CHAPTER VI

A COMPARAIVE STUDY OF PHYSICO-CHEMICAL PARAMETERS OF TWO WATER BODIES

INTRODUCTION

All the organisms in various ecosystems need water for their life activities. Though 70% of earth is covered with water, but only 0.2 percent fresh water is available for human being and other freshwater dependent organisms (Aydemir *et al.,* 2005). Most of this fresh water is present in rivers, ponds, lakes and wells. These are patchy areas separated by land creating the transitional zones known as Wetlands. These wetlands supporting great diversity of organisms are known as the second most productive zone in the world (Ramchandra *et al.*, 2002). The wetland is an environment "at the interface between truly terrestrial and truly aquatic ecosystems, making them inherently different form, but highly dependent on both" (Mitsch & Gosselink, 1986). Dependence of organism on a wetland or water body is based on its physical and chemical properties. In other words, these properties are also reflected through the diverse variety of flora and fauna supported by it.

The dependency of urban man on water has increased tremendously, resulting into the production of huge quantity of waste water. Thus the urbanization directly or indirectly influences the quality of water, by changing its characteristics and polluting it. Changes in pure water from beneficial to harmful state for the organisms influence the organisms relying on them for their well being (Aydemir *et al.,* 2005). Water bodies exhibit a wide range of ecological, social and aesthetic values (Gledhill *et al.*, 2005). Pouraghniaei (2002) assumed that urbanization too has important impacts on both the availability and quality of water resources. The calibre of water in a water body is not only essential for the human being but also for the survival of flora and fauna supported by it (Aydemir *et al.*, 2005). The properties of freshwater bodies are the characteristics of the climatic, geochemical, geomorphological and pollution conditions prevailing in the drainage basin and the underlying aquifer (Ramchandra *et al.*, 2002). These characteristics with natural or manmade changes determine the quality of water (Anonymous, 2003). The influence of human utilization or dependency on urban water resources could not be ignored. Human development added various organic and inorganic components to water. Further, high amount of nutrients were also loaded into water bodies from human settlements via sewage (Khan and Ansari, 2005). The seasonal changes in the environment with such human pressures change the quality of water bodies, especially in the semiarid zone where seasonal changes are pronounced (Deshkar, 2008). Present study is carried out to understand direct or indirect effects of human activities on the quality of water at the two water bodies described in chapter IV and V in this chapter the physico-chemical parameters were correlated with avifaunal (Chapter IV) and plankton (Chapter V) diversity and densities.

Physico-chemical parameters of water from two water bodies are evaluated to know the differences in the quality of water. The parameters are divided as physical and other aggregate properties and inorganic non-metallic constituents. The physical and other aggregate properties included are Temperature, Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), pH, Acidity, Bicarbonate Alkalinity (HCO_3^-), Hydroxyl Alkalinity (OH^-), Salinity, Total Hardness, Calcium Hardness and Magnesium Hardness. While Inorganic Non-metallic Constituents included are Dissolved Oxygen (DO), Carbon dioxide (CO_2), Chloride (Cl^-), Nitrate (NO_3^-), Nitrite (NO_2^-) and Phosphate (PO_4^{-3}).

PHYSCAL AND OTHER AGGREGATE PROPERTIES:

Temperature has a significant ecological impact. Compared to the other factors, the temperature plays significant role on the algal growth (Khan and Ansari, 2005). *Solids* refer to the matter suspended or dissolved in water or waste water. Solids may affect water or effluent quality adversely in a number of ways (APHA, 1989). Water with high dissolved solids generally is of inferior palatability and may induce an unfavorable physiological reaction in the transient consumer. For these reasons, a limit of 500 mg dissolved solids/l is permissible in drinking waters. Highly mineralized water is also unsuitable for many industrial applications. Water with high suspended solids may be aesthetically unsatisfactory for purposes such as bathing. Solid analysis is important for the control of biological and physical wastewater treatment processes and for assessing compliance with regulatory wastewater effluent limitation agency. *Total Solids* include Total Suspended Solids (TSS), the portion of solids retained on a filter paper and Total Dissolved Solids (TDS), the portion that passes through the filter paper and precipitate on the evaporation of water.

pH is one of the most important and frequently used environmental parameter. It is used to know the intensity of the acidic or basic character of water. The absorption of phosphate by plants was accelerated by an acidic pH (Devlin and

Witham, 1986). According to George and Heaney (1978), high pH values promoted the growth of phytoplankton and resulted in algal bloom. Measurement of *Acidity* might reflect a change in the quality of water (APHA, 1989). The anthropogenic acidification is reported to change the prey base and vegetation structure in wetlands, which in turn has impact on other biota (Doherty *et al*., 2000). *Alkalinity* of surface water is its acid-neutralizing capacity. Alkalinity of surface water is primarily a function of carbonate, bicarbonate and hydroxide content; it is generally taken as an indication of the concentration of these constituents (APHA, 1989). Here the alkalinity is measured in the form of bicarbonate and hydroxyl alkalinity. Raw domestic waste water has an alkalinity less than or only slightly greater than that of the municipal water supply (APHA, 1989). According to Dunn (1965), direct comparisons of alkalinity are difficult because of differing ionic constituents of different water bodies. It has been reported that the alkaline ponds supported high rotifer density and low species richness (Sladecek, 1983). Further, it has been noted by George and Heaney (1978) that highly alkaline ponds promoted the growth of phytoplankton resulting in their bloom. *Salinity* is an important component to measure the mass of dissolved salts in a given mass of solution (APHA, 1989). According to Grillas *et al*., (1993) the total biomass of the submerged communities decreases exponentially and also the species richness decreases linearly with increasing salinity.

Water hardness is a measure of the capacity of water to precipitate chiefly by the calcium and magnesium ions present (APHA, 1989). *Total Hardness* is defined as the sum of the calcium and magnesium concentrations, both expressed as calcium carbonate, in milligrams per litre (APHA, 1989). The hardness may range from zero to hundreds of milligrams per liter, depending on the source and treatment to which the water has been subjected (APHA, 1989).

Inorganic non-metallic constituents:

Dissolved Oxygen levels in natural and waste water depend on the physical, chemical and biochemical activities in the water body. Estimation of dissolved oxygen is a key test in water pollution and waste treatment process (APHA, 1989). According to Khan and Ansari (2005), the minima and maxima in the concentration of dissolved oxygen are found to be directly related to the maxima and minima of the phytoplankton. A direct relationship between phytoplankton and dissolved oxygen content has been reported (Saad, 1973; Misra *et al.*, 1975; Schindler, 1971). *Carbon dioxide* content of water contributes significantly to corrosion (APHA, 1989). The amount of free carbon dioxide available for photosynthetic activity is a limiting factor that influences diversity and density of phytoplankton (Khan and Ansari, 2005).

Chloride in water occurs in the form of chloride ion (Cl^-), one of the major inorganic anions in water and waste water (APHA, 1989). It is one of the major inorganic non-metallic constituents. Other important inorganic non-metallic constituent is *Nitrogen*. Information of forms of Nitrogen in water and waste water is of greatest interest. Nitrogen occurs in order of decreasing oxidation state as nitrate, nitrite, ammonia, and organic nitrogen (APHA, 1989). *Nitrate* and *Nitrite*, the forms of nitrogen are evaluated in the present study. Nitrite is an intermediate oxidation state of nitrogen, both in the oxidation of ammonia to nitrate and in the reduction of nitrate whereas nitrate is found only in small amounts in fresh domestic waste water (APHA, 1989). *Phosphate*: phosphorus occurs in natural and waste water almost solely as phosphates. Larger quantities of phosphates are added when the water is used for laundering or other cleaning, because they are major constituents of many commercial cleaning preparations (APHA, 1989). Phosphorus concentration in clean water was reported to be very low (Khan and Ansari, 2005). Phosphorus has been identified as the limiting nutrient to phytoplankton development (Khan and Ansari, 2005). However, when present in too greater quantity in surface water it was associated with the excessive growth of algae (Lean, 1973; Ambasht and Ambasht, 1992).

MATERIALS AND METHODS:

To analyze physico-chemical parameters using standard methods described in APHA (1989). As described in chapter V, water samples were collected form three selected points of each waterbody twice in a month.

Physical and other aggregate property:

Temperature was measured at the site itself by using Mercury thermometer and was noted in °C.

Total Solids (TS) (APHA, 1989):

The total solids included the total suspended solids that were left on the filter paper during filtration and the total dissolved solids that were left after the evaporation of the filtered water in a petri dish. Total solids were measured by evaporating 10 ml of samples in a pre-weighed evaporating dish and finding out the difference after evaporating the sample in an oven at 102-103°C. The evaporating dish was cooled and accurately weighed to constant weight. The difference in the two weights was considered as TS. It is calculated as:

$$\text{Total Solids (mg/l)} = \frac{(W_2 - W_1) \times 1000}{\text{Amount of Sample taken (ml)}}$$

Where,
W_1 = Weight of empty evaporating dish.
W_2 = Weight of dried residue + evaporating dish.

