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WATER QUALITY PARAMETERS AND THEIR CORRELATION WITH AQUATIC INSECTS IN VILLAGE PONDS OF SOUTH-WEST PUNJAB

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ABSTRACT
A comparative study was conducted at three villages of Faridkot district viz, Pakka(30.716◦N and 74.802◦E), Chambeli(30.671◦N and 74.847◦E) and Bhana(30.683◦N and 74.828◦E) from June 2018 to May 2019. Water quality parameters like temperature, pH, EC, alkalinity, free CO_2, DO, BOD, SDT was observed at fortnightly intervals. These water quality parameters were studied in relation to aquatic insect diversity in three village ponds. It was observed that there were slight variations in the water quality parameters in three ponds and most of the parameters had great influence on abundance of aquatic insects. There was significant positive correlation of various abiotic parameters with different insect orders.
Keywords: Water quality, Aquatic insects, Abundance.

INTRODUCTION
Water is one of the most important and basic natural resource which covers about 75 per cent of earth's crust.Rivers, streams, lakes and ponds are home to a large variety of aquatic insects belonging to various groups and orders. Some of them live in water throughout their life while others spend only their pupal or larval stages in water (Baruah and Hazarika 2018). Aquatic forms of life and several physico-chemical parameters of water showed relationship between them. Various physical and chemical factors like water depth, water temperature, water velocity, canopy cover, pH and dissolved oxygen (DO) highly influence the abundance & diversity of aquatic insects. Any fluctuation in water quality due to physical and chemical environment affects their richness in the habitat area (Hasmi *et al* 2017). In the past, water quality was assessed using only physicochemical parameters but due to development in recent years water quality is monitored by biological methods that include using plant, animals, bacteria, viruses etc. Aquatic insects are good indicators of pond health and water quality because they are affected by physical, chemical and biological conditions of water body. Physicochemical parameters and aquatic insect indicators may work together effectively in assessing water quality (Hussieny *et al* 2015). Variations in these water properties greatly influence the distribution patterns of aquatic insects in the water because of their various environmental disturbances tolerant levels (Bauernfeind and Moog 2000, Arimoro and Ikomi 2008).

MATERIAL AND METHODS
Water samples of 3 village ponds were collected for physico-chemical analysis following the standard methods given in APHA 2005 at fortnightly intervals from June 2018 to May 2019.

RESULTS AND DISCUSSION

Physico-chemical characteristics of water

i) Air Temperature (^{0}C)

Table 1 shows data on air temperature (AT) of three village ponds of Faridkot district annually (June 2018 to May 2019). Mean and standard error values of AT ranged from 15±0°C (January) to 42.5±0.5°C (June) in Pakka, 15±0°C (January) to 42.5±0.5°C (June) in Chambeli 14.5±0°C. (December) to 42.5 ± 0.5°C (June) inBhana. The variation in AT of three village ponds have been shown in Fig. 1. The lowest value of AT being recorded in month of December in Bhana and highest in June from all the village ponds.

Figure 1 shows variation in AT (°C) of three village ponds of south west Punjab. Variations in air temperature (°C) were highest in June while minimum in month of December. Temperature had great impact on distribution of aquatic insects as more species were collected during high temperature as compared to low temperature (Oku *et al* 2014). Similar observations were recorded by Oben (2000) during his study also and all these are in confirmation with our findings.

Table 1. Variations in air temperature in different ponds of Faridkot District

Month/Location→ ↓	Pakka	Chambeli	Bhana
June	42.5 ± 0.5^{a}	42.5 ± 0.5^{a}	42.5 ± 0.5^{a}
July	41.0 ± 1^{ab}	41 ± 1^{ab}	41 ± 1^{ab}
August	34.5 ± 1.5^{abcde}	34.5 ± 0.5^{abcde}	33 ± 1^{abcde}
Sept	32.5 ± 0.5^{abcde}	32 ± 0^{abcde}	32 ± 0^{abcde}
Oct	29 ± 0^{bcdef}	28.5 ± 0.5^{cdef}	28.5 ± 0.5^{cdef}
Nov	22.5 ± 2.5^{efgh}	27.5 ± 2.5^{efgh}	26.5 ± 1.5^{defgh}
Dec	18 ± 1^{fgh}	18 ± 1^{fgh}	14.5 ± 0.5^{h}
Jan	15 ± 0^{h}	15 ± 0^{h}	15.5 ± 0.5^{gh}
Feb	18 ± 3^{fgh}	18 ± 3^{feg}	18.5 ± 3.5^{fgh}
March	28.5 ± 5.5^{cdef}	28 ± 5^{cdef}	27.5 ± 5.5^{bcdefg}
Apr	35 ± 1^{abcd}	34.5 ± 1.5^{abcde}	34.5 ± 1.5^{abcde}
May	39.5 ± 1.5^{abc}	39.5 ± 1.5^{abc}	39 ± 2^{abc}

Values with Mean ± SE

Value followed with different superscripts are significantly different ($p<0.05$).

