A Comparative Study of Water Quality of a Suburban Pond and an Irrigation Reservoir in Savli Taluka of Vadodara District, Central Gujarat, India

Rathod Jagruti, Geeta Padate and Deshkar Sonal

Department of Zoology, Faculty of Science, The M. S. University of Baroda, Vadodara 390002
e-mail : rathod21@gmail.com, geetapadate@gmail.com, sdeshkar.101@gmail.com

ABSTRACT

The seasonal changes in the environment are known to change the quality of water bodies, especially in the semiarid zone where seasonal changes are pronounced. In addition, the influence of human utilization or dependency can not be ignored. Urban development adds various organic and inorganic components to water influencing the physical and chemical properties of water.

Present study attempts to relate direct or indirect influences of urbanization as well as seasonal changes on the quality of water. To find out the influence of urbanization on water qualities, annual changes in physicho-chemical parameters of water from Savli pond (22° 33' 37 N and 73° 13' 27 E) under pressure of urbanization are compared with water from Jawala Irrigation reservoir (22º 33' 30 N and 73º 14' 24 E). Savli is a fast developing town in Vadodara district whereas at Jawala, just one kilometer away, an irrigation reservoir is present. The seasonal changes in physico-chemical parameters of Savli pond are compared with seasonal changes in the quality of water at a small irrigation reservoir, Jawala. The two water bodies are exposed to similar climatic conditions. Savli pond is perennial, whereas Jawala reservoir dries up during summer. Water was collected from both the water bodies fortnightly over a period of two years. A comparative study of the seasonal changes in the physicho-chemical parameter was carried out for the two water bodies. The data for seasonal variation is analyzed with the help of ANOVA and for comparison of two water bodies with the help of t-test. Majority of parameters are higher at Savli – the pond under urban pressures whereas the seasonal changes are pronounced at the Jawala Irrigation Reserviour. The positive and negative impacts of urbanization on quality of water and seasonal changes at both the water bodies are discussed.

INTRODUCTION

Ponds exhibit a range of ecological, social and aesthetic values (Gledhill *et al.*, 2004). The dependency of modern man on the water has increased in urban conditions, resulting in production of huge quantity of waste water or deteriorating the conditions of existing water bodies. Urbanization is known to influence the quality of water directly or indirectly, by polluting or draining it. Quality of the 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. It depends on the physical and chemical properties (Aydemir *et al.*, 2005). The properties of freshwater body are 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 sources can not be ignored. Human development adds various organic and inorganic components to water influencing the physical and chemical properties of water. High amount of nutrients are also unloaded into water bodies from human settlements via sewage (Khan and Ansari 2005). The seasonal changes in the environment with addition of human pressures are known to change the quality of water bodies, especially in the semiarid zone where seasonal changes are pronounced (Deshkar, 2008). In the present study physicho-chemical parameters of water from two different water bodies subjected to similar climatic conditions but different anthropogenic pressures were studied to find out effect of expanding urban population. Of these two water bodies, one is suburban pond; Savli Village Pond (SVP), near a developing town Savli and the second is an undisturbed reservoir Jawala Irrigation Reservoir (JIR) present in the same region in the out skirts of Savli Town.

STUDY AREA

Savli (22° 33' 37' N and 73° 13' 27' E) is a developing town in Vadodara district of central Gujarat. It has a pond which is under enormous pressure of urbanization. The water from the pond is used for domestic purpose like washing the clothes and utensils, bathing, *etc.* It is a perennial pond that spreads in approximately 0.34 Km2 areas. A kilometer south east of Savli pond, JIR (22º 33' 30 N and 73º 14' 24 E) is located outside Jawala village (now a suburb of Savli Town). At JIR monsoon water is stored for irrigation purpose. The reservoir spreads in approximately 0.78 Km2. It is surrounded by agricultural fields and dries up totally in summer. Both the water bodies face same climatic conditions of temperature, rains, wind, *etc.* The distance between the two water bodies is about 1.5 kilometers with distance between northern most point of SVP and Southern most point of JIR about 3.5 kilometers (Fig 1).