Total Dissolved Solids (TDS) (APHA, 1989):

A known volume of the well-mixed sample (10ml) was filtered and evaporated to dryness at 103-105 °C in a pre-weighed evaporating dish. The evaporating dish was cooled until constant weight was recorded. The difference in the two weights was considered as TDS and it is calculated by using the formula as above.

Total Suspended Solids (TSS) (APHA, 1989):

Suspended solids were the portions of the Total solids that were retained on a filter paper after filtering the sample. Alternatively the difference between the total solids and the total dissolved solids could be taken as total suspended solids.

Total Suspended Solids TSS mg/l = TS mg/l – TDS mg/l

pH was measured using pH Scan Eutech Instruments.

Acidity (***Titrimetric Method)*** (APHA, 1989 and GPCB, 2003):

Hydrogen ions present in a sample as a result of dissociation or hydrolysis of solutes react with additions of standard alkali and influence the acidity. Acidity of the solution thus depends on the end-point pH or the indicator used. For routine titrations or rapid preliminary estimates of acidity, the change in the colour of the indicator is the end point.

To estimate acidity, in 10ml or 50ml of sample, 2 to 4 drops of Phenolphthalein were added and titrated against 0.02 N NaOH solutions. Whenever necessary the samples were made colourless with the charcoal. Acidity is calculated by using following formula.

$$\text{Acidity, as } CaCO_3 \text{ mg / l} = \frac{\text{B.R.} \times 1000}{\text{Amount of Sample Taken (ml)}}$$

Where, B.R. = Burette reading (Amount of titrant used)

Alkalinity (***Titrimetric Method***) (APHA, 1989, GPCB, 2003):

Total alkalinity is the sum of Hydroxyl Alkalinity and Bicarbonate Alkalinity.

Hydroxyl Alkalinity (APHA, 1989):

Hydroxyl ions present in a sample as a result of dissociation or hydrolysis of solutes react with additions of standard acid. Alkalinity also depends on the end-point and pH of the indicator used. To estimate hydroxyl alkalinity, 3 to 4 drops of phenolphthalein indicator were used for 50 ml sample. If pink colour was developed then it was titrated against 0.02 N H_2SO_4 to the perfect point of pH 8.3. If no colour change occurred, the phenolphthalein alkalinity was considered as zero. The Hydroxyl Alkalinity is calculated by using following formula.

$$\text{Hydroxyl Alkalinity, as } CaCO_3 \text{ mg / l} = \frac{A \times N \times 50 \times 1000}{\text{Amount of Sample taken (ml)}}$$

A= Burette reading (Amount of titrant used)

N= Normality of H_2SO_4

50= equivalent weight of $CaCO_3$

Bicarbonate Alkalinity: (APHA, 1989, GPCB, 2003):

Few drops of methyl orange indicator were added to the sample in which the phenolphthalein alkalinity was determined. This mixture was titrated against

0.02 N H_2SO_4 to the colouration corresponding to the perfect point. The Bicarbonate Alkalinity is calculated using following formula.

$$\text{Bicarbonate Alkalinity, as } CaCO_3 \text{ mg / l} = \frac{B \times N \times 50 \times 1000}{\text{Amount of Sample taken (ml)}}$$

Where,

B= Total ml of titrant used for neutralizing sample to reach the second end point.

N= Normality of Sulphuric acid (0.02).

50= equivalent weight of $CaCO_3$

Salinity: Salinity is calculated on the bases of chloride value (Page 10)

Salinity = mg Cl/ lit × 1.805 (APHA, 1989)

mg Cl^- /lit as calculated for the chloride content in sample is multiplied by 1.805.

Estimation of Total Hardness: (EDTA Titrimetric Method- APHA, 1998)

Ethylene di-amine tetra acetic acid (EDTA) and its sodium salts form a chelated soluble complex when added to a solution of certain metal cations. A small amount of the dye such as Eriochrome Black T/ Calmagite when added to the aqueous solution containing calcium and magnesium ions at pH of 10.0 turns the solution wine red. With addition of titrant, the solution turns from wine red to blue, that was the end point.

For the estimation of Total Hardness, in 50 ml of sample 1 to 2ml of buffer solution and a pinch of Eriochrome Black T (used as an indicator) were added. After the wine red colour appeared the mixture was titrated against EDTA stirring continuously till end point of wine red to blue appeared. The hardness is calculated using following formula.

Hardness as mg $CaCO_3$ / l = $\underline{\text{A X N X 1000}}$

Amount of Sample taken (ml)

Where A = ml of titrant (EDTA) used.

N= Normality of EDTA (0.02N).

Estimation of Calcium Hardness: (***EDTA Titrimetric Method*** -APHA, 1998)

When EDTA was added to water containing both calcium and magnesium, it combined first with calcium. Calcium could be determined directly with EDTA when pH was sufficiently high. At this pH the magnesium was largely precipitated as the hydroxide. The indicator used (Murexide indicator) combined with calcium only. As all Calcium was used up the colour changed from pink to violet indicating the end point.

To estimate calcium hardness, in 50 ml of sample 3ml of 0.1 N NaOH (upto pH 12) and 0.2 to 0.4 gm of Murexide indicator were added and titrated against 0.02 N EDTA. The pinkish tinge disappeared and violet colour appeared. This was the end point and was noted as B. As per need to remove turbidity charcoal was used. The calcium hardness is calculated as

$$\text{Hardness mg } CaCO_3\text{/l} = \frac{B \times N \times 1000}{\text{Amount of sample taken (ml)}}$$

Where B = ml of titrant (EDTA) used.

N = Normality of EDTA (0.02N)

Magnesium Hardness is calculated as $CaCO_3$ mg / lit = $\frac{A - B \times 1000}{\text{Amount of Sample taken (ml)}}$

Inorganic Non-metallic Constituents

Dissolved Oxygen (Wrinkler's Methods) (APHA, 1989):

The manganese sulphate ($MnSo_4$) reacts with the alkali (KOH) to form white precipitates of manganese hydroxide. In the presence of oxygen, highly alkaline solution of the white manganese hydroxide was oxidized to brown coloured manganese oxyhydrate. This occurred in direct proportion to the amount of oxygen present. In strong acidic medium manganic ions were freed and they reacted with the iodine ions of potassium iodide to release free iodine. The amount of free iodine was equivalent to the oxygen present in the solution. The amount of iodine could be determined by titration with sodium thiosulphate by using starch as indicator.

To estimate dissolved oxygen, the water was collected with care in BOD bottles without bubble formation. The DO was then fixed at the site itself by adding 1 ml each of Manganese Sulphate and Alkali-iodide azide reagents. The precipitates formed were dissolved by adding 2 ml of concentrated sulphuric acid. 10ml or 50ml sample was taken and some amount of Sodium thiosulphate was added until pale yellow colour developed. To this mixture 2 to 4 drops of Starch solution were added as indicator. This mixture was then titrated further till the disappearance of blue colour. Dissolved oxygen is calculated by using following formula:

$$\textbf{D.O.} = \frac{\text{B.R} \times \text{N} \times 1000}{\text{Amount of Sample taken (ml)}}$$

B.R. = Burette reading (Amount of titrant used)

N= Normality of Sodium thiosulphate (0.1N).

Carbon dioxide (CO_2) (APHA, 1989):

Surface water normally contained less amount of free carbon dioxide as compared to ground water. Free carbon dioxide reacted with sodium hydroxide to form sodium bicarbonate.

To 50 ml of sample, 2 to 3 drops of phenolphthalein were added and titrated against 0.02 N Sodium hydroxide. The end point was noted as colour change from pink to colourless. The carbon dioxide is calculated by using following formula.

$$\text{mg } CO_2\text{/l} = \frac{\text{B.R.} \times \text{N} \times 44 \times 1000}{\text{Amount of Sample taken (ml)}}$$

Where, B.R. = Burette reading (Amount of titrant used)

N = Normality of Sodium Hydroxide (0.02 N)

44 = equivalent weight of CO_2

(The estimation of Carbon dioxide was carried out only in the 2nd year of this study.)

Chloride **(Cl^-)** (APHA, 1989):

In a neutral or slightly alkaline solution, potassium chromate indicated the end point of the silver nitrate titration of chloride. Silver chloride was precipitated quantitatively before red silver chromate was formed. To 10ml or 50ml sample 1 ml Potassium Chromate was added as an indicator and titrated against 0.0282 N Silver Nitrate. Red precipitates developed from pale yellow colour indicated end point. When necessary the sample was made colourless by adding the charcoal. The amount of Chloride is calculated by using following formula.

$$\text{mg } Cl^-\text{/l} = \frac{\text{A X N X35.45 X 1000}}{\text{Amount of Sample taken (ml)}}$$

Where, A = Burette reading (Amount of titrant used)

N = Normality of Silver Nitrate

35.45 is the equivalent weight of Chloride.

Nitrogen:

Nitrates (NO_3^-) (Cadmium Reduction Method) (APHA, 1989):

NO_3^- is reduced almost quantitatively to nitrite (NO_2^-) in the presence of cadmium (Cd). This method uses commercially available Cd granules treated with copper sulphate ($CuSO_4$) and packed in a glass column. The nitrite (NO_2^-) produced was then determined by diazotizing it with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form highly coloured azo dye that was measured colorimetrically. A correction could be made for any NO_2^- present in the sample by analyzing without the reduction step.