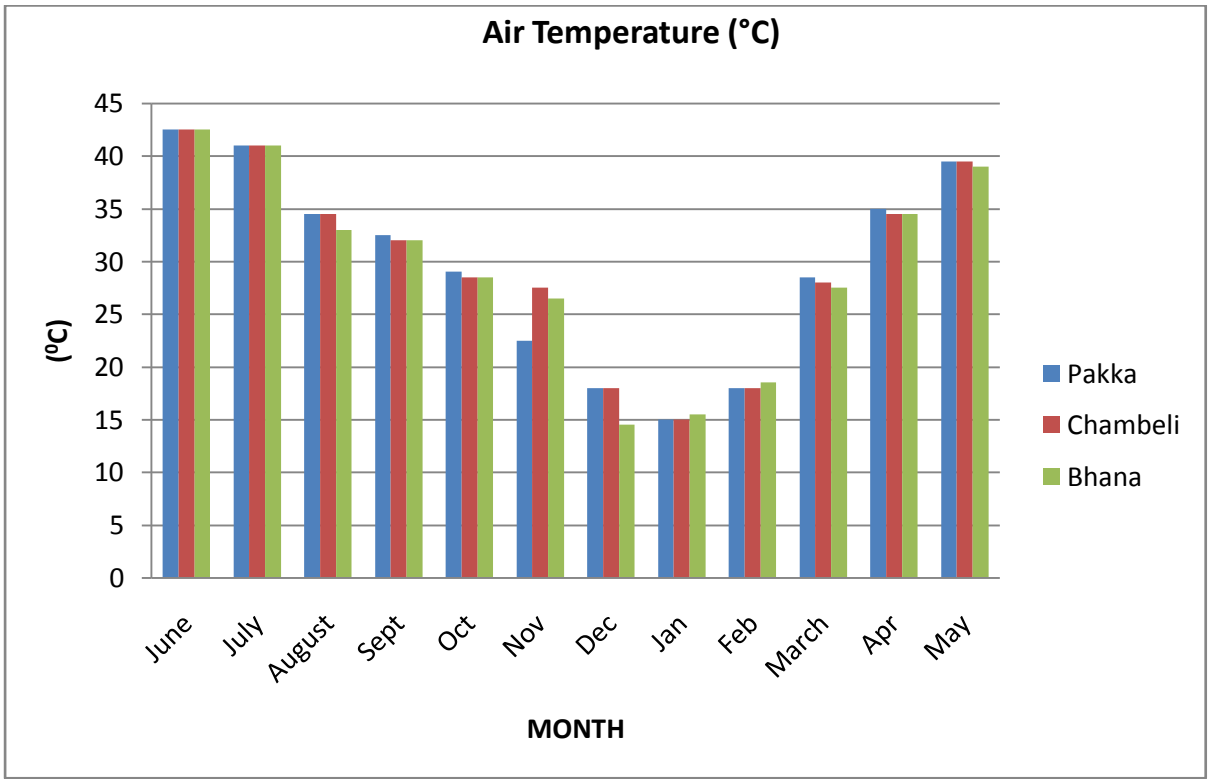

Figure 1. Variations in air temperature in different ponds of Faridkot District

ii) Water Temperature (^{0}C)

Water temperature is very important water quality parameter and can be measured easily. Water temperature recorded annually from different villages of south west Punjab have been shown in Table 2.The minimum water temperature of 13± 0°Cwas recorded from village Pakka and village Chambeli during January and during December from village Bhana. All the three village ponds had maximum temperature of 40 ± 0°Cduring June.Variations in water temperature observed from the three village ponds have been depicted in Fig.2. The highest WT was recorded in the month of June which started declining towards winters and was minimum in January. It again started increasing from February to May. There were significant variations in WT at ($p< 0.05$) at different locations during different months of the year. There is a great influence of WT on abundance of aquatic insects. WT affects the number of aquatic insects as each species requires a particular range of temperature to survive because of different respiratory rate and metabolism. They migrate to areas where they find suitable temperature for their survival (Hering *et al* 2009). The abundance of aquatic insects has been found to increase with increase in WT because the metabolism of aquatic insects is increased. Moreover, WT is also responsible for emergence of several aquatic insects resulting in earlier emergence of insects (Burgmer 2007).