MATERIALS AND METHODS

Both the study areas were visited twice in a month from July 2005 to August 2007 in the morning, within 2 hours form sunrise. Water was collected in the plastic bottles and brought to the laboratory to estimates different physicho-chemical parameters. The Physical and other aggregate properties that included Temperature, Total Solids (TS), Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) present in water, pH, Acidity, Alkalinity- Bicarbonate (HCO_3-) and Hydroxyl (OH-), Salinity, Total Hardness - Calcium and Magnesium were estimated. Temperature, pH and Carbon dioxide in

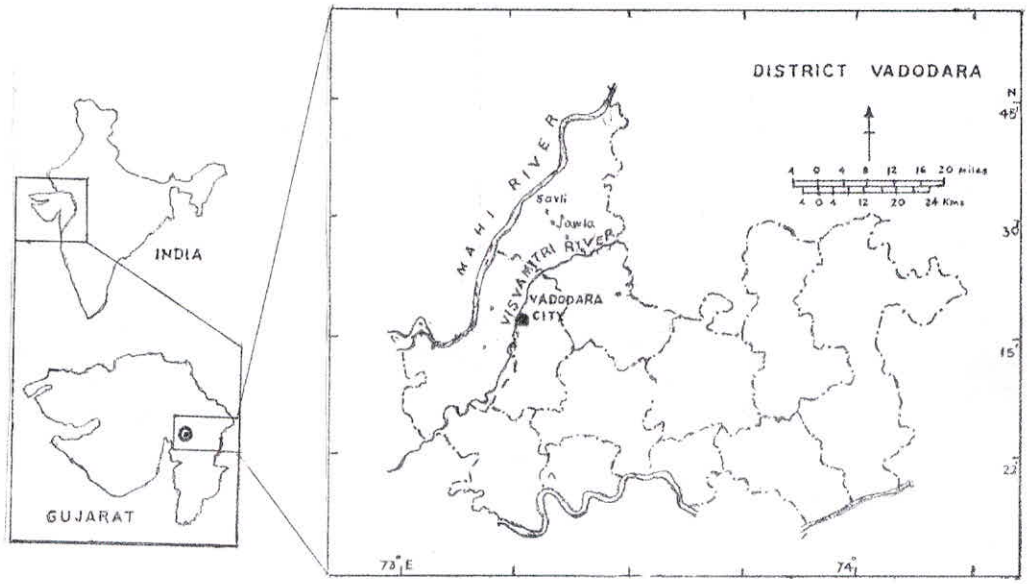

Fig. 1 : Location of Savli and Jawala pond in Vadodara District of Gujarat state in India

water were measured at the collection center itself. pH was measured by using electronic pH meter (pH Scan Eutech Instruments). The data collected were pooled for four seasons *i.e.* monsoon (June to August), pre-winter (September to November), winter (December to February) and summer (March to May). Total 12 visits were made per season, amounting to 48 visits per site. All physicho-chemical parameters were analyzed by using standard methods described in APHA (1989). The seasonal variations at each water bodies were analyzed using ANOVA while the data collected for two study areas were compared using t-test (Graph Pad Prism 3 and Excel).

RESULTS AND DISCUSSIONS

Quality of water depends on chemical, biological and physical properties of water. Various human activities, depending on the stage of development around the water body affect the quality of water. The human settlements at various stages of urbanization create new hydrological environments. Thus, the quality of a water resource depends on the anthropogenic discharges as well as the natural physico-chemical characteristics of the catchments areas (Efe *et al.*, 2005). *Temperature*: it is known to influence certain physico-chemical components of water. The seasonal variations in water temperature were highly significant ($P < 0.0001$) across the seasons at Savli Village Pond (SVP) ($F_{3, 57}$ 27.77) as well as at Jawala Irrigation Reservoir (JIR) ($F_{3, 65}$ 87.65). However, when water temperature of SVP and JIR were compared, the differences were insignificant ($P>0.05$) during all the seasons (Fig 2a & b). Most of the organisms are unable to

