate that is insoluble at pH values between 3 and 9. Additionally, the aluminum undergoes hydrolysis to form aluminum hydroxide floc that clarifies the water column and adsorbs additional phosphorous (P). The aluminum hydroxide precipitate and floc settle to the lake bottom, forming a thin film over the sediment. This thin film decreases phosphate release and recycling from the bottom sediments. Alum will decrease the pH of the water. It is an established practice to maintain the water pH between 6 and 7.5 during treatment. If the receiving water is already low pH or low alkalinity, buffered alum will be better. If further inputs of phosphate to the lake are managed, nutrient inactivation can last 10 to 20 years. Many lakes treated in the 1970s and 1980s, that had best management practices established in their watershed, are still clean.

### 5.9.5 Necessary Dredging

The depth of lake is very much reduced. The average depth is less than 2.40 m (maximum depth around 9m originally) and rate of sediment is 0.58±0.028 cm/year. The sediment deposited at the lake bottom emits very foul smell. During summer, when the lake level recedes, the bottom sediment starts emitting very foul smell on the lake surroundings. This is a normal phenomenon every year, which affects routine activities in the surroundings of lake every year.

The lake needs hydraulic dredging inside the lake to protect the biodiversity and dry dredging around lake periphery and in front of inflow channels during summer when the lake level recedes to around 524.90 (msl). This aspect may also help in removing nutrient-rich sediments, toxic substances (if any), rooted aquatic plants, lessen sediment resuspension and improve fish habitat. The plan should include the removal of contaminated sediment from the lake bottom. Removal of contaminated sediment is accomplished by using mechanical equipment to excavate the sediments from the lake bottom. The contaminated sediment should be properly disposed off after its removal.

The lake dredging is a very costly affair and should be avoided as far as possible. However, it can be practiced if justified.

### 5.9.6 Sluice Gate Operation at Mogha Weir and Construction of Silt Traps

As the lake water reaches to 526.479 (msl), the lake starts overflowing at the Mogha weir. So all the pollutants, which enter into the lake through various surrounding nalahs with high velocity, settle into the lake as velocity of inflow water reduces tremendously at the confluence. Presently the lake water is not refreshed during monsoon. So, sluice gates need to be constructed and operated to refresh the water in bottom layer of lake for deepwater discharge. This will result in removal of nutrient rich waters from hypolimnion. This may cause problem to streams and hence needs a little testing.

The silt traps should also be constructed on the inflow channels which bring sufficient silt and sediment. Essentially these traps could be an enlargement of the drain or water course wherever possible, both in width and depth, to allow the water flowing through the channel to slow sufficiently and allow the sediments to settle out in the trap.

### 5.9.7 Hypo-Limnetic Zone Aeration

The DO level of lake water is significantly low (1.2 to 9.0mg/L) and the average value is 4.4mg/L, which is close to the lower borderline. Presently there is no boating activity open to public and no form of artificial aeration to the lake.

The bottom of a nutrient-rich lake requires a great deal of oxygen. In an algae infested lake, oxygen is absorbed and produced at the surface but it never makes it down to the bottom due to thermal stratification as well as poor circulation and rapid consumption. Without bottom oxygen, the self-purification abilities of the lake are reversed. Nutrients that are normally bound to the bottom sediments are now released into the water column. A lake's condition deteriorates when its bottom environment cannot support animal life. The bottom is the area that runs out of oxygen first (the bottom is where the most oxygen is used and is the farthest from the surface where it is replenished). The absence of oxygen kills the entire bottom dwelling animals that help keep a lake clean. The loss of these animals (snails, mussels, worms, etc.) will greatly reduce the lake's ability to clean itself. Nutrients (fish waste, grass clippings, dead algae, etc.) cause most water quality problems. Nutrients are cleaned from a lake's bottom by the small bottom dwelling animals mentioned above. When these animals do not exist the nutrients accumulate on the bottom forming a layer of "muck" which serves as fertilizer for weeds and algae. If a lake is allowed to get seriously infested with weeds, herbicide treatment may be the only way to gain control.

The water in the hypolimnetic zone of lake needs aeration. In this, the hypolimnetic waters are raised to the surface, aerated and returned to the lower layers. This encourages breakdown of organic matter and lowers algal densities. This aeration may be provided through mechanical aerators, boating activities, installation of fountains in the lake, etc.

Thus aeration keeps the aerobic bacteria on the job by assuring them a constant supply of oxygen. The rate that the aerobic bacteria will digest the amount of dead vegetation and change into carbon dioxide and water in one year that anaerobic bacteria take 30 years to digest. So there is strong need to generate aeration like boating, aerators, etc. Further it will also add beauty to the lake. The aeration will help in reducing BOD and COD, increase bottom redox potential, reduce sedimentation rate (muck accumulation), improve water clarity, eliminate fish kill and improve fishery, reduce algae growth and no suspended bottom sediments.

