The Manas lake is one of the most important lakes near Pune city, Maharashtra state that there is a large number of tourist come there for enjoying scenery and recreation reason. Also there are many restaurants, hotels and agricultural land that direct or indirect discharge their sewage into the lake. For identify measure of pollution on this lake sampling and measuring process was taken place on December 2008 and April 2009. The analysis of water has been done and the results for pH, Biological oxygen demand, Chemical oxygen demand, Total alkalinity, Hardness, Dissolved oxygen, Sulphate, Nitrate and other parameters in both samples were compared to understanding the level of pollution on this lake.

In this study, various water quality parameters were analyzed, as well as influence of the pollution sources on the water quality parameters was ascertained.

**Material and methods**

The Water samples collected 2time. First sample was collected December 2008 almost after monsoon season and second sample was collected on April 2009 in summer season from 13 sites in pre washed plastic container which were sterile having capacity of two liter. After sampling collected samples were immediately brought to analytical laboratory and kept in refrigerator at temperature below 4C and further analysis started without delay. Analysis was carried according to standard methods of physico-chemical parameters analyzed for water and sediments samples include: pH (digital pH meter), Colour, Total dissolve solid (TDS), biological Oxygen Demand (BOD), Chemical oxygen demand (COD). Dissolved Oxygen(DO), Total Suspended Solid (TSS), Total Alkalinity (TA) as HCO3⁻, Biological oxygen demand, Chemical oxygen demand (COD). Dissolved Oxygen(DO), Total Suspended Solid (TSS), Total Alkalinity (TA) as HCO₃⁻, Calcium (Ca²⁺), Magnesium (Mg²⁺), Total hardness (TH), Chloride (Cl⁻), Sulphates (SO₄²⁻), Nitrate (NO₃⁻), Iron (Fe), Aluminium (Al), Fluoride (F⁻), Mercury.

**ABSTRACT**

The Manas lake is one of the most important lake near Pune city, Maharashtra state that there is a large number of tourist come there for enjoying scenery and recreation reason. Also there are many restaurants, hotels and agricultural land that direct or indirect discharge their sewage into the lake. For identify measure of pollution on this lake sampling and measuring process was taken place on December 2008 and April 2009. The analysis of water has been done and the results for pH, Biological oxygen demand, Chemical oxygen demand, Total alkalinity, Hardness, Dissolved oxygen, Sulphate, Nitrate and other parameters in both samples were compared to understanding the level of pollution on this lake.

In this study, various water quality parameters were analyzed, as well as influence of the pollution sources on the water quality parameters was ascertained.

**Material and methods**

The Water samples collected 2time. First sample was collected December 2008 almost after monsoon season and second sample was collected on April 2009 in summer season from 13 sites in pre washed plastic container which were sterile having capacity of two liter. After sampling collected samples were immediately brought to analytical laboratory and kept in refrigerator at temperature below 4C and further analysis started without delay. Analysis was carried according to standard methods of physico-chemical parameters analyzed for water and sediments samples include: pH (digital pH meter), Colour, Total dissolve solid (TDS), biological Oxygen Demand (BOD), Chemical oxygen demand (COD). Dissolved Oxygen(DO), Total Suspended Solid (TSS), Total Alkalinity (TA) as HCO₃⁻, Calcium (Ca²⁺), Magnesium (Mg²⁺), Total hardness (TH), Chloride (Cl⁻), Sulphates (SO₄²⁻), Nitrate (NO₃⁻), Iron (Fe), Aluminium (Al), Fluoride (F⁻), Mercury.
1. **PH:**

The PH is the activity of Hydrogen ions in the water and expressed by negative logarithm to the base 10 of the \( H^+ \) ion activity in moles/L. pH is measured with the help of portable pH meter. The pH meter is first calibrated by using buffer solution having pH 4.7 and 9.2.

2. **BOD (Biological Oxygen Demand):**

Biological Oxygen Demand (BOD) is a measure of the oxygen used by microorganisms to decompose the waste. If there is a large quantity of organic waste in the water supply, there will also be a lot of bacteria present working to decompose this waste.

3. **COD (Chemical Oxygen Demand):**

Chemical oxygen demand is related to biochemical oxygen demand (BOD), another standard test for assaying the oxygen-demanding strength of waste waters. However, biochemical oxygen demand only measures the amount of oxygen consumed by microbial oxidation and is most relevant to waters rich in organic matter.