Table 2. Variations in water temperature in different ponds of Faridkot District

Month /Loctaion→ ↓	Pakka	Chambeli	Bhana
June	40 ± 0^{a}	40 ± 0^{a}	40 ± 0^{a}
July	38.50 ± 0.5^{ab}	38.50 ± 0.5^{ab}	39.50 ± 1.5^{a}
August	33 ± 1^{abcd}	33 ± 0^{abcd}	32 ± 1^{abcde}
September	31.50 ± 0.5^{abcde}	31 ± 0^{abcde}	30 ± 0^{abcde}
October	27.50 ± 0.5^{bcdef}	27 ± 1^{bcdef}	27 ± 1^{bcde}
November	20.50 ± 1.5^{efgh}	26 ± 2^{def}	25 ± 1^{defg}
December	16.50 ± 1.5^{fgh}	16.50 ± 1.5^{fgh}	13 ± 0^{h}
January	13 ± 0^{h}	13 ± 0^{h}	13.50 ± 0.5^{gh}
February	16.50 ± 3.5^{fgh}	16.50 ± 2.5^{fgh}	17 ± 3^{fgh}
March	27.50 ± 5.5^{bcdef}	27 ± 5^{bcdefg}	26.50 ± 5.5^{cdef}
April	34 ± 1^{abcd}	34 ± 2^{abcd}	33 ± 1^{abcd}
May	38.50 ± 1.5^{ab}	38.50 ± 1.5^{ab}	38 ± 2^{abc}

Values with Mean ± SE

Value followed with different superscripts are significantly different ($p<0.05$).

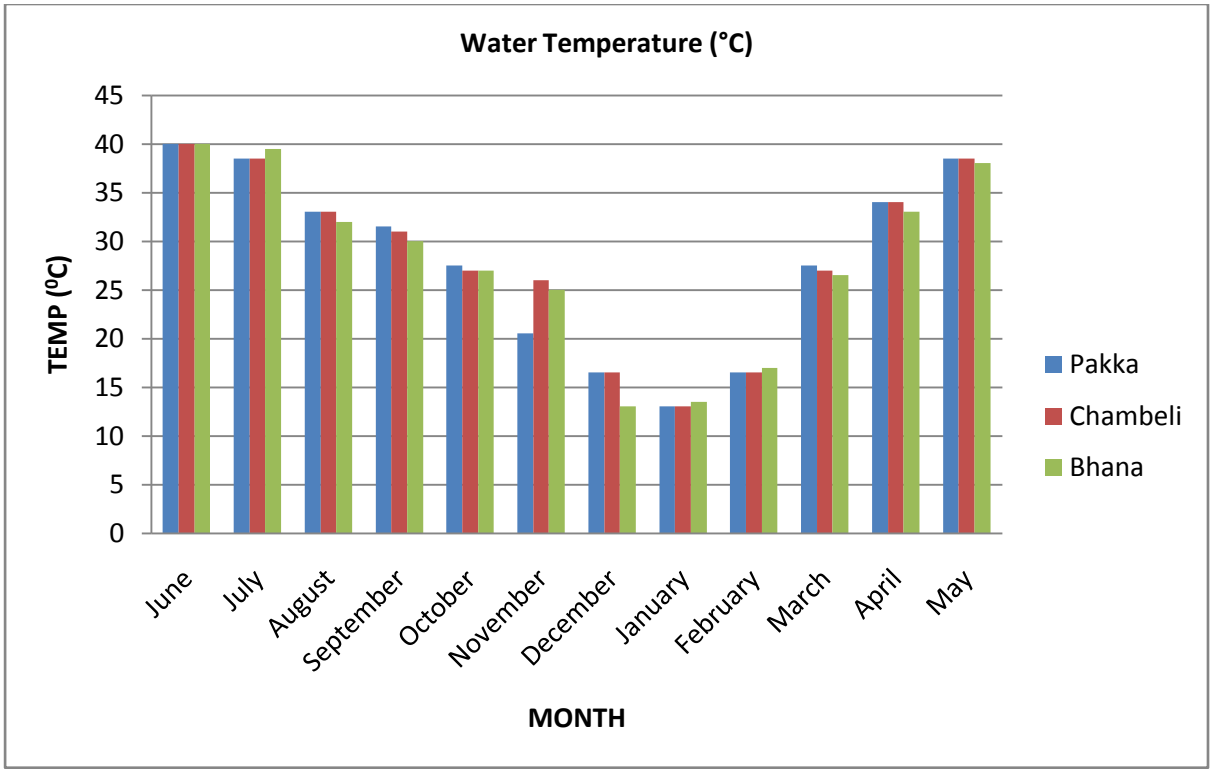

Figure 2. Variations in water temperature in different ponds of Faridkot District

iii) pH

The changes in pH at different villages have been shown in Table 3 during different months of the year. pH ranged from 6.92 ± 0.04 (May) to 8.88 ± 0.005 (June) in village Pakka, 6.85 ± 0.03 (October) to 8.83 ± 0.81 (May) in village Chambeli and 7.52 ± 0.11 (October) to 8.34 ± 0.19 (May) in village Bhana. So the maximum pH was recorded from Village Chambeli while minimum was recorded from Pakka during the month of May.