In this method 50 ml sample was taken and passed through the Cadmium column. The initial 10 ml was discarded and then 25 ml was collected for estimation. To this 25ml, 2 ml of colour reagent was added and optical density was measured at 543 nm with colorimeter model Photochem 5. A reagent Blank was used to set the instrument. The Nitrate is calculated using following formula.

$$NO_3^-N \text{ mg/l} = \frac{\text{O.D X Factor}}{\text{Amount of Sample taken (ml)}}$$

O.D is Optical Density

Factor is obtained from standard graph.

Nitrites (**NO_2^-**) (Colorimetric Method) (APHA, 1989):

Nitrite was determined by the formation of reddish purple azo dye produced at pH 2.0-2.5 with colour reagent.

To estimate Nitrites 50ml of sample was taken in a beaker and 2 ml colour reagent was added to it. The colour developed was read immediately at 543 nm. with colorimeter model Photochem 5 indicateing O.D. A standard graph was plotted to obtain factor. A reagent blank was run to set the instrument. The Nitrite are calculated as

$$NO_2^-N\ mg/l = \frac{O.D\ X\ Factor}{Amount\ of\ Sample\ taken\ (ml)}$$

O.D is Optical Density

Factor is obtained from standard graph.

Phosphate (PO_4^{3-}) (APHA, 1989):

When the Ammonium Molybdate was added to the sample, molybdophosphoric acid was formed. This was reduced by stannous chloride to intensely coloured molybdenum blue and measured colorimetrically.

In a conical flask containing 100ml of sample, 4ml strong acid and 4ml of ammonium molybdate were added followed by 10 drops $SnCl_2$. The blue colour developed was measured after 10 minutes at 690 nm. with colorimeter model Photochem 5 indicating O.D. A standard graph was plotted to obtain factor. A reagent blank was run to set the instrument. The Phosphates are calculated as

$$Amount\ of\ PO_4^{3-}\ as\ mg/l = \frac{O.DX\ Factor}{Sample\ take\ in\ ml}$$

O.D is Optical Density

Statistical analysis

For the convenience of analysis the monthly data is pooled for four seasons. Total 12 visits were made per season at both the water bodies, amounting to 48 visits per site in two years. The four seasons are pre-winter (September to November), winter (December to February), summer (March to May) and monsoon (June to August). The results given are in the form of Mean ± SEM. The data collected for two water bodies are compared using t-test while the seasonal variations at each water bodies are analyzed using ANOVA (Graph Pad

Prism 3 and Excel). The p value is insignificant if $P > 0.05$, significant if $P < 0.05$ (*), significantly significant if $P < 0.001$ (**) and highly significant if $P < 0.0001$ (***) as described by Fowler, J and Cohen, L.

Results

Physical and other aggregate properties: (Fig.6.1)

Temperature: Temperature is known to influence certain physico-chemical components of water. The seasonal variations in water temperature were highly significant ($P < 0.0001$, $F_{3,57}$ 27.77) across the seasons at Savli Pond (SVP) with maximum temperature (36.33 ± 0.3 C°) during summer and minimum (13.1 ± 0.79 C°) during winter. In monsoon it was 29.42 ± 0.16 C° and pre-winter 24.59 ± 1.34 C°. At Jawala Irrigation Reservoir (JIR) also the variations were highly significant ($P < 0.0001$, $F_{3,65}$ 87.65) with maximum during summer (35.33 ± 0.49 C°) and minimum in winter (13.1 ± 0.58 C°), while 28.83 ± 0.3 C° in monsoon and 23.62 ± 1.43 C° during pre-winter. When SVP and JIR were compared, the differences were insignificant ($P > 0.05$) in each season.

Total Solids (TS) in SVP water was low during pre-winter (256.7 ± 80.9 mg/l), it increased through winter (384.6 ± 59.45 mg/l) and summer 540 ± 78.32 mg/l, reaching to maximum level during monsoon (1898 ± 886.3 mg/l) with insignificant differences ($P > 0.05$, $F_{3,25}$ 2.304). The amounts of TS in JIR water were also minimum in pre-winter (190 ± 93.54 mg/l), it increased through winter (996 ± 449.4 mg/l) and reached to maximum level in summer (1508 ± 319.3 mg/l), but decreased in monsoon (526.7 ± 139.1 mg/l). At JIR also seasonally insignificant ($P > 0.05$, $F_{3,14}$ 2.430) variations were noted. When SVP and JIR were compared, the differences in TS values were significantly significant ($P < 0.001$) during summer and insignificant ($P > 0.05$) in pre-winter, winter and monsoon. The *Total Dissolved Solids (TDS)* at SVP were also minimum during pre-winter (113.3 ± 54.57 mg/l) and increased in winter (240.0 ± 79.88 mg/l) and maintained in summer (237.3 ± 59.19 mg/l) and then reached to maximum level during monsoon (292.5 ± 94.92 mg/l). At JIR also TDS were low during pre-winter (60.0 ± 21.21 mg/l) but gradually increased through winter (186.7 ± 53.89 mg/l) and summer (236.0 ± 46.75 mg/l) reaching to maximum level in monsoon (473.3 ± 143.1 mg/l). Seasonal variations were insignificant ($P > 0.05$) at SVP ($F_{3,\,25}$ 0.4984) but significant ($P < 0.05$) at JIR ($F_{3,\,14}$ 5.455). When SVP and JIR were compared the insignificant ($P > 0.05$) seasonal differences were noted during all seasons. The *Total Suspended Solids (TSS)* at SVP fluctuated over the year with 143.3 ± 89 mg/l during pre-winter that increased to 532 ± 305 mg/l in winter 303 ± 85 mg/l during summer and highest 1605 ± 794.2 mg/l in monsoon. In JIR water minimum TSS were noted during monsoon 53.33 ± 6.66 mg/l, but increased from pre- winter (130 ± 84 mg/l), winter (810 ± 440.2 mg/l) and reached to maximum level in summer (1272 ± 339 mg/l). Seasonally insignificant differences were noted at both the water bodies (at SVP $P > 0.05$, $F_{3,\,25}$ 1.954 and at JIR $F_{3,\,14}$ 2.410). When the TSS values of SVP and JIR were compared significantly significant ($P < 0.001$) differences were noted during summer and insignificant ($P > 0.05$) in pre-winter, winter and monsoon.

At SVP *pH* was maximum during summer (8.88 ± 0.08) and gradually decreased to 8.11 ± 0.26 in monsoon, 7.23 ± 0.06 in pre-winter and was maintained around 7.34 ± 0.07 during winter. The seasonal variations were highly significant ($P < 0.0001$, $F_{3,\,57}$ 27.77). At JIR also maximum pH was noted during summer (8.1 ± 0.042) followed by monsoon (7.5 ± 0.141), pre-winter (7.2 ± 0.087) and winter (7.1 ± 0.046) with highly significant seasonal variations ($P < 0.0001$, $F_{3,\,36}$ 15.08). When two water bodies were compared, pH of both the water bodies differed highly significantly ($P < 0.0001$) during summer, significantly ($P < 0.05$) in winter and insignificantly ($P > 0.05$) in monsoon and pre-winter. At SVP *Acidity* was noted high during monsoon (37.61 ± 2.99 $CaCO_3$ mg/l), and in pre-winter (35.72 ± 4.33 $CaCO_3$ mg/l) whereas low during winter (21.52 ± 4.17 $CaCO_3$ mg/l) and in summer (24.43 ± 4.2 $CaCO_3$ mg/l). The seasonal variations were significantly significant ($P < 0.001$, $F_{3,\ 105}$ 4.122). At JIR highest acidity was noted during monsoon (16.86 ± 3.05 $CaCO_3$ mg/l) and lowest during winter (5.62 ± 1.80 $CaCO_3$ mg/l) with 14.0 ± 2.89 $CaCO_3$ mg/l in pre-winter and 13.37 ± 2.81 $CaCO_3$ mg/l in summer. Seasonal differences were insignificant ($P > 0.05$). When the two water bodies were compared for seasonal acidity, highly significant ($P < 0.0001$) variations were noted during pre-winter, winter and monsoon whereas insignificant ($P > 0.05$) variations were noted in summer.