4. **TA (Total Alkalinity):**

Total alkalinity is the total concentration of bases in the water expressed as parts per million (ppm) or milligrams per liter (mg/L) of calcium carbonate (CaCO₃). These bases are usually bicarbonates (HCO₃⁻) and carbonates (CO₃⁻), and they act as a buffer system that prevents drastic changes in pH. Alkalinity is usually given in the unit mEq/L (milli-equivalent per liter). Commercially, as in the pool industry, alkalinity might also be given in the unit ppm or parts per million.

5. **Temporary hardness:**

Temporary hardness is caused by a combination of calcium ions and bicarbonate ions in the water. It can be removed by boiling the water or by the addition of lime (calcium hydroxide). Boiling promotes the formation of carbonate from the bicarbonate and precipitates calcium carbonate out of solution, leaving water that is softer upon cooling.

The following is the equilibrium reaction when calcium carbonate (CaCO₃) is dissolved in water:

\[
CaCO_3(s) + H_2CO_3(aq) \rightleftharpoons Ca^{2+}(aq) + 2HCO_3^-(aq)
\]

6. **Parameter Hardness:**

Permanent hardness is hardness (mineral content) that cannot be removed by boiling. It is usually caused by the presence of calcium and magnesium sulfates and/or chlorides in the water, which become more soluble as the temperature rises. Despite the name, permanent hardness can be removed using a water softener or ion exchange column, where the calcium and magnesium ions are exchanged with the sodium ions in the column.

### Tables

**Hardness based classification of water**

<table>
<thead>
<tr>
<th>Hardness (mg/L)</th>
<th>Classification of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-60</td>
<td>Soft</td>
</tr>
<tr>
<td>121-180</td>
<td>Hard</td>
</tr>
<tr>
<td>&gt;180</td>
<td>Very hard</td>
</tr>
</tbody>
</table>

Hardness (mg/L) As 
\[ \text{Ca}^{2+} \text{EDTA used for titration} \times 1000 \]

where, \( a \) = ml of EDTA with blank

\[ C_{\text{Ca}^{2+}} = \frac{a}{b} \times \frac{1000}{t} \]

Where, \( a = ml \) of titrant with sample, \( b = ml \) of titrant with blank

**Results and analysis:**

Information is presented on water quality variations of color, pH, BOD, COD, TDS, TSS, nitrate, sulfate, fluoride, chloride, phosphorus, alkalinity, hardness, Fe, Hg, Al and algae. Sampling and analyzing was done after monsoon and in February i.e. winter season in the Manas Lake.

### December 2008 (table 1)

### April 2009 (table 2)
The concentration of BOD5 values that observed after monsoon can be attributed in increased quantities of organic matter that flow in the Manas Lake (Bhugaon). Although rain can increase the amount of lake water DO due to dilution and turbulence but simultaneously the runoff due to rain from the city and agricultural area around the lake are coming into this lake and consequently increase the amount of organic matter and other pollutant that cause an increase in the BOD and COD factor.

The COD concentration is 2.7 time higher than the BOD5, non-biodegradable compounds might cause this imbalance with BOD5, which might have a high potential of adverse health effects on humans. These non-biodegradable compounds might accumulate and biomagnified in living organism tissue.

DO does not present certain particular local fluctuation, merely due to the renewal of body water of lake. Generally, the conditions of oxygenation in the lake water are satisfactory and the degree of saturation of water in oxygen is larger than 70%, value that constitutes the minimal allowed level. However, it can be seen from the result the amount of DO increased in the rainy season and this change can be due to turbulence of water because of rain.

The TDS of both sampling were almost stable in the period of research with an increasing in the second sampling, which shows no problem for agricultural irrigation water. Although, no absolute TDS also is at an acceptable level and consequently low in EC (Electroconductivity). TSS is at an acceptable level and more after monsoon.

The concentrations of hardness in both sampling are at acceptable level and almost same that indicate the amount of calcium and magnesium remain almost stable in lake water.

The concentration of sulfate shows significant change and almost it became half in February, from 24.3 mg/l reduced to 13.42 in February. In other word, the concentration of Sulphate in monsoon was almost two times of the concentration in February. This high change of sulfate concentration is related to the effluent of waste-water and runoff and discharge of agricultural wastewater. Although the permissible standards for this anion is 250 mg/l (desirable < 50 mg/l) (Hammer, 2003), and therefore at an acceptable level but the high change of concentration of this anion should take into consideration to find out the source of pollution and avoid the adverse effect of this anion. Here the main reason can be agricultural drainage and runoff that contains pollutant during rainy season.