Table 3. Variations in pH in different ponds of Faridkot District

Month /Location→ ↓	Pakka	Chambeli	Bhana
June	8.33 ± 0.005^{abc}	8.71 ± 0.05^{ab}	8.28 ± 0.06^{abc}
July	8.27 ± 0.49^{abc}	7.97 ± 0.01^{abc}	8.14 ± 0.03^{abc}
August	7.34 ± 0.16^{abc}	8.34 ± 0.54^{abc}	7.61 ± 0.50^{abc}
September	6.94 ± 0.05^{c}	7.38 ± 0.23^{c}	7.57 ± 0.25^{abc}
October	7.02 ± 0.09^{c}	6.85 ± 0.03^{abc}	7.52 ± 0.11^{abc}
November	7.48 ± 0.14^{abc}	7.59 ± 0.08^{abc}	7.74 ± 0.02^{abc}
December	7.19 ± 0.15^{abc}	7.67 ± 0.21^{abc}	7.60 ± 0.03^{abc}
January	7.76 ± 0.24^{abc}	8.17 ± 0.32^{abc}	8.11 ± 0.73^{abc}
February	7.41 ± 0.18^{abc}	7.59 ± 0.09^{abc}	8.18 ± 0.39^{abc}
March	7.38 ± 0.25^{abc}	7.46 ± 0.02^{abc}	7.96 ± 0.07^{abc}
April	7.27 ± 0.03^{abc}	7.69 ± 0.17^{abc}	8.12 ± 0.07^{abc}
May	6.92 ± 0.04^{c}	8.83 ± 0.81^{a}	8.34 ± 0.19^{abc}

Values with Mean ± SE

Value followed with different superscripts are significantly different ($p<0.05$).