At SVP ***Hydroxyl alkalinity*** was nil throughout the study period, while at JIR it was highest during winter (3.72 ± 0.85 $CaCO_3$ mg/l), and decreased during summer 0.75 ± 0.43 $CaCO_3$ mg/l, was nil during monsoon and reappeared during pre-winter (0.19 ± 0.13 $CaCO_3$ mg/l). The seasonal variations were highly significant ($P < 0.0001$, $F_{3,\ 73}$ 8.231). When compared insignificant differences ($P > 0.05$) were noted between the two water bodies. SVP had maximum ***Bicarbonate Alkalinity*** during monsoon (125.3 ± 29.89 $CaCO_3$ mg/l) and minimum in pre-winter (67.54 ± 6.991 $CaCO_3$ mg/l). During summer it was 121.80 ± 5.47 $CaCO_3$ mg/l and in winter it was 101.0 ± 3.7 $CaCO_3$ mg/l. The seasonal differences were insignificant ($P>0.005$, $F_{3,\ 102}$ 2.135) at SVP while highly significant ($P < 0.0001$, $F_{3,76}$ 12.84) at JIR during the study period. At JIR bicarbonate alkalinity was 36.58 ± 3.42 $CaCO_3$ mg/l during pre- winter; it started increasing in winter (64.08 ± 3.64 $CaCO_3$ mg/l) and reached to maximum level in summer (96.68 ± 6.94 $CaCO_3$ mg/l) but decreased during monsoon (74.24 ± 11.73 $CaCO_3$ mg/l). When compared, the differences in the bicarbonate alkalinity at both the water bodies was highly significantly ($P < 0.0001$) during pre-winter and winter whereas, significantly significant ($P < 0.001$) in summer and insignificant ($P > 0.05$) in monsoon.

At SVP maximum *Salinity* was noted during summer (99.85 ± 7.4 mg/l) and minimum in pre-winter (44.96 ± 1.56 mg/l). During monsoon it was 78.46 ± 10.31 mg/l and during winter it was 66.13 ± 4.1 mg/l with highly significant ($P < 0.0001$, $F_{3,\ 105}$ 9.617) seasonal variations. At JIR also maximum salinity was noted during summer (62.98 ± 1.7 mg/l) and minimum in pre-winter (27.52 ± 2.28 mg/l). During monsoon it was 28.09 ±1.9 mg/l and winter it was 37.15 ± 1.8 mg/l and. The seasonal variations were highly significant ($P < 0.0001$, $F_{3,\ 73}$ 7.21) over the study period. When, the two water bodies were compared highly significant ($P < 0.0001$) differences were noted during pre-winter, winter and monsoon and significantly significant ($P < 0.001$) in summer.

At SVP *Total Hardness* was lowest during monsoon (63.89 ± 10.31 $CaCO_3$ mg/l) and highest during winter (109.4 ± 3.84 $CaCO_3$ mg/l). The total hardness was 86.25 ± 2.82 $CaCO_3$ mg/l during pre-winter and 83.43 ± 3.19 $CaCO_3$ mg/l in summer. Highly significant seasonal variations ($P < 0.0001$, $F_{3,\ 101}$ 32.71) were noted over the study period. However, at JIR the total hardness was minimum during monsoon (49.56 ± 2.8 $CaCO_3$ mg/l), and increased marginally through pre-winter (52.26 ± 2.26 $CaCO_3$ mg/l) and winter (60.37 ± 4.87 $CaCO_3$ mg/l) reaching to maximum level in summer (102.4 ± 12.09 $CaCO_3$ mg/l) with highly significant seasonal variations ($P < 0.0001$, $F_{3, 62}$ 10.72). Between the two water bodies insignificant ($P > 0.05$) differences were noted during summer, significant ($P < 0.05$) in monsoon and highly significant ($P < 0.0001$) during pre-winter and winter. At SVP *Calcium Hardness* gradually increased from summer (18.18 ± 1.60 $CaCO_3$ mg/l) to monsoon (23.44 ± 1.7 $CaCO_3$ mg/l) and pre-winter (26.58 ± 0.75 $CaCO_3$ mg/l) reaching its maximum level in winter (27.00 ± 2.43 $CaCO_3$ mg/l) with highly significant ($P < 0.0001$, $F_{3, 98}$ 5.98) seasonal variations. While, at JIR calcium hardness was highest during pre-winter (15.92 ± 0.99 $CaCO_3$ mg/l) and the lowest in summer (10.19 ± 1.74 $CaCO_3$ mg/l) while it was 12.9 ± 1.0 $CaCO_3$ mg/l in monsoon and 12.69 ± 1.9 $CaCO_3$ mg/l in winter. Insignificant seasonal variations ($P > 0.05$, $F_{3, 36}$ 2.243) were noted at JIR during study period. Differences in calcium hardness between both the study areas were significant ($P < 0.05$) in summer, significantly significant ($P < 0.001$) in monsoon and highly significant ($P < 0.0001$) during pre-winter and winter. The seasonal variations in *Magnesium Hardness* were highly significant ($P < 0.0001$, $F_{3, 98}$ 28.23) at SVP over the two years of study period with minimum in monsoon (40.44 ±3.37 $CaCO_3$ mg/l) and maximum during winter (81.30 ± 4.0 $CaCO_3$ mg/l) and 59.68 ± 2.66 $CaCO_3$ mg/l in pre- winter and 65.25 ± 2.44 $CaCO_3$ mg/l in summer. However, insignificant seasonal variations ($P > 0.05$, $F_{3, 36}$ 0.4295) were noted in magnesium hardness at JIR with maximum magnesium hardness during summer (44.38 ± 1.78 $CaCO_3$ mg/l) and minimum in monsoon (36.64 ± 2.26 $CaCO_3$ mg/l). In Pre-winter it was 37.84 ± 3.14 $CaCO_3$ mg/l and during winter 41.22 ±8.14 $CaCO_3$ mg/l. Highly significant ($P < 0.0001$) differences were noted during pre-winter, winter and summer and insignificant

(P > 0.05) differences during monsoon when magnesium hardness of the two water bodies were compared.

Inorganic non-metallic constituents (Fig.6.2)

Highly significant seasonal variations ($P < 0.0001$, $F_{3,\ 102}$ 3.69) were noted in *Dissolved Oxygen* content over the study period at SVP. Highest DO were noted during pre-winter (4.87 ± 0.88 mg/l) and lowest in summer (2.78 ± 0.24 mg/l) with 3.59 ± 0.55 mg/l in winter and 2.72 ± 0.30 mg/l in monsoon. At JIR significant seasonal variations ($P < 0.05$, $F_{3,\ 62}$ 2.97) were noted during the same period with low DO in summer (4.41 ± 0.62 mg/l) that increased in monsoon (5.76 ± 0.65 mg/l), and pre-winter 5.43 ± 0.62 mg/l and reached to highest level in winter (6.89 ± 0.6 mg/l). The difference in DO at both the water bodies was highly significant ($P < 0.0001$) during monsoon, winter and summer and insignificant ($P > 0.05$) in pre-winter. *Carbon dioxide* could not be detected in surface water during summer at SVP. However in monsoon it was 1.75 ± 0.85 mg/l, during pre-winter 9.53 ± 2.06 mg/l and winter 4.40 ± 1.37 mg/l. The seasonal variations were highly significant ($P < 0.0001$, $F_{3,\ 44}$ 10.04) over the study period. Whereas, at JIR the Carbon dioxide was detected only during monsoon with 2.35 ± 1.2 mg/l and was nil during rest of the year which amounted to significant seasonal variation ($P < 0.05$, $F_{3,\ 44}$ 3.44). The differences in amount of carbon dioxide between two water bodies were insignificant ($P > 0.05$) during monsoon.

At SVP *Chloride* contents were highest during summer (55.32 ± 4.11 mg/l) and lowest in pre-winter (24.91 ± 0.86 mg/l). In monsoon it was 43.47 ± 5.7 mg/l and in winter 36.64 ± 2.29 mg/l. The seasonal variations were highly significant

($P < 0.0001$, $F_{3, 105}$ 9.617) throughout the study period. At JIR chloride contents were low during pre-winter 15.25 ± 1.26 mg/l, and monsoon with 15.56 ± 1.05 mg/l, increased to 20.58 ± 0.01 mg/l during winter and reached to highest level 34.89 ± 6.5 mg/l in summer. The seasonal variations were highly significant ($P < 0.0001$, $F_{3, 73}$ 7.21) at JIR. When the chloride content at both the water bodies were compared highly significant ($P < 0.0001$) differences were noted during pre-winter, winter and monsoon while significantly significant ($P < 0.001$) in summer.

At SVP, *Nitrate* concentrations were minimum during winter 0.04 ± 0.009 mg/l and maximum during monsoon (0.16 ± 0.01 mg/l). During pre-winter it was 0.1 ± 0.005 mg/l and during summer 0.06 ± 0.009 mg/l with highly significant ($P < 0.0001$, $F_{3, 71}$ 14.93) seasonal variations. At JIR these variations were significantly significant ($P < 0.001$, $F_{3, 44}$ 5.26) with 0.1 ± 0.01 mg/l in summer, 0.1 ± 0.02 mg/l in monsoon, 0.1 ± 0.004 mg/l in pre-winter and 0.06 ± 0.009 mg/l in winter. Seasonal comparisons between the two water bodies were significantly significant ($P < 0.001$) during summer, whereas insignificant ($P > 0.05$) in pre-winter, winter and monsoon. The high values of *Nitrite* were noted during monsoon (0.052 ± 0.009 mg/l) and low in winter (0.01 ± 0.002 mg/l) with 0.02 ± 0.002 mg/l during pre-winter and 0.03 ± 0.004 mg/l in summer at SVP. At JIR also maximum values were noted in monsoon (0.07 ± 0.01 mg/l) and minimum during winter (0.01 ± 0.002 mg/l) with 0.02 ± 0.007 mg/l in pre-winter and 0.03 ± 0.007 mg/l during summer. Seasonal variations were highly significant ($P < 0.0001$, $F_{3, 89}$ 0.205 at SVP and $F_{3, 54}$ 10.64 at JIR) at both the water bodies during study period while seasonal comparisons between the two water bodies were insignificant ($P > 0.05$).