Nitrate represent the final product of the biochemical oxidation of ammonia. Its presence is probably due to the presence of nitrogenous organic matter of animal and, to some extent, vegetable origin, for only small quantities are naturally present in water.

At the second sampling an increase is observed for nitrate i.e. 3.26 mg/l. Concentrations greater than 3 mg/l indicate significant man-made contribution (Salvato, 2003). Although organic matter containing nitrogen is discharged into the lake, in nitrification process it finally changes to nitrate ion, which is consumed by algae or the mycrophyes. High growth of algae and green color of lake water is well indicating an increase in concentration of nitrate. Maximum concentration of N03 in drinking water is 45 mg/l for human and 100 mg/l for livestock. It seems no limitation exist from this aspect for drinking water consumption. Although nitrate at this level could cause algal blooms if other nutrients such as phosphorous and CO2 present.

High phosphorus concentration, as phosphates, together with nitrate and carbon dioxide are often associated with heavy aquatic plant growth, although other substances in water also have an effect. Uncontaminated waters contain 0.01 to 0.03 mg/l total phosphorus. Most waterways naturally contain sufficient nitrogen and phosphorus to support massive algal blooms. The concentration of phosphorus of the lake water is very small (0.014 mg/l). However the effluents of two restaurants, contain 3.26 mg/l. Concentrations greater than 3 mg/l indicate significant man-made contribution (Salvato, 2003). Although organic matter containing nitrogen is discharged into the lake, in nitrification process it finally changes to nitrate ion, which is consumed by algae or the mycrophyes. High growth of algae and green color of lake water is well indicating an increase in concentration of nitrate. Maximum concentration of N03 in drinking water is 45 mg/l for human and 100 mg/l for livestock. It seems no limitation exist from this aspect for drinking water consumption. Although nitrate at this level could cause algal blooms if other nutrients such as phosphorous and CO2 present.

The concentration of BOD5 values that observed after monsoon can be attributed in increased quantities of organic matter that flow in the Manas Lake (Bhugaon). Although rain can increase the amount of lake water DO due to dilution and turbulence but simultaneously the runoff due to rain from the city and agricultural area around the lake are coming into this lake and consequently increase the amount of organic matter and other pollutant that cause an increase in the BOD and COD factor.

The COD concentration is 2.7 time higher than the BOD5, non-biodegradable compounds might cause this imbalance with BOD5, which might have a high potential of adverse health effects on humans. These non-biodegradable compounds might accumulate and biomagnified in living organism tissue.

DO does not present certain particular local fluctuation, merely due to the renewal of body water of lake. Generally, the conditions of oxygenation in the lake water are satisfactory and the degree of saturation of water in oxygen is larger than 70%, value that constitutes the minimal allowed level. However, it can be seen from the result the amount of DO increased in the rainy season and this change can be due to turbulence of water because of rain.

The TDS of both sampling were almost stable in the period of research with an increasing in the second sampling, which shows no problem for agricultural irrigation water. Although, no absolute TDS also is at an acceptable level and consequently low in EC (Electroconductivity). TSS is at an acceptable level and more after monsoon.

The concentrations of hardness in both sampling are at acceptable level and almost same that indicate the amount of calcium and magnesium remain almost stable in lake water.

The concentration of sulfate shows significant change and almost it became half in February, from 24.3 mg/l reduced to 13.42 in February. In other word, the concentration of Sulphate in monsoon was almost two times of the concentration in February. This high change of sulfate concentration is related to the effluent of waste-water and runoff and discharge of agricultural wastewater. Although the permissible standards for this anion is 250 mg/l (desirable < 50 mg/l) (Hammer, 2003), and therefore at an acceptable level but the high change of concentration of this anion should take into consideration to find out the source of pollution and avoid the adverse effect of this anion. Here the main reason can be agricultural drainage and runoff that contains pollutant during rainy season.

Nitrate represent the final product of the biochemical oxidation of ammonia. Its presence is probably due to the presence of nitrogenous organic matter of animal and, to some extent, vegetable origin, for only small quantities are naturally present in water.

At the second sampling an increase is observed for nitrate i.e. 3.26 mg/l. Concentrations greater than 3 mg/l indicate significant man-made contribution (Salvato, 2003). Although organic matter containing nitrogen is discharged into the lake, in nitrification process it finally changes to nitrate ion, which is consumed by algae or the mycrophyes. High growth of algae and green color of lake water is well indicating an increase in concentration of nitrate. Maximum concentration of N03 in drinking water is 45 mg/l for human and 100 mg/l for livestock. It seems no limitation exist from this aspect for drinking water consumption. Although nitrate at this level could cause algal blooms if other nutrients such as phosphorous and CO2 present.