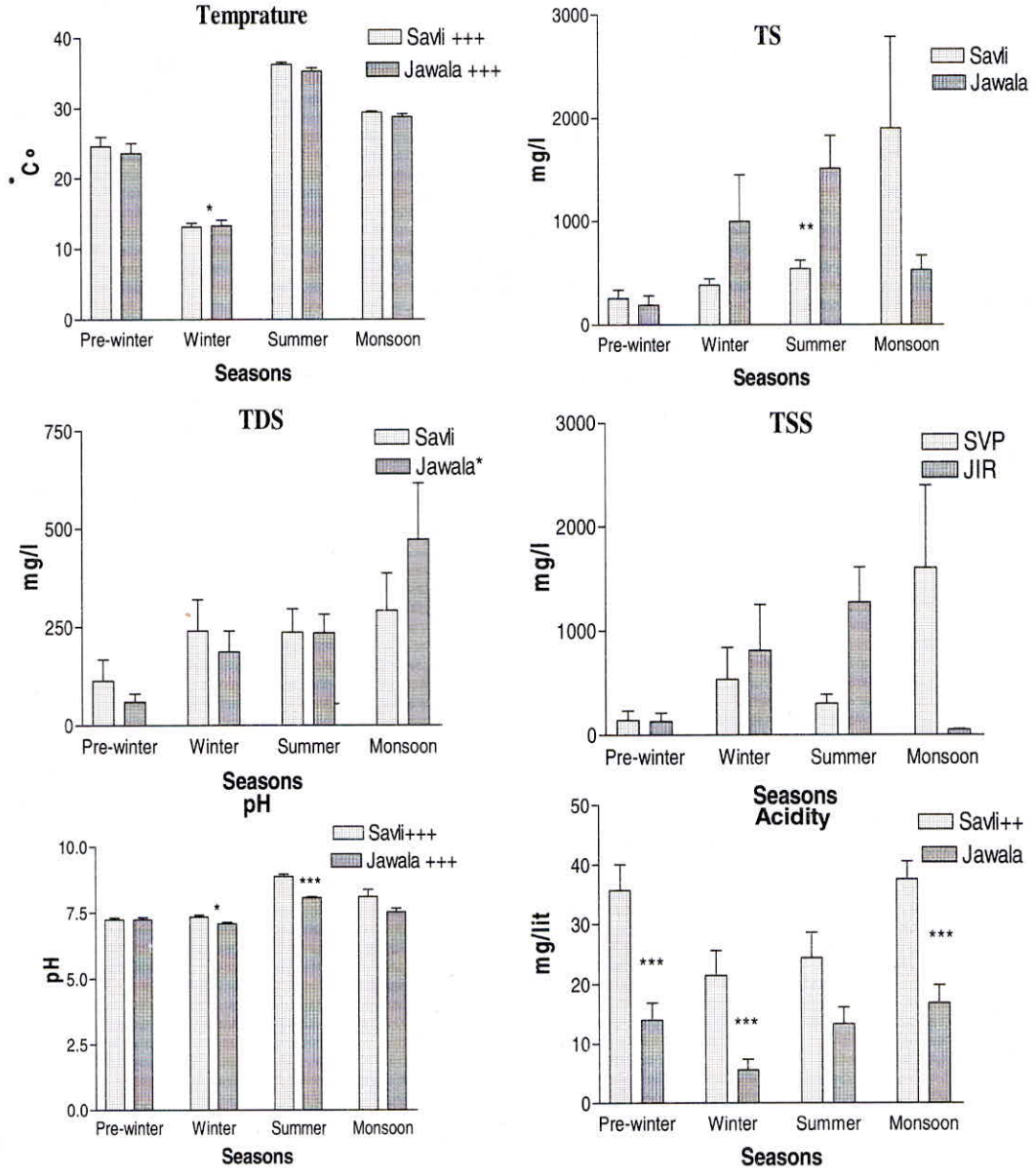

Fig. 2a : Seasonal comparisons of Phsicho-chemical parameters at Savli VillagPond (SVP) and Jawala Irrigation Reservoir (JIR)