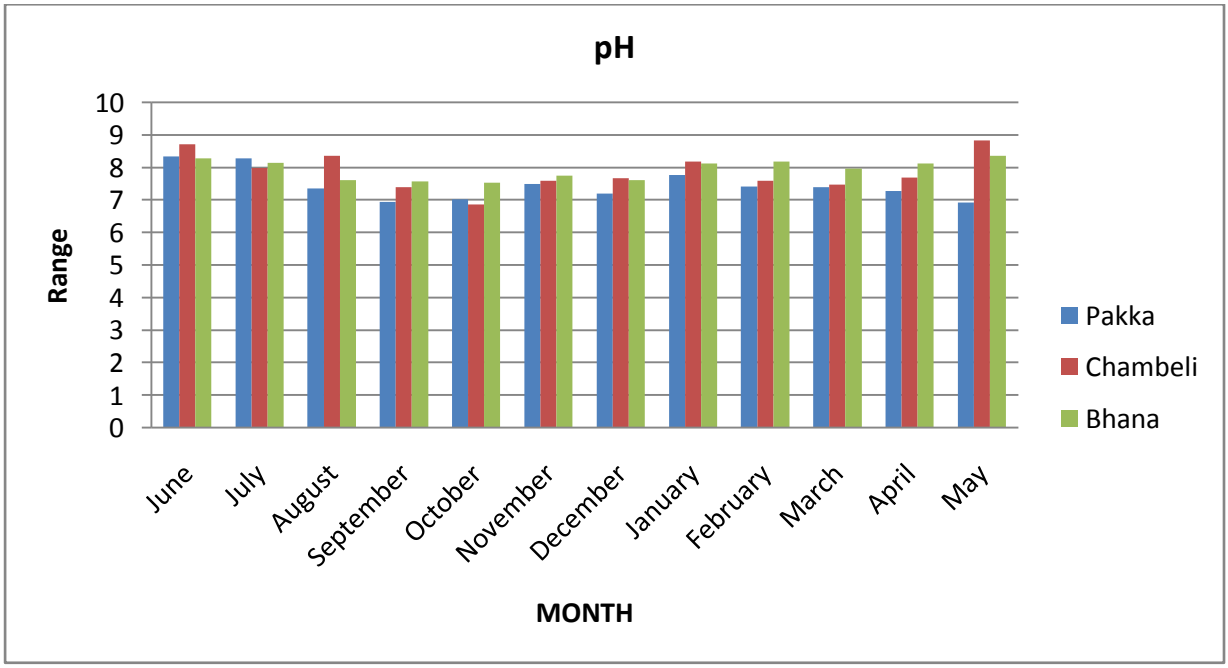

Figure 3. Variations in pH in different ponds of Faridkot District

pH is vital environmental factor that affects life processes of various aquatic organisms. Slight variations were observed in pH of 3 village ponds, shown in Fig. 3. Ngodhe *et al* (2014) indicated that pH of water affected normal physiological functions of aquatic organisms, including exchange of ions with water and respiration. These vital physiological processes operate under wide pH range of 6-9 units. The increased rate of decomposition of organic matters, influx of CO_2, source of high water temperature, mixing of domestic sewage caused low pH (Dubey *et al* 2006). The USEPA (1999) indicated that pH of 6.5 -9.0 provides adequate protection for bottom dwelling macroinvertebrates. Scheibler *et al*(2014) reported that taxa richness and diversity increased with increase in pH.

iv) Electrical Conductivity (µS/Cm)

The values of conductivity recorded during present study at various ponds during different months of year have been shown in Table 4. Electrical conductivity fluctuated between 3.93±6µS/cm (June) to 6.84±21 µS/cm (August) in Pakka, 1.06±508.5 µS/cm (February) to 8.87±34.5 µS/cm (May) in Chambeli, 1.16±50 µS/cm (April) to 9.01 ± 74.5 µS/cm (May) in Bhana. Therefore, the maximum EC was recorded from Village Bhana and minimum from Village Chambeli. The electrical conductivity is a function of total dissolved solids whichdetermines quality of water (Tariq *et al* 2006). The general trend seen inconductivity was that it tended to increase in dry season in village Bhana. This could be attributed to the fact that it suffered from high anthropogenic pressure and pollution. If conductivity of pond increases immediately then there is some source of dissociation in vicinity. As a result, conductivity can be used as an efficient way to locate water quality parameters. Increase in EC in village Pakka could be due to high rate of decomposition and mineralisation by microbes (Egborge 1994).

Table 4. Variations in electrical conductivity in different ponds of Faridkot District

Month / LOCATION→ ↓	**Pakka**	**Chambeli**	**Bhana**
June	3.93 ± 6^{g}	6.21 ± 54^{fg}	8.92 ± 1^{cdefg}
July	5.03 ± 80.5^{fg}	8.42 ± 144.5^{defg}	7.08 ± 80^{fg}
August	6.84 ± 21^{fg}	1.10 ± 10^{bcdefg}	1.92 ± 111^{a}
September	6.45 ± 13.5^{fg}	8.22 ± 206^{defg}	1.66 ± 197^{abc}
October	6.16 ± 17.5^{fg}	7.99 ± 79^{defg}	1.58 ± 94^{abcd}
November	6.63 ± 18.5^{fg}	1.08 ± 103.5^{bcdefg}	1.67 ± 43.5^{abc}
December	6.06 ± 46.5^{fg}	1.09 ± 108.5^{bcdefg}	1.60 ± 20.5^{abcd}
January	5.04 ± 15.5^{fg}	7.58 ± 107.5^{efg}	1.72 ± 192.5^{ab}
February	5.75 ± 7^{fg}	1.06 ± 508.5^{bcdefg}	1.55 ± 412.5^{abcde}
March	4.43 ± 93^{fg}	5.61 ± 51^{fg}	1.23 ± 78.5^{abcdef}
April	4.83 ± 77^{fg}	5.75 ± 5^{fg}	1.16 ± 50^{abcdefg}
May	4.85 ± 13^{fg}	8.87 ± 34.5^{cdefg}	9.01 ± 74.5^{cdefg}

Values with Mean ± SE

Value followed with different superscripts are significantly different ($p<0.05$).