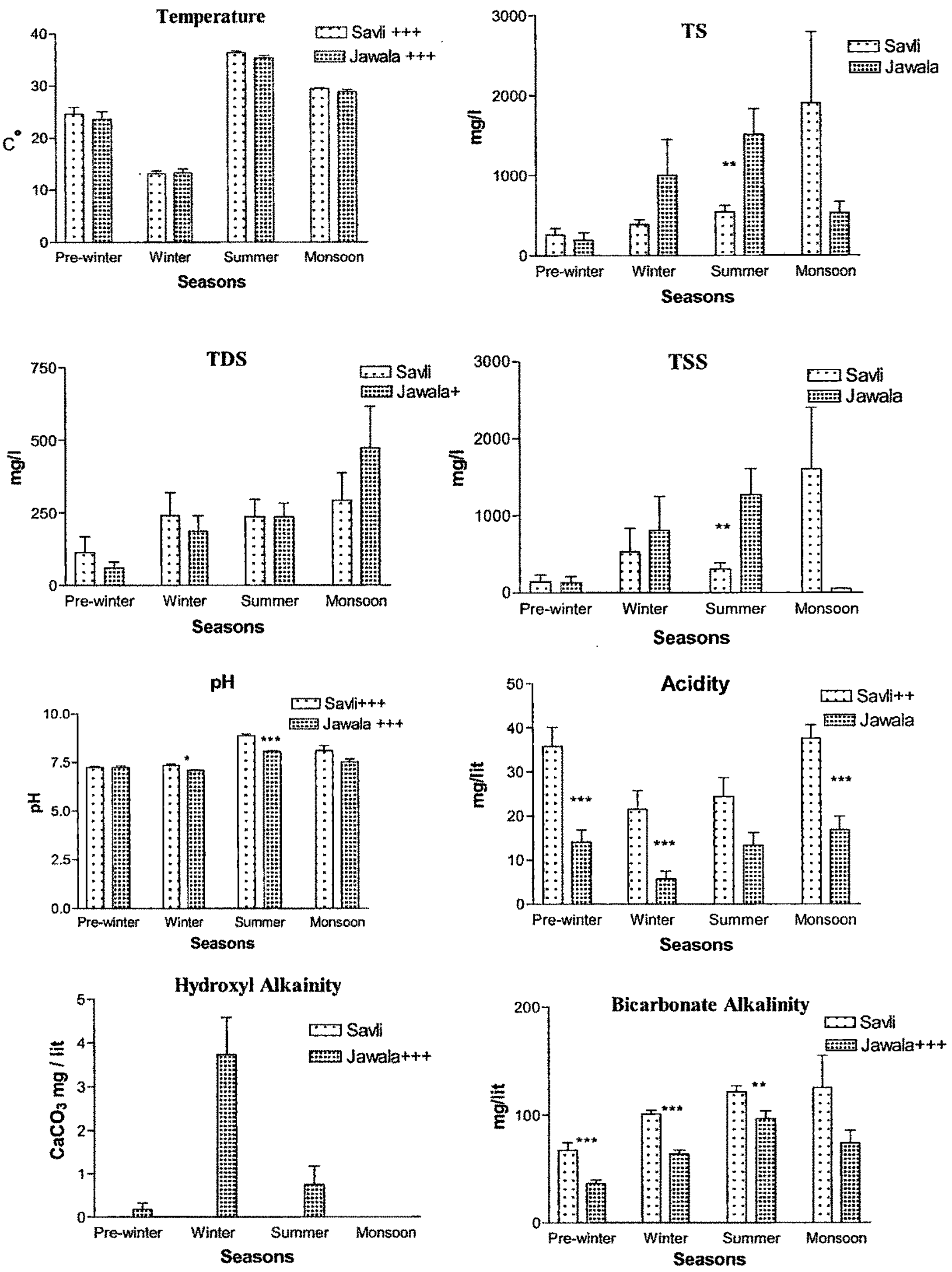
Phosphate concentrations were low at SVP during pre-winter (0.03 ± 0.004 mg/l) and (0.03 ± 0.005 mg/l) in winter, while high during summer (0.1 ± 0.01 mg/l) and in monsoon (0.1 ± 0.02 mg/l). At JIR, high phosphate concentrations were noted in monsoon (0.09 ± 0.02 mg/l) and summer (0.1 ± 0.02 mg/l) and low in pre-winter (0.04 ± 0.004 mg/l) and winter (0.03 ± 0.008 mg/l). Seasonally highly significant variations ($P < 0.0001$, $F_{3,\,98}$ 14.5 at SVP and $F_{3,\,62}$ 9.865 at JIR) were noted at both the water bodies. The Seasonal comparisons between two water bodies were insignificant ($P > 0.05$) during study period.

The intra correlations between various physicochemical parameters are given in Tables 6.1 and 6.2 for SVP and JIR respectively. At SVP, chloride and salinity are positively correlated at the level of 0.01 with bicarbonate alkalinity, nitrate and phosphate whereas negatively correlated with oxygen, magnesium hardness, carbondioxide and phosphate, nitrate positively with the chloride and salinity and carbondioxide are negatively with the total hardness; nitrite positively with temperature and negatively with bird density. Dissolved oxygen negatively with temperature and salinity; pH positively with total hardness and negatively with the carbondioxide; phosphate positively with chloride as well as salinity and temperature while negatively with calcium hardness, magnesium hardness and total hardness; total hardness positively with magnesium hardness, pH and negatively with nitrate; TDS positively with TSS; temperature positively with nitrite and negatively with bird density.

At JIR, when correlation between various parameters at the level of 0.01 is considered, calcium hardness was negatively correlated with bicarbonate alkalinity; chloride positively with total hardness; carbondioxide positively with hydroxyl alkalinity; hydroxyl alkalinity in addition with the bird density and pH; magnesium hardness positively with bicarbonate alkalinity; nitrite with temperature and total hardness; dissolved oxygen negatively with temperature; pH positively with bird density, hydroxyl alkalinity and temperature; phosphate positively with temperature and total hardness; salinity positively with bicarbonate alkalinity and total hardness; TDS negatively with bicarbonate alkalinity; temperature positively with nitrite, phosphate and total hardness and negatively with dissolved oxygen and pH; total hardness positively with bicarbonate alkalinity, chloride, nitrite, phosphate, salinity and temperature.

Fig 6.1 Seasonal comparisons of Physico-chemical parameters at Savli Pond (SVP) and Jawala Irrigation Reservoir (JIR).

Physical and other aggregate properties



***/ + P< 0.05, ** /++ P< 0.001, *** / +++ P < 0.0001**
***For T-test, + For ANNOVA .**

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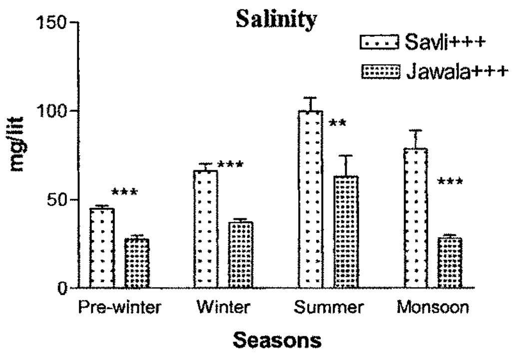
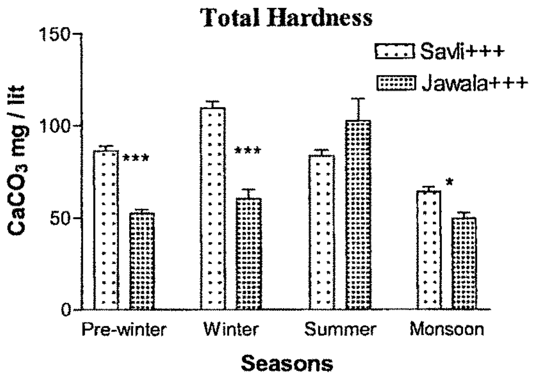
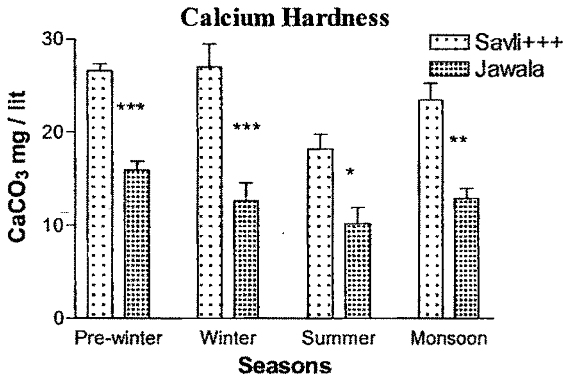
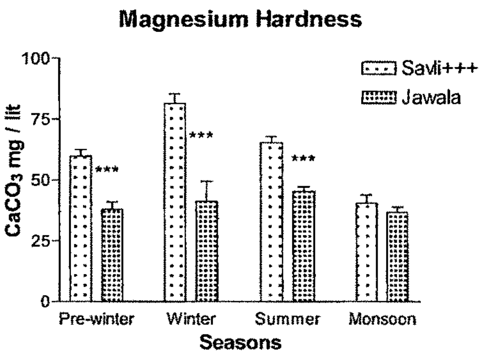