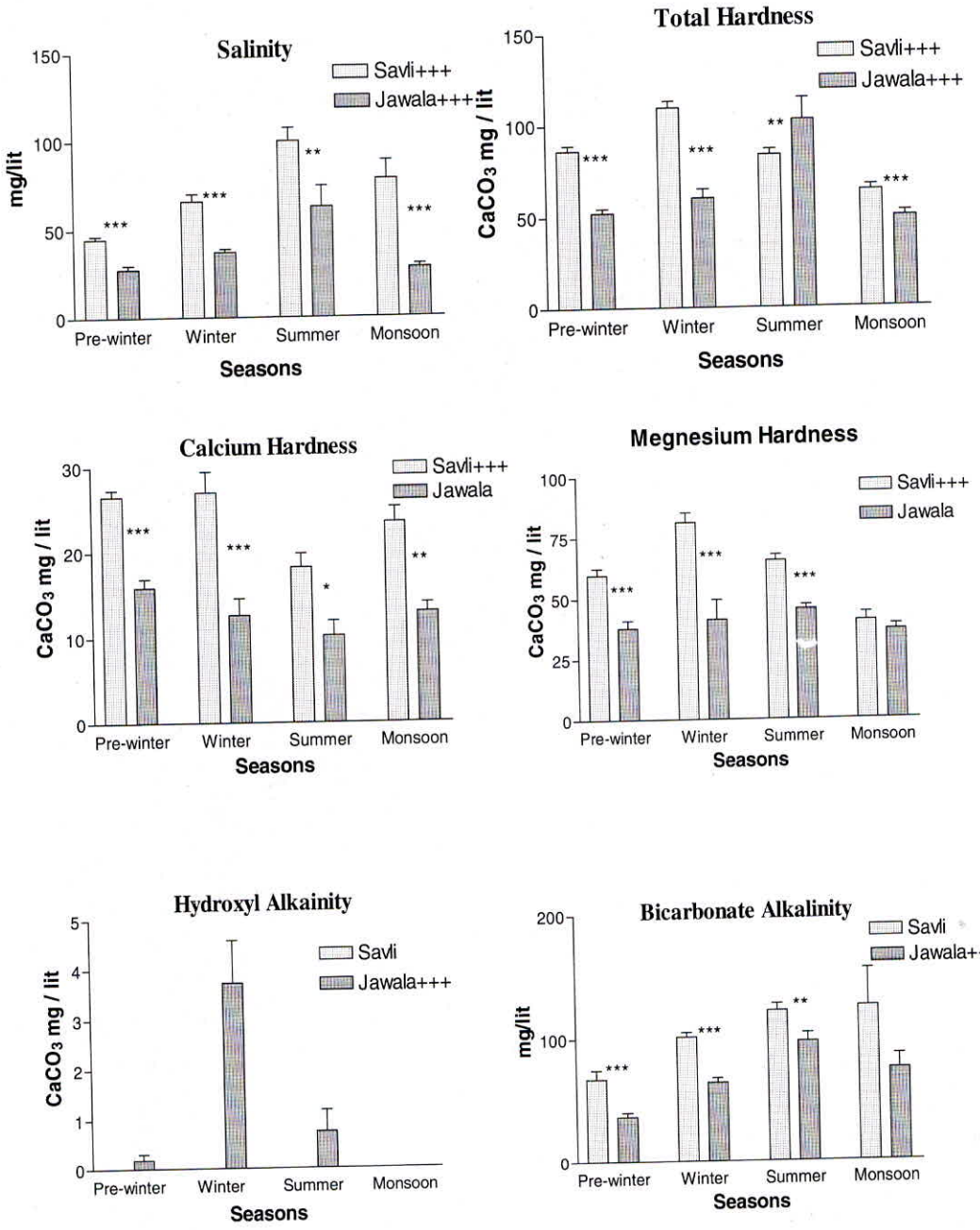

Fig. 2b : Seasonal comparisons of Phsicho-chemical parameters at Savli VillagPond (SVP) and Jawala Irrigation Reservoir (JIR)