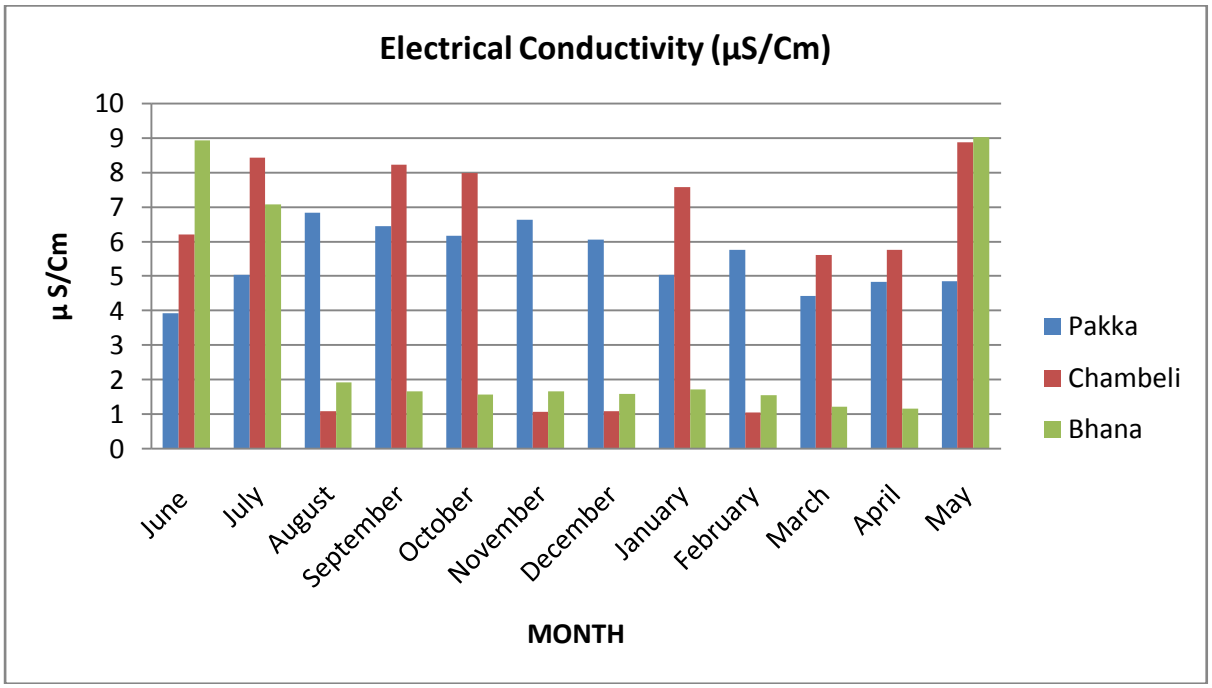

Figure 4. Variations in electrical conductivity in different ponds of Faridkot District

v) Dissolved Oxygen (mg/L)

Table 5 shows the changes in the value of DO at different ponds of Faridkot district during different months of year. The DO value ranged from 0.85 ± 0.45 (October) to 14.90 ± 5.3 (March) in village Pakka, 2.85 ± 1.45(February) to 18.10 ± 2.5(May) in village Chambeli, 2.75 ± 0.55 (October) to 12.70 ± 3.1(March) in village Bhana. The highest value of DO was recorded from village Chambeli in month of May (18.10 mg/L) whereas minimum value was observed from pond of village Pakka (0.85 mg/L).

DO is one of the major factor that determines water purity and distribution of several aquatic insects (Wahizatul *et al* 2011). The low values of DO concentration is an indication of deterioration of water quality as a result of various anthropogenic activities. Low value of DO could also be attributed to small surface area and less impact of organic waste in these stations. It was reported that suspended particles absorb heat in water thus increasing water temperature and leading to reduction of oxygen content of water bodies because warm water holds less dissolved DO as compared to cold (Paaijmans *et al* 2008, Mandal 2014).

vi) Free CO_2 (mg/L)

The highest significant difference was observed in the month of September in pond of village Pakka. The lowest significant difference occurred in all the village ponds in different months of the year. CO_2 may be produced in water by biological oxidation of organic matter, mainly in the polluted water. Free CO_2 of water samples were highest in July which may be due to discharge of domestic wastes, sewage and decomposition of organic matter (Devi B *et al* 2013).

The variations in the values of free CO_2 in different villages of Faridkot district during different months of the year have been shown in Table 6 and Figure 6. The value of free CO_2 ranged from 0 ± 0 (June) to 93.50 ± 18.5mg/L(September) in Village Pakka, 0 ± 0 to 36.00 ± 4mg/L in village Chambeli, 0 ± 0 to 20.00 ± 1mg/L in village Bhana. The highest value of free $CO_2$was recorded from village Pakka (93.50 mg/L) in September which may be due to discharge of domestic wastes, sewage and decomposition of organic matter while minimum from all the three village ponds during different months.