High phosphorus concentration, as phosphates, together with nitrate and carbon dioxide are often associated with heavy aquatic plant growth, although other substances in water also have an effect. Uncontaminated waters contain 0.01 to 0.03 mg/l total phosphorus. Most waterways naturally contain sufficient nitrogen and phosphorus to support massive algal blooms. The concentration of phosphorus of the lake water is very small (0.014 mg/l). However the effluents of two restaurants, contain 3.26 mg/l. Concentrations greater than 3 mg/l indicate significant man-made contribution (Salvato, 2003). Although organic matter containing nitrogen is discharged into the lake, in nitrification process it finally changes to nitrate ion, which is consumed by algae or the mycrophyes. High growth of algae and green color of lake water is well indicating an increase in concentration of nitrate. Maximum concentration of N03 in drinking water is 45 mg/l for human and 100 mg/l for livestock. It seems no limitation exist from this aspect for drinking water consumption. Although nitrate at this level could cause algal blooms if other nutrients such as phosphorous and CO2 present.

The concentration of BOD5 values that observed after monsoon can be attributed in increased quantities of organic matter that flow in the Manas Lake (Bhugaon). Although rain can increase the amount of lake water DO due to dilution and turbulence but simultaneously the runoff due to rain from the city and agricultural area around the lake are coming into this lake and consequently increase the amount of organic matter and other pollutant that cause an increase in the BOD and COD factor.

The COD concentration is 2.7 time higher than the BOD5, non-biodegradable compounds might cause this imbalance with BOD5, which might have a high potential of adverse health effects on humans. These non-biodegradable compounds might accumulate and biomagnified in living organism tissue.

DO does not present certain particular local fluctuation, merely due to the renewal of body water of lake. Generally, the conditions of oxygenation in the lake water are satisfactory and the degree of saturation of water in oxygen is larger than 70%, value that constitutes the minimal allowed level. However, it can be seen from the result the amount of DO increased in the rainy season and this change can be due to turbulence of water because of rain.

The TDS of both sampling were almost stable in the period of research with an increasing in the second sampling, which shows no problem for agricultural irrigation water. Although, no absolute TDS also is at an acceptable level and consequently low in EC (Electroconductivity). TSS is at an acceptable level and more after monsoon.

The concentrations of hardness in both sampling are at acceptable level and almost same that indicate the amount of calcium and magnesium remain almost stable in lake water.

The concentration of sulfate shows significant change and almost it became half in February, from 24.3 mg/l reduced to 13.42 in February. In other word, the concentration of Sulphate in monsoon was almost two times of the concentration in February. This high change of sulfate concentration is related to the effluent of waste-water and runoff and discharge of agricultural wastewater. Although the permissible standards for this anion is 250 mg/l (desirable < 50 mg/l) (Hammer, 2003), and therefore at an acceptable level but the high change of concentration of this anion should take into consideration to find out the source of pollution and avoid the adverse effect of this anion. Here the main reason can be agricultural drainage and runoff that contains pollutant during rainy season.

Nitrate represent the final product of the biochemical oxidation of ammonia. Its presence is probably due to the presence of nitrogenous organic matter of animal and, to some extent, vegetable origin, for only small quantities are naturally present in water.

At the second sampling an increase is observed for nitrate i.e. 3.26 mg/l. Concentrations greater than 3 mg/l indicate significant man-made contribution (Salvato, 2003). Although organic matter containing nitrogen is discharged into the lake, in nitrification process it finally changes to nitrate ion, which is consumed by algae or the mycrophyes. High growth of algae and green color of lake water is well indicating an increase in concentration of nitrate. Maximum concentration of N03 in drinking water is 45 mg/l for human and 100 mg/l for livestock. It seems no limitation exist from this aspect for drinking water consumption. Although nitrate at this level could cause algal blooms if other nutrients such as phosphorous and CO2 present.

High phosphorus concentration, as phosphates, together with nitrate and carbon dioxide are often associated with heavy aquatic plant growth, although other substances in water also have an effect. Uncontaminated waters contain 0.01 to 0.03 mg/l total phosphorus. Most waterways naturally contain sufficient nitrogen and phosphorus to support massive algal blooms. The concentration of phosphorus of the lake water is very small (0.014 mg/l). However the effluents of two restaurants, containing detergents, which contain phosphorus, are discharging to this lake.