tolerate very high or very cold temperature of water. In the present study the seasonal trend in temperature of water followed the trend in ambient temperature. High temperature was noted during summer at both the sites. The ambient temperature in hot semi arid climate of India fluctuates above 40°C in summer. In present study the temperature of water in the water body that is under the influence of urban conditions (SVP) was higher compared to the irrigation reservoir located some distance away from the urban conditions as is also reported by Deshkar (2008). However, Deshkar (2008) reported higher temperature of water during monsoon rather than summer. The difference between the two studies could be due to the difference in the location of study cites with respect to the stage of development around the water body. Present study was carried out in suburban conditions whereas Deshkar's one water body is located in city limits and other just out side Vadodara city, one of the largest town of Gujarat. Temperature is one of the important factors for the growth of plant as well as the planktons. This is evinced by the algal growth observed in water at high temperature in summer at SVP. The most favourable temperature for algal growth was 30º C (Khan and Ansari, 2005; Shen, 2002). Though the water temperature is high at JIR during summer, it totally dries up in late summer and hence, no algal growth is observed over here. Among the two water bodies SVP the pond under the influence of urban conditions always had higher temperature. Though direct discharge of sewage and drainage water is not observed at SVP, cattle are tied on road side from where cattle shed runoff to water is prominent. In addition SVP water is also used for domestic purpose that further adds organic nutrient to water body. This can influence microbial growth as well as increase in temperature. This water is used for domestic purpose adding additional organic nutrients. 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.*, 1977). The differences over the seasons as well as between two ponds are insignificant ($P>0.05$) (Fig 2a & b).

Total Solids (TS) and Total Suspended Solids (TSS)

The seasonal variations in TS are insignificant at both the water bodies with $P>0.05$ at SVP ($F_{3, 25}$ 2.304) and at JIR ($F_{3, 14}$ 2.430). With reference to TSS also seasonally insignificant differences ($P>0.05$, $F_{3, 25}$ 1.954 at SVP and at JIR $F_{3, 14}$ 2.410) were noted at both the places.

When SVP and JIR compared significantly significant ($P<0.001$) difference was noted in the values of TS during summer and insignificant ($P>0.05$) in pre-winter, winter and monsoon. The TSS values of SVP and JIR also were noted significantly significant difference ($P<0.001$) during summer and insignificant ($P>0.05$) in pre-winter, winter and monsoon (Fig 2). TS and TSS were high at SVP compared to JIR during monsoon as SVP receives direct runoff from the agricultural fields due to soil erosion and also from soil covered concrete jungle of Savli Town. Around JIR a scrub land is present in the catchments area preventing soil erosion to some extent during monsoon.

Opposite condition is observed during winter and summer where TS and TSS are higher at JIR. As the summer approaches water level declines at JIR and wallowing by cattle in the shallow water is common disturbing the solids which had settled down during pre-winter. Similar situation is also noted at SVP but to a lesser extent. According to Rytwo and Gonen (2005) solids in water may be 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 is often used to measure the amount of pollution (Rytwo and Gonen, 2005). As per these values of TSS, the water of both the places is not suitable for drinking purpose.

Total Dissolved Solids (TDS)

Seasonal variations in TDS were insignificant ($P>0.05$, $F_{3, 25}$ 0.4984) at SVP and significant ($P<0.05$, $F_{3, 14}$ 5.455) at JIR. However when SVP and JIR were compared the insignificant ($P>0.05$) seasonal variations were noted during each seasons (Fig 2). According to Indian standard specification for drinking water IS: 10500 the maximum permissible value for TDS is 500 mg/l. Wallowing of cattle, especially buffaloes, as they have black skins, is a common practice in the summer of semiarid zone in central Gujarat. TDS was high at both the water bodies during monsoon but it was higher at JIR during same period. JIR receives runoff water from natural sources like soil and bedrock erosion where as SVP receives water from anthropogenic sources like domestic waste, road runoff, industrial process and urban runoff from structures like streets, parking lots and building that cover the soil and do not allow rain water to soak in to the ground. Under such conditions rain water runs over this covered surface, washes pollutants as well as soils from open spaces in to ponds, lakes, rivers and seas Rytwo and Gonen (2005). Man made ponds like irrigation water bodies can collect and filter rain water before it can reach a larger body of water that can be noted at JIR.

pH

Measures the concentration of H+ and it is important to chemical reactions and microorganisms while total acidity is the reactive hydrogen that also includes the bound hydrogen and it matters for the taste. 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 (Fig 2). Both the ponds have basic pH values. The maximum pH was noted at SVP in summer. This can be attributed to input of organic waste in the form of cattle shed run off as well as concentration due to evaporation. JIR water dries off during later part of summer. Other wise basic pH is maintained at both the water bodies in semiarid zone of central Gujarat as is also reported by Deshkar (2008). High acidity was noted in SVP water as compare to JIR water. As said earlier, input of organic matter with cattle shed runoff is the cause of adding acidity to the water especially during monsoon and pre-winter with highly significant differences between the two water bodies during monsoon, pre-winter and winter but insignificant difference during summer when water level declines. pH is an important plant-growth limiting factor in aquatic environment. The change in pH is

directly related to the availability and absorption of nutrients from water. The acidic pH accelerate absorption of phosphate, (Devlin and Witham, 1986) an important nutrient for plant growth which may result in to the growth of phytoplankton and result in algal bloom (George and Heaney 1978). No striking algal bloom is observed at both the ponds.