### 5.9.8 Aquatic Plant Control and Vegetation Restoration

The nuisance plants may be controlled either by occasionally draining the lake over the winter or by mechanical harvesting. Although some aquatic plants could be nuisances, other plants could be essential in the restoration efforts. These plants are capable of removing pollutants through a variety of physical, chemical and biological processes. In addition, aquatic vegetation near the shoreline provides valuable fish and wildlife habitat and can be visually attractive using plants with showy flowers. The restoration of vegetation back into the lake, primarily near the shore area (known as the littoral zone) is accomplished by physically planting the selected vegetation.

### 5.9.9 Contaminated Fish Removal, Restocking and Wildlife Habitat Enhancement

If the lake is subjected to any form of sediment removal or dredging, then a primary goal of the lake restoration effort is to assure that there are no remaining contaminated fish after the sediment remediation. The Sagar lake also contains Cyanobacteria, which is very harmful to human beings. These bacteria leave a poison compound named micosystien, which remains floating on the surface water in green colour. Due to these bacteria, many species of fish have been disappeared. Hence all fish need to be eradicated and removed and the source of the contaminants also be removed. Then the final phase of the restoration is to restock native fish in the lake.

An important goal of the vegetation restoration is to support a viable fishery, contributing to healthy lake ecology as well as providing recreation. This is done through a combination of planting appropriate areas with a variety of plant life beneficial to fish and construction of deeper water holes and areas containing rocks to create a diversity of habitats. Many of the plant species selected for the restoration enhances the wildlife in the area. In addition, wildlife is enhanced by landscaping wildlife-attractive trees and shrubs.

### 5.9.10 Catchment Treatments

There is always a major threat to lake from the catchment activities in the form of: excessive use of pesticides and fertilizers for maximizing the agricultural production, faulty septic systems, improper waste disposal and accelerated soil erosion.

The treatment practices for the lake should include the following in and around the lake as well as in the catchment:

i. Maintaining septic systems.
ii. Managing waterfowl.
iii. Developing good landscape practices adjacent to lake.
iv. Controlling runoff and soil erosion.
v. Reducing or eliminating fertilizer use.
vi. Properly disposing of pet wastes.

vii. Washing of vehicles away from the lake and drains.

viii. Reducing or eliminating pesticides.

### 5.9.11 Development of Adequate Institutional Capability

Institutional inefficiency in terms of inadequate cooperation and coordination among stakeholders hinders efforts on sustainable management of the lake resources. Hence, there is strong need of a specific authority responsible for the conservation and management of the lake resources.

### 5.9.12 Public Awareness

Presently the people around the lake are not aware about the upkeep of the lake. They use the lake like a dustbin and are unaware of the importance of the lake. Hence, there is strong need for creation of awareness in public about the lake conservation by means of education, cultural activities, recreational activities, social and legal law enforcement.

The public awareness programme including the tourists should be organized at all levels in order to avoid the pollution problem and each tourist or a group of tourists should be provided written instructions regarding what to do and what not to do in order to avoid unwanted pollutants and waste materials reaching into the lake. It should be clearly indicated that the suitable penalty will be imposed, if the instructions are not followed strictly. The same instructions should be applicable to the residents of the Sagar town.

The above plan needs to be implemented as early as possible to further diminish the lake. Some of the activities the management plan may also proceed simultaneously. The above water quality management plan is based on the twelve general water quality parameters. However, some more aspects like analysis of heavy metals, pesticide, etc need to be included in the management plan.

# 6.0 CONCLUSIONS

The physico-chemical analysis of the lake water has been carried out to assess the present status of lake water quality. Water samples were collected from twenty one locations of the lake at three different depths. The transparency, dissolved oxygen, pH, BOD, iron and phosphate of the lake water are in intolerable limits. A comparison of the present status of lake water with earlier study shows that the pollution level of the Sagar lake has greatly increased over the past eighteen years. The water of the Sagar lake can not be used for drinking purpose with regards to the IS:10500 standards of *class A* type water. The lake water also contains the fecal coliform bacteria. The results show that most of the water quality parameters viz. pH, DO, BOD, transparency, iron and phosphate are beyond the permissible limits. All the nalahs discharging wastewater into the lake contribute pH, alkalinity, nitrate, phosphate, iron, BOD and TDS in high quantities and are the point sources of major pollution to the lake.

The increased level of nitrogen and phosphorous contents in the lake water indicates that the lake has attained the hyper eutrophic state. The analysis of seasonal variation indicates that the concentration of chloride, nitrate and iron increases during summer and decreases during monsoon season due to dilution of lake water. The analysis of annual variation indicates that transparency and dissolved oxygen are still decreasing while alkalinity, nitrate, phosphate and iron contents are increasing year by year. An overall water quality index is developed to categories the water of the Sagar lake and is found to be 47. Based on this index value the lake water is of poor quality and can not be used for the drinking purpose. The lake water quality has reached the shocking stage and needs urgent attention for its survival. In this view, a water quality management plan has been suggested for the rejuvenation of Sagar lake.

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