Table 5. Variations in dissolved oxygen in different ponds of Faridkot District

Month / Location→ ↓	Pakka	Chambeli	Bhana
June	4.10 ± 0.5^{bc}	9.20 ± 0.5^{abc}	5.80 ± 0.9^{abc}
July	3.95 ± 0.15^{bc}	8.80 ± 0.5^{abc}	5.35 ± 0.55^{abc}
August	3.65 ± 0.05^{bc}	4.85 ± 2.35^{abc}	10.95 ± 8.65^{abc}
September	3.20 ± 0.6^{bc}	3.50 ± 0.1^{bc}	11.40 ± 3.8^{abc}
October	0.85 ± 0.45^{c}	5.10 ± 0.9^{abc}	2.75 ± 0.55^{bc}
November	2.00 ± 0.1^{bc}	6.60 ± 1.6^{abc}	4.55 ± 0.25^{bc}
December	2.35 ± 0.05^{bc}	8.00 ± 0.3^{abc}	7.35 ± 0.45^{abc}
January	11.70 ± 1.9^{abc}	7.45 ± 0.45^{abc}	3.25 ± 0.15^{bc}
February	7.10 ± 0.5^{abc}	2.85 ± 1.45^{bc}	4.55 ± 0.05^{bc}
March	14.90 ± 5.3^{ab}	8.10 ± 1.9^{abc}	12.70 ± 3.1^{abc}
April	8.30 ± 1.3^{abc}	9.70 ± 1.6^{abc}	12.50 ± 1.5^{abc}
May	9.60 ± 4.4^{abc}	18.10 ± 2.5^{a}	3.90 ± 0.3^{bc}

Values with Mean ± SE

Value followed with different superscripts are significantly different ($p<0.05$).