Total alkalinity

Is a sum of Hydroxyl Alkalinity and Bicarbonate Alkalinity and depends on several factors as dissolution and precipitation of carbonate mineral dissolution and precipitation, decomposition of organic matter, and assimilation of nutrients (Stumm and Morgan, 1996). It is difficult to correlate alkalinity to a single parameter. *Hydroxyl alkalinity* was nil at SVP throughout the study period however at JIR lowest hydroxyl alkalinity was noted during pre-winter (0.19 + 0.13 $CaCO_3$ mg/l), and highest during winter (3.72 + 0.85 $CaCO_3$ mg/l). In summer it was 0.75 + 0.43 $CaCO_3$ mg/l and no alkalinity was detected during monsoon with highly significant seasonal variations ($P<0.001$, $F_{3, 73}$ 8.231) (Fig 2). Maximum *Bicarbonate Alkalinity* was noted at SVP during summer (121.80 + 5.47 $CaCO_3$ mg/l) and minimum in pre-winter (67.54 + 6.991 $CaCO_3$ mg/l). The seasonal differences were insignificant ($P>0.005$) at SVP while highly significant ($P<0.0001$, $F_{3, 76}$ 12.84) at JIR during the study period. At JIR bicarbonate alkalinity increased form pre- winter (36.58 + 3.42 $CaCO_3$ mg/l) to winter 64.08 + 3.64 $CaCO_3$ mg/l to summer (96.68 + 6.94 $CaCO_3$ mg/l) but decreased during monsoon (74.24 + 11.73 $CaCO_3$ mg/l). When the bicarbonate alkalinity at both the places were compared highly significant ($P<0.0001$) differences were noted during pre-winter and winter whereas significantly significant difference ($P<0.001$) in monsoon and Insignificant ($P>0.05$) differences were noted in summer (Fig 2). High bicarbonate alkalinity was noted at SVP as compared to JIR. This can be attributed to the high pH value and anthropogenic activities at SVP. Ammonia (Strong base) and weak organic acids probably contribute to alkalinity (Manahan, 2000). That is also observed at SVP in the form of cattle shed runoff and sewage input is high at SVP. Alkalinity is not considered to be a water pollutant and its main environmental significance is as an indicator for the susceptibility of the water to pH changes as a result of pollution (Rytwo and Gonen, 2005). Here the range of Bicarbonate Alkalinity was 67.54 + 6.991 $CaCO_3$ mg/l to 125.30 + 29.880 $CaCO_3$ mg/l. (Fig 2). Both the water bodies it shows typical fresh water alkalinity between 20 to 200 mg/l as is indicated by Rytwo and Gonen (2005).

Salinity

Certain amount of salts is necessary for aquatic life. Changes in the amount of dissolved salts can be harmful to organisms as they are adapted to life within a range of salinity. Changes in salinity are results of variations in evaporations and fresh water flow. This can be natural and occur seasonally or they can 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 bases of chlorides. Maximum Salinity was noted (99.85 + 7.4 mg/l) at SVP and (62.98 + 1.7 mg/l) at JIR during summer. Salinity was always high at SVP as compared to JIR during the study period. Due to the difference in the organic matter such as cattle shed run off and garbage thrown by human being. The JIR receives only rain water which dries off during summer hence the lower salinity compared to SVP because of to minimum input of leaves and entry of sewage in to this pond. The two water bodies being located in semiarid zone, the seasonal climatic fluctuations are pronounced with high temperature during summer and low during winter; fresh water input in the form of rains loaded with runoff of organic material during monsoon and moderate weather during pre-winter. The seasonal variations were highly significant ($P<0.0001$, $F_{3, 73}$ 7.21) over the study period. When the two water bodies are compared highly significant ($P<0.0001$) differences were noted during pre-winter and winter, significantly significant ($P<0.001$) in summer. The difference were insignificant ($P>0.05$) during monsoon when new water is added as both water bodies. As these water bodies face similar natural environmental changes, the highly significant and significantly significant differences as the monsoon is over, can be attributed to anthropogenic pressures.