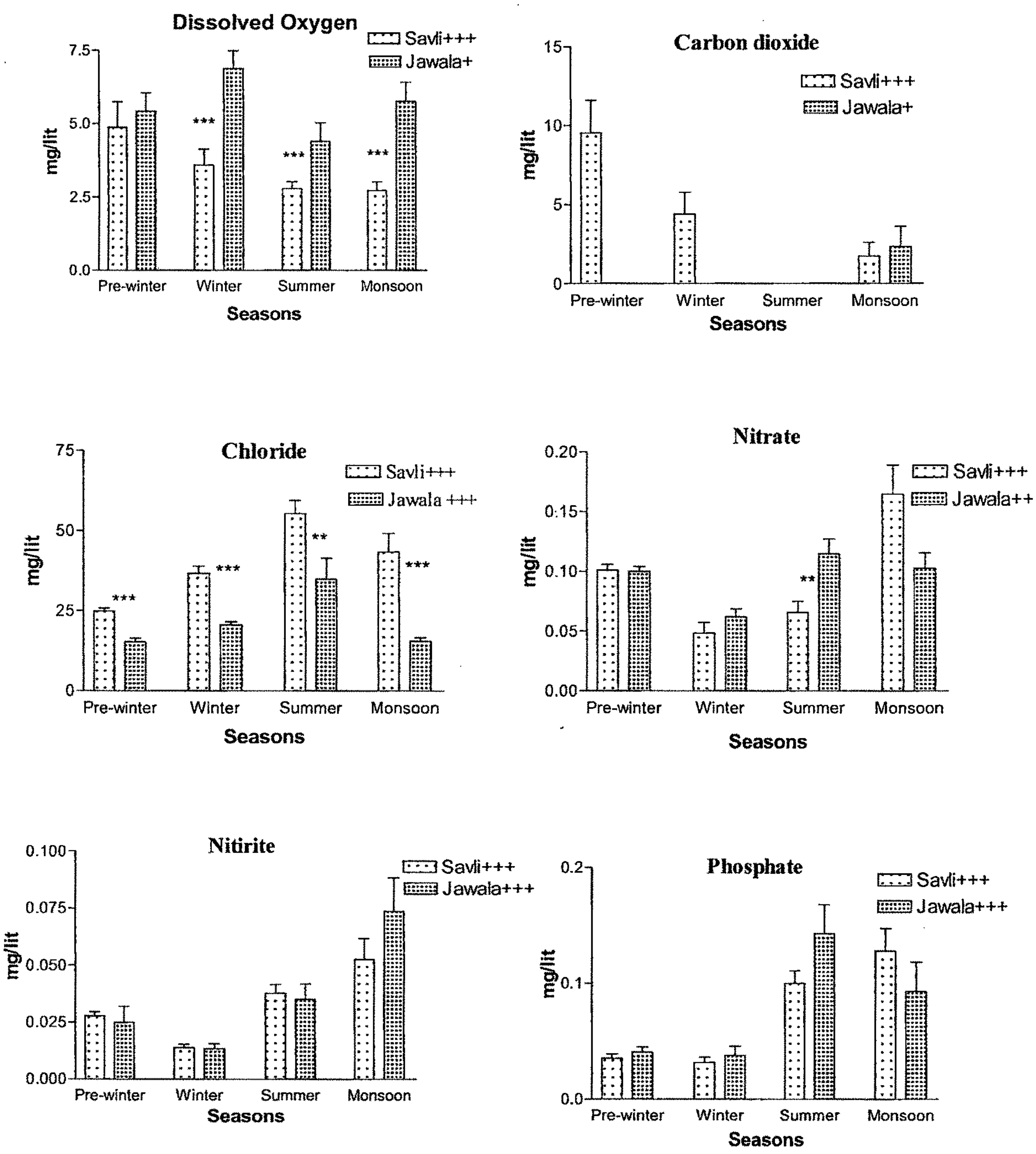




***/ + P< 0.05, ** /++ P< 0.001, *** / +++ P < 0.0001**
***For T-test, + For ANNOVA**

Fig 6.2 Seasonal comparisons of Phsico-chemical parameters at Savli Pond (SVP) and Jawala Irrigation Reservoir (JIR).

Inorganic non-metallic constituents



***/ + P< 0.05, ** /++ P< 0.001, *** / +++ P < 0.0001**
***For T-test, + For ANNOVA**

Table 6.1 Intra correlation between various physico-chemical parameters of Savli Village Pond (SVP)

Correlations

	ACIDITY	BICA.ALK	BIRDS	CA.HARD	CHLORIDE	CO2	HYD.ALK	MG.HARDN	NITRATE	NITRITE	OXYGEN	PH	PLANKTON	PO4	SALINITY	T.HARD	TDS	TEMP	TS	TSS
ACIDITY	1.000																			
BICA.ALK	-.103	1.000																		
BIRDS	-.103	.025	1.000																	
CA.HARD	.153	.028	.104	1.000																
CHLORID	-.055	.266**	.207	-.093	1.000															
CO2	.155	-.060	-.243	-.096	-.352*	1.000	.[a]													
HYD.ALK	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]													
MG.HAR	-.159	-.029	.074	-.074	-.083	-.403**	.[a]	1.000												
NITRATE	.273*	.102	-.294*	-.012	.334**	.590**	.[a]	-.166	1.000											
NITRITE	-.124	.098	-.373**	-.119	.171	.142	.[a]	-.033	.270*	1.000										
OXYGEN	.240*	-.192*	.311*	.159	-.267**	-.037	.[a]	.216*	-.100	-.102	1.000									
PH	-.187	.144	-.218	-.104	.177	-.419**	.[a]	.276*	-.013	.109	-.099	1.000								
PLANKT	.361	-.329	.258	-.015	-.044	-.161	.[a]	.155	-.022	-.598**	.217	-.242	1.000							
PO4	-.109	.197*	-.200	-.295**	.328**	-.006	.[a]	-.366**	-.091	.038	-.243*	.052	.100	1.00						
SALINITY	-.055	.266**	.207	-.093	1.000**	-.352*	.[a]	-.083	.334**	.171	-.267**	.177	-.044	.328**	1.000					
T.HARD	-.109	-.219*	-.013	.081	-.186	-.484**	.[a]	.504**	-.329**	.045	.239*	.421**	.112	.356**	-.186	1.000				
TDS	-.117	-.180	.062	.204	.074	-.109	.[a]	.084	-.217	-.102	-.052	-.129	.175	.065	.074	.118	1.000			
TEMP	.020	.210	-.444**	-.209	.221*	.157	.[a]	-.191	.175	.388**	-.297**	.309*	-.503**	.378**	.221*	-.080	-.297	1.000		
TS	-.029	-.157	.036	.043	.071	-.264	.[a]	.313	-.341	-.111	-.065	.144	.013	.200	.071	.284	.755**	-.258	1.00	
TSS	-.008	-.166	.027	.016	.073	-.279	.[a]	.340	-.349	-.109	-.062	.188	-.009	.227	.073	.301	.686**	-.248	.995**	.000

*.Correlation is significant at the 0.05 level (2-tailed).

**.Correlation is significant at the 0.01 level (2-tailed).

a.Cannot be computed because at least one of the variables is constant.

Table 6.2 Intra correlation between various physico-chemical parameters of Jawala Irrigation Reservoir (JIR).

Correlations

	CIDITY	BICA.AL	BIRDS	CAHARD	HLORIDE	CO2	YD.ALKA	GHARD	NITRATE	NITRITE	OXYGEN	PH	HOSPHAT	LANKTON	ALINITY	TDS	TEMP	OTALHAR	TS	TSS
ACIDITY	1.000																			
BICA.AL	-.014	1.000																		
BIRDS	-.290	.520*	1.000																	
CAHARD	.282	-.499*	-.356*	1.000																
CHLORID	-.012	.380*	.084	.138	1.000															
CO2	.195	.000	.[a]	.[a]	-.075	1.0														
HYD.ALKA	-.166	.010	.422*	-.238	-.081	466*	1.000													
MGHARD	-.212	.450*	.269	-.382*	-.293	.[a]	.234	1.000												
NITRATE	-.212	-.152	-.047	.254	.139	-.13	-.186	-.133	1.000											
NITRITE	.087	.315*	-.293	.115	-.009	-.08	-.112	-.179	.261	1.000										
OXYGEN	.110	-.194	.186	-.283	-.155	-.31*	-.033	-.163	.021	-.249	1.000									
PH	-.247	.237	.501*	-.112	.058	.[a]	.659*	.126	.319	-.040	.079	1.000								
PHOSPHA	-.094	.303*	-.148	-.051	.106	235	.142	.020	.115	.404*	-.081	-.153	1.000							
PLANKTO	.025	-.132	.280	-.191	-.073	.[a]	-.092	.278	.097	-.330	.492*	.052	.432	1.000						
SALINITY	-.012	.380*	.084	.138	1.000*	-.07	-.081	-.293	.139	-.009	-.155	.058	.106	-.073	1.000					
TDS	.212	-.629*	-.106	.145	.101	.[a]	-.350	-.515*	-.289	-.036	.490*	-.045	-.086	-.043	.101	1.000				
TEMP	-.074	.266*	-.394*	.230	.159	277*	-.236	.003	.289*	.440*	-.336*	-.530*	.475*	.309	.159	-.097	1.000			
TOTALHA	-.118	.359*	.084	-.028	.344*	099	.126	.124	.042	.448*	-.113	.198	.608*	-.084	.344*	-.425	.324*	1.000		
TS	-.037	-.483*	.202	-.022	-.268	.[a]	-.119	.160	.030	-.362	.227	.038	.041	.194	-.268	.339	.270	-.224	1.0	
TSS	.020	-.337	.035	-.534*	-.094	.[a]	-.183	.147	.079	.318	.401	.007	.094	.501*	-.094	-.066	.440	-.486*	084	1.000

**.Correlation is significant at the 0.01 level (2-tailed).

*.Correlation is significant at the 0.05 level (2-tailed).

[a] Cannot be computed because at least one of the variables is constant.

Discussions

Quality of water depends on its chemical, biological and physical properties. Various activities of man, depending on the urban development, also affects the quality of water (Khan and Ansari 2005). In other words the human settlement at various stages of urbanization has created a new hydrological regime. Thus, the quality of water depends on its resources like the natural physico-chemical characteristics of the catchments areas as well as anthropogenic discharges (Efe *et al.*, 2005). Such change in quality of water directly or indirectly affected the fauna and flora of a particular water body. pH, Dissolved oxygen, Temperature and Salinity are the factors that affect the quality of water (Anonymous, 2000).

Temperature: Most of the organisms can not tolerate very high or very low temperature of the water. In the present study the seasonal trend in temperature of water follows the trend in ambient temperature with high water temperature noted during summer at both the water bodies. The ambient temperature in hot semi arid climate of India where the two water bodies studied were located, reached above 40°C in summer. However, the temperature of water in the water body that is under the influence of urban conditions (SVP) is higher compared to the irrigation reservoir located some distance away from the urban conditions. Similar observations are reported by Deshkar (2008). However, Deshkar (2008) reported higher temperature in water during monsoon rather than summer. The higher summer temperature is evinced by the algal growth observed in the water at high temperature in summer at SVP. The most favourable temperature for algal growth was reported to be around 30° C (Shen, 2002; Khan and Ansari, 2005). Though the water temperature is high at JIR during summer, it totally dried up in late summer and hence, no algal growth is observed. Among the two water bodies, temperature is always higher at SVP. Though direct discharge of sewage and drainage water is not observed at SVP, cattle were tied on the road side from where cattle shed runoff into water is evident. In addition SVP water is also used for domestic purpose that further adds organic and inorganic nutrient to the water body. These organic and inorganic inputs influenced microbial growth and in turn increase the temperature because of the decomposition. The sewage and drainage discharge has been reported to change the temperature and pH in rain fed freshwater ponds in South India (Francis *et al.*, 1997). The difference in the water temperature over the seasons in both the ponds were highly significant and between the two ponds were insignificant.

Total Solids (TS) and *Total Suspended Solids (TSS):* SVP received direct runoff from the agricultural fields due to soil erosion and also from soil covered concrete jungle of Savli Town resulting in high TS and TSS as compared to JIR during monsoon. Around JIR a scrub land is present in the catchments area preventing soil erosion to some extent during monsoon. Different situations were observed during winter and summer where TS and TSS were higher at JIR. During prewinter the solids starts settling down. However, during winter and summer because of the wallowing of the cattle the water got agitated and the solids content were disturbed increasing their level in water. Further the water level also declined during summer; hence the solid content is high. Similar situation is also noted at SVP but to a lesser extent. According to Rytwo and Gonen (2005), solids enter in water from natural (soil and bedrock erosion) or anthropogenic sources (domestic wastes, road runoff, industrial processes and so on). TSS is important in the analysis of waste water and often used to measure the level of pollution (Rytwo and Gonen, 2005). As per Indian Standard specification for drinking water IS: 10500, value of TSS 100 mg/l is the permissible limit for drinking water. Therefore with these values of TSS, the water of both the water bodies is unsuitable for drinking purpose.

Total solids also contain *Total Dissolved Solids (TDS)*: According to Indian standard specification for drinking water IS: 10500 the maximum permissible value for TDS is 500 mg/l. TDS is high at both the water bodies studied during monsoon but it is higher at JIR as compared to SVP. JIR received runoff water from natural sources like soil and bedrock erosion or agricultural field where as SVP received water from anthropogenic sources like domestic waste, road runoff, industrial process and urban runoff from structures like streets, parking lots and buildings that covered the soil and did not allowed rain water to soak in to the ground. Under such urban conditions rain water that ran over covered surfaces washed pollutants as well as soils from open spaces into the ponds. (Rytwo and Gonen 2005). Man made ponds like irrigation reservoir collected and filtered rain water before it could reach a larger water body as is noted at JIR.

pH measures the concentration of H^+. pH is important for chemical reactions as well as microorganisms, while total acidity is the reactive hydrogen that includes the bound hydrogen too and it influences the taste. In the present study the pH ranged from 7.23 ± 0.06 to 8.88 ± 0.086 at SVP and 7.1 ± 0.046 to 8.1 ± 0.042 at JIR. Thus water in both the ponds had mild basic pH. This is in accordance to the basic pH maintained at other water bodies in semiarid zone of Central

Gujarat (Deshkar, 2008). pH is an important limiting factor for plant-growth in aquatic environment. The change in pH is directly related to the availability and absorption of nutrients by plants from water. The acidic pH accelerated absorption of phosphate (Devlin and Witham, 1986), an important nutrient for plant growth resulting in the growth of phytoplankton and result in algal bloom (George and Heaney 1978). No conspicuous algal bloom was observed at both the water bodies.

High *acidity* is noted at SVP as compared to JIR which could be due to input of organic matter with cattle shed runoff and various anthropogenic activities around SVP especially during monsoon and pre-winter when highly significant differences between the two water bodies were noted. These differences were insignificant during summer when the water level declined. *Hydroxyl alkalinity* is zero at SVP all throughout the present study period while at JIR it ranged between 0.0 mg $CaCO_3$ mg/l to 3.72 ± 0.85 $CaCO_3$ mg/l. It was difficult to correlate alkalinity to a single parameter (Rytwo and Gonen, 2005). However, bicarbonate alkalinity is high at SVP as compared to JIR. Untreated domestic waters usually had alkalinity between 50 and 200 mg/l (Rodjevic and Bashkin, 1999) this might be due to the anthropogenic inputs. Ammonia (Strong base) and weak organic acids have been reported to contribute to alkalinity (Manahan, 2000). Alkalinity was not considered to be a water pollutant and its main environmental significance was an indicator for the susceptibility of the water to pH changes as a result of pollution (Rytwo and Gonen, 2005). The range of *Bicarbonate Alkalinity* was between 67.54 ± 6.991 $CaCO_3$ mg/l to 125.30 ±

29.880 $CaCO_3$ mg/l at both the water bodies that falls in typical fresh water alkalinity range of 20 to 200 mg/l as indicated by Rytwo and Gonen (2005).

Salinity is the mass of dissolved salts in a sample of water. Salts could come from organic material such as leaves, silt, plankton, sewage or from inorganic materials such as rocks (Anonymous, 2000). Certain amounts of salts are necessary for aquatic life. Changes in the amount of dissolved salts could be harmful to organisms as they were adapted to life within a range of salinity. Changes in salinity result due to variations in evaporations as well as fresh water flow. These changes could be natural and occur seasonally or they result from human influence, such as increasing freshwater flow, discharge from power plants or diverting freshwater for drinking and irrigation of fields (Anonymous 2000). Salinity is calculated on the basis of chlorides. During summer it is high at both the water bodies. Salinity is always high at SVP as compared to JIR due to the difference in amount of the organic matter such as cattle shed run off and garbage thrown by human being. JIR received only rain water which dries off during summer hence lower salinity compared to SVP. At JIR there was minimum input of leaves as well as sewage into the pond. The two water bodies being located in semi-arid zone, the seasonal climatic fluctuations were pronounced with high temperature during summer and low during winter. Fresh water input in the form of rains loaded with runoff of organic material was high during monsoon and weather was moderate during pre-winter. The difference between two water bodies were highly significant ($P < 0.0001$) during monsoon when fresh water get mixed. As these water bodies faced similar natural environmental changes, the highly significant and significantly significant differences could be attributed to the difference in the anthropogenic pressures as the monsoon gets over.

Total hardness is the sum of calcium hardness and magnesium hardness. According to Indian Standard Specification for drinking water IS: 10500 (www. Indiawater portal.org/blog/wp-content/uploads/2008/07/is-10500.pdf) desirable limit for total hardness is 300 mg/lit. The total hardness at SVP ranged from minimum 63.89 ± 10.31 $CaCO_3$ mg/l in monsoon to maximum109.4 ± 3.84 $CaCO_3$ mg/l during winter (Fig 6.1). However, at JIR the total hardness ranged from 49.56 ± 2.8 $CaCO_3$ mg/l in monsoon to 102.4 ± 12.09 $CaCO_3$ mg/l during summer. This is rainfed reservoir and has less human disturbances. Between the two water bodies the insignificant differences ($P > 0.05$) were noted during summer could be due to higher evaporation of water from irrigation reservoir with low vegetation resulting in concentration of salts. While significant differences ($P < 0.05$) in monsoon could be due to mixing of fresh water and highly significant differences ($P < 0.0001$) during pre-winter and winter, attributed to the similar influence of climatic changes on one side and difference in the anthropogenic pressures on other side. Total hardness is recorded high at SVP as compared to JIR during this study period. The addition of salts from the concrete covered urban structure at SVP and scrub covered land at JIR should not be ignored. Further, calcium and magnesium hardness were also always higher at SVP. Anthropogenic pressures were probably adding hardness to the water.

Inorganic non-metallic constituents:

The presence of *Dissolved Oxygen* in lakes and rivers is important as most aquatic plants and animals need dissolved oxygen for their survival. Therefore, in present study, it is one important component for assessing the quality of water. The high level of oxygen during all seasons at JIR as compared to SVP indicated the quality of water better at JIR. At SVP the waste discharge in the form of organic matter and nutrients were high. As reported by Rytwo and Gonen (2005), this resulted to decline in DO concentration due to increased microbial respiration that occurred during the degradation of the organic matter. According to Happey (1970), algal production is involved in maintaining high levels of oxygen in the surface layers and frequently influences entire epilimnion. The oxygen content of water is known to vary with temperature, salinity, turbulence, the photosynthetic activity of plants, and the atmospheric pressure (Anonymous, 2000; Rytwo and Gonen 2005 and Khan and Ansari, 2005). In present study, the level of dissolved oxygen is low at both the water bodies in summer when temperature and salinity were high. A gradual decrease is noted in DO from pre-winter through winter and summer to monsoon at SVP. This indicated maximum photosynthetic activity during pre-winter when monsoon got over. This was the time when water became dilute and there was minimum direct dependency by man on the pond. The agitation of water due to input was over, turbulence was low as TSS had settled down increasing light penetration in water from pre-winter to winter. As JIR is monsoon dependent the vegetation probably grows to full extent by winter and hence maximum photosynthetic activity took place in winter. At JIR, a different trend *i.e.* with increased salinity increase in oxygen levels was observed. The main human factor causing change in dissolved oxygen levels to negativity was build up of organic wastes coming from the grass clippings, leaves, dead plants, animals and sewage. When organic wastes were dumped in to water bodies it caused decrease in dissolved oxygen that resulted in death of plants and animals (Anonymous, 2000). The direct relationship between phytoplankton and dissolved oxygen content has been reported by a number of researchers (Lean,1973; Misra *et al.*, 1975; Saad, 1973; Schindler, 1971).

Absence of *Carbon dioxide* in JIR surface water during pre-winter, winter and summer could be attributed to the wee hours when the sample was collected and the region of pond where vegetation was low (Deshkar, 2008). At SVP it is maximum in pre-winter and minimum during monsoon. The amount of free carbon dioxide, carbon trioxide and bicarbonate were governed by the change occurring in the pH of the pond (Kant and Raina, 1990). The high values of *chloride* in SVP water as compared to JIR during study period could be attributed to the input through sewage or cattle shed runoff. *Nitrate* an essential nutrient for synthetic autotrophs, occurred in smaller amounts in surface waters. It was identified as one of the growth limiting nutrient. Nitrate occurred only in small amounts in fresh domestic wastewater (APHA, 1989). Higher concentrations of nitrate were reported in water in close contact with human or animal waste, especially in the cow manure drainage and the sewage reservoir, and to lesser extent at the henhouse puddles and recreational ponds (Rytwo and Gonen 2005). Similar results were observed in the present study where higher concentrations of nitrate are found at SVP as compared to JIR. This is attributed to animal waste, especially in the form of cow dung runoff from cattle tied all along the narrow road running on western side of the pond as well as human activities. Further, in lakes and ponds, concentrations of nitrate in excess of 1.0 mg/l stimulated algal growth and indicated possible eutrophic conditions (Rytwo and Gonen, 2005). During pre-winter growth of algae and aquatic vegetation were observed at SVP whereas it was observed during monsoon and winter at JIR. The highest *Nitrite* concentrations found during monsoon at both the study areas might be because of release of nitrogen from the sediments on the arrival of fresh water in monsoon. Minimum concentration was noted during winter at both the places. This was the period when cattle, mainly bullocks, were taken to agriculture field for ploughing and hence runoff from cattle shed was low and with minimum leaching from soil. In addition, it might also be because of utilization of nitrogen by plants for growth during moderate winter of subtropical zone. High nitrite concentrations (higher than 1.0 mg/l) were generally indicative of flow of industrial effluents and were often associated with contaminated water (Rytwo and Gonen, 2005). In all samples collected from both the study areas, concentration of nitrates and nitrites were below these levels. This indicated that there is no possibility of eutrophication in the water at JIR in near future however if anthropogenic pressures are permitted to grow and care is not taken eutrophication may result at SVP.

Phosphorus occurs in natural waters and in wastewaters almost solely as *phosphates*. The phosphorus is known to enter the water in two ways the natural phosphorus cycle originating from weathering of phosphate rocks and the sewage from the house hold discharge (anthropogenic sources). Larger quantities of phosphates are added when the water is used for laundering or other cleaning, as it is a major constituent of many commercial cleaning preparations (APHA, 1989). Phosphorus concentration in clean water is generally very low (Khan and Ansari, 2005). Phosphorus has been identified as one of the limiting nutrient to phytoplankton development (Khan and Ansari, 2005). However, when present in too greater quantity in surface water, phosphate has been also associated with the excessive growth of algae (Lean, 1973; Ambasht and Ambasht, 1992). High amount of phosphate was noted during monsoon at SVP and during summer at JIR. This could be due to the perennial and annual nature of the respective water bodies. Phosphate was often the limiting compound in eutrophication of freshwater, as nitrogen was in marine waters (Aydemir *et al.,* 2005). During this study period eutrophication was observed during summer and monsoon at certain points of both the ponds. Large amounts of phosphate reaching surface waters often results in great increase in the growth of algae and the reduction of other life forms in these waters (Sims, 1998). The main source for phosphorus in the environment is agricultural drainage, and detergents containing phosphorus (Radojevic and Bashkin, 1999, Boehnke and Delumyea, 2000). As noted earlier at SVP where washing clothes is a regular practice addition of high amount of phosphates occurred as compared to JIR in all seasons except summer.

These nutrients resulted in the extensive growth of aquatic flora. Eutropication is a kind of nutrient enrichment process of any aquatic body which resulted in excessive growth of vegetation. This undesirable overgrowth of aquatic plants and their subsequent death form a slime layer over the surface of the water body, which reduces light penetration and restricts reoxygenation of water through air current (Khan and Ansari, 2005). Greenish layer of algae was observed during monsoon and winter at some patches of SVP but was not found at JIR. The death and decay of aquatic plants produces a fowl smells and renders the water more turbid (Beeby, 1995).

Correlation of physico- chemical parameters:

A positive correlation between Bicarbonate alkalinity and Chloride including salinity was also noted at both the water bodies as was also reported by Deshkar (2008) in other water bodies in semiarid zone of central Gujarat. Similarly a significant positive correlation was also noted between temperature and nitrite and between alkalinity and phosphate. However, in Deshkar's studies these relations were insignificant whereas in the present study, they are highly significant. Further, a negative correlation is noted in temperature and oxygen, with increase in temperature, water known to loose dissolved oxygen. According to Constantinescu (2007), temperature influenced the DO concentration maximum and the activity of all in stream organisms. A highly significant co-relation between temperature and pH is also noted in present study. This indicated that water bodies under urban influence probably showed negative correlation between temperature and pH. As said earlier SVP is receiving cowshed runoff which is not that prominent at JIR. However, at JIR village cattle were taken to the catchment areas for grazing, which added cow dung into the reservoir.

As these studies were based on variations in the density and diversity of birds over the season, an attempt is also made to correlate birds with various physico-chemical parameters. However, bird density is correlated only with temperature.

On one hand there is pronounced fluctuation in the ambient temperature of the semiarid zone of the Central Gujarat and on the other hand the migratory birds returned to their breeding grounds.

CONCLUSION:

Physico-chemical parameters were the indicators of the quality of water. From the variations over the seasons and differences in between the two water bodies it showed that though SVP is under anthropogenic pressure its condition had not totally deteriorated. Among the two water bodies, SVP located adjacent to a developing town is under anthropogenic pressures. This should be properly managed and developed thus producing a healthy ecosystem.