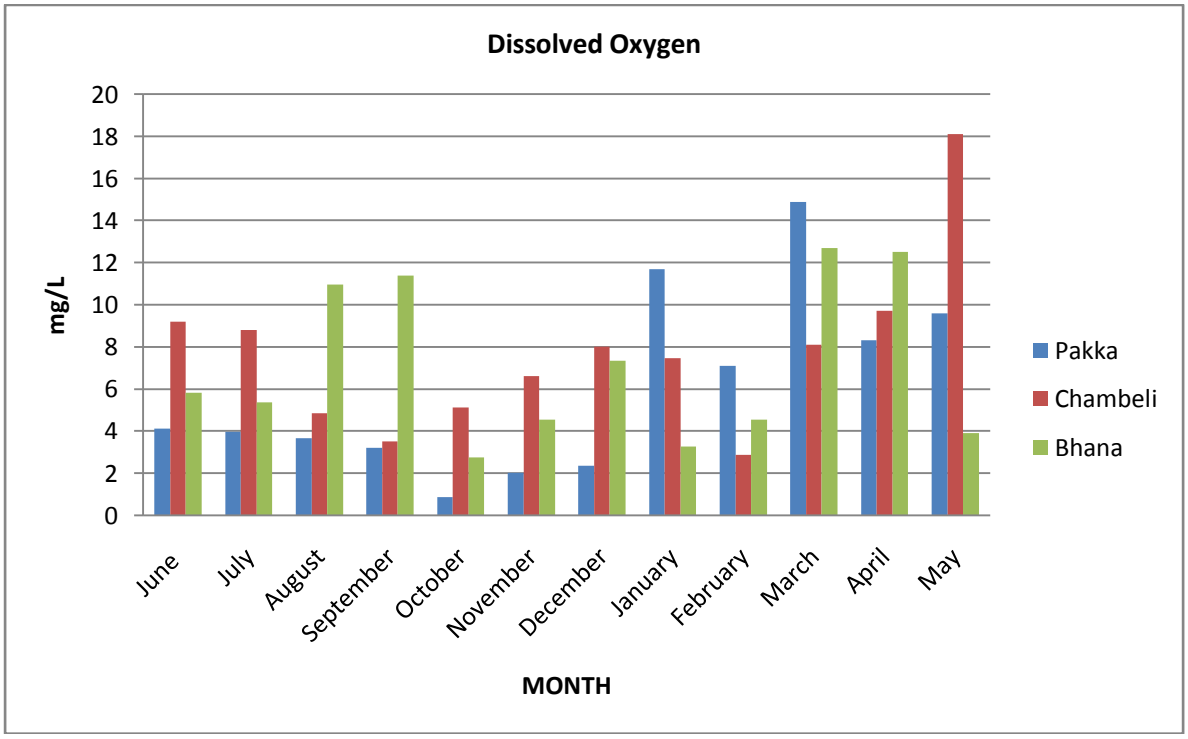

Figure 5. Variations in dissolved oxygen in different ponds of Faridkot District

Table 6. Variations in free CO_2 in different ponds of Faridkot District

Month /Location→ ↓	Pakka	Chambeli	Bhana
June	0 ± 0^{c}	13.00 ± 13^{bc}	16.50 ± 5.5^{bc}
July	30.00 ± 13^{bc}	3.50 ± 3.5^{c}	20.00 ± 1^{bc}
August	61.00 ± 15^{ab}	2.50 ± 2.5^{c}	9.00 ± 9^{bc}
September	93.50 ± 18.5^{a}	17.50 ± 11.5^{bc}	0 ± 0^{c}
October	17.50 ± 17.5^{bc}	36.00 ± 4^{bc}	19.00 ± 19^{bc}
November	10.00 ± 0^{bc}	0 ± 0^{c}	6.00 ± 6^{c}
December	10.00 ± 0^{bc}	7.50 ± 7.5^{bc}	0 ± 0^{c}
January	19.50 ± 1.5^{bc}	4.50 ± 4.5^{c}	0 ± 0^{c}
February	22.50 ± 1.5^{bc}	22.50 ± 3.5^{bc}	0 ± 0^{c}
March	16.00 ± 0^{bc}	18.50 ± 1.5^{bc}	8.50 ± 8.5^{bc}
April	18.00 ± 3^{bc}	0 ± 0^{c}	0 ± 0^{c}
May	30.50 ± 2^{bc}	0 ± 0^{c}	0 ± 0^{c}

Values with Mean ± SE

Value followed with different superscripts are significantly different ($p<0.05$).

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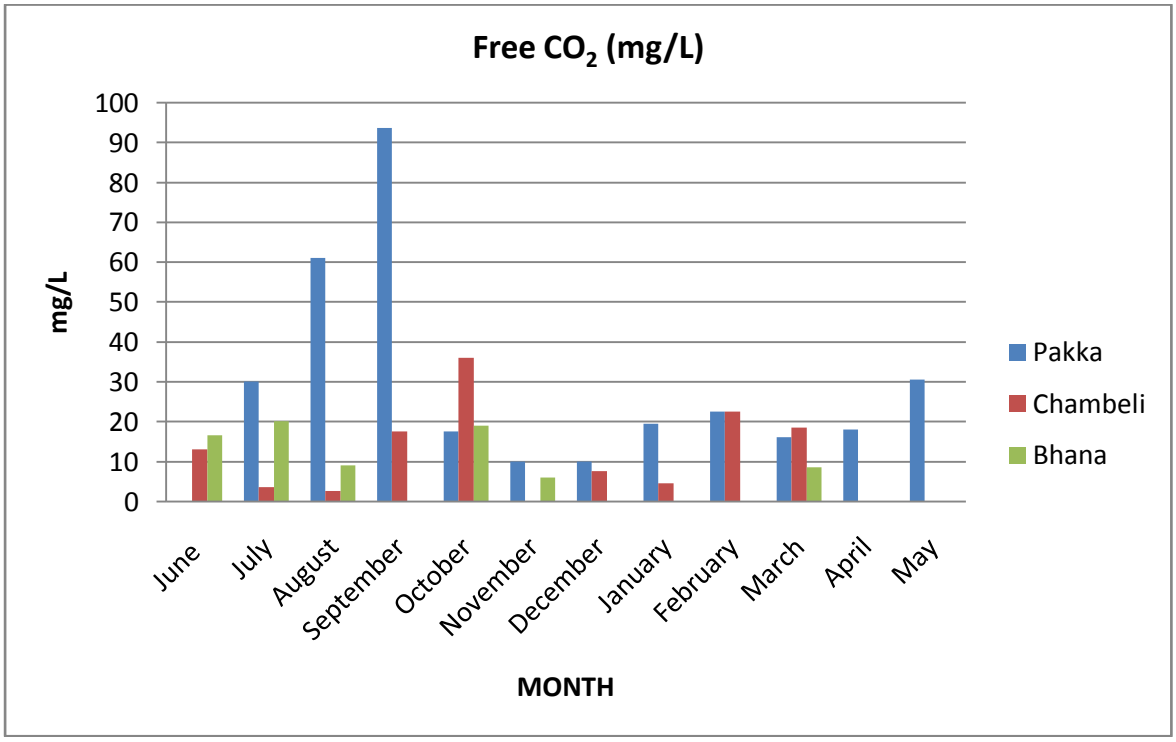

Figure 6. Variations in free CO_2 in different ponds of Faridkot District

vii) Alkalinity (mg/L)

The details of alkalinity at different ponds of Faridkot district have been shown in Table 7. Fig. 7 depicts the changes in values of alkalinity during different months of year from June 2018 to May 2019. It fluctuated between 5.00 ± 1mg