Total Hardness

Is the sum of calcium 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 range from minimum 63.89 + 10.31 $CaCO_3$ mg/l in monsoon to maximum109.4 + 3.84 $CaCO_3$ mg/l during winter (Fig 2). The SVP has moderately soft to moderately hard water depending on seasons. At JIR also 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 that indicates moderately soft water. This is a rainfed reservoir and has less human disturbances. Total hardness was high at SVP as compared to JIR during the study period. Seasonally highly significant variations ($P<0.0001$, $F_{3, 101}$ 32.71 at SVP, $F_{3, 62}$ 10.72 at JIR) were noted at both the ponds. Between the two water bodies insignificant ($P>0.05$) differences were noted during summer highly significant ($P<0.0001$) during pre-winter and winter and significant ($P<0.05$) in monsoon are as said earlier due to the similar influence of climatic changes on one side and difference in anthropogenic pressures. As the water evaporates during summer there is increase in the concentration of Calcium salts in water at both the ponds. However when the new water is added during monsoon this differences increases from monsoon ($P<0.05$) to pre-winter ($P<0.0001$) (Fig 2). The differences were due to addition of salts from the concrete covered urban structure at SVP and scrub covered land at JIR. *Calcium Hardness* showed gradual increase from minimum in summer (18.18 + 1.60 $CaCO_3$ mg/l), to monsoon (23.44 + 1.7 $CaCO_3$ mg/l), pre-winter (26.58 + 0.75 $CaCO_3$ mg/l) and winter (27.00 + 2.43 $CaCO_3$ mg/l) at SVP with highly significant ($P<0.0001$, $F_{3, 98}$ 5.98) seasonal variations. While, at JIR calcium hardness was high during pre-winter (15.92 + 0.99

$CaCO_3$ mg/l) and lower in summer (10.19 + 1.74 $CaCO_3$ mg/l), monsoon (12.9 + 1.0 $CaCO_3$ mg/l) and winter (12.69 + 1.9 $CaCO_3$ mg/l). Seasonal variations were insignificant ($P>0.05$). Differences in calcium hardness between both the study areas were highly significant ($P<0.0001$) during pre-winter and winter, significantly significant ($P<0.001$) in monsoon and significant ($P<0.05$) in summer. 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 with minimum in monsoon (40.44 +3.37 $CaCO_3$ mg/l) and maximum during winter (81.30 + 4.0 $CaCO_3$ mg/l). Insignificant seasonal variations ($P>0.05$) were noted at JIR with maximum magnesium alkalinity during summer (44.38 + 1.78 $CaCO_3$ mg/l) and minimum in monsoon (36.64 + 2.26 $CaCO_3$ mg/l). Highly significant differences ($P<0.0001$) were noted during pre-winter, winter and summer and insignificant ($P>0.05$) differences during monsoon when two water bodies were compared. Total hardness at SVP was always higher highly significant ($P<0.0001$) as compared to JIR all through out the year except during summer when it was significantly significant ($P<0.001$) with higher total hardness at JIR when water totally dries up. However, calcium and magnesium hardness were always higher at SVP. Anthropogenic pressures are probably adding hardness to the water. Deshkar (2008) has related total hardness with water level but no such relation could be established in the present study.

CONCLUSIONS

Among the two water bodies SVP located adjacent to a developing town is under anthropogenic pressures. From the variations in the physico chemical parameter over the seasons and differences in between the two water bodies it can be said that though SVP is under anthropogenic, pressure its condition has not deteriorated completely. If managed properly it can be developed and maintained as a healthy ecosystem.

ACKNOWLEDGEMENT

We are thankful to the Head of Department of Zoology, The Maharaja Sayajirao University of Baroda for providing necessary facilities. The first author is thankful to UGC, Delhi for providing UGC Research Fellowship under RFSMS scheme under which the work was carried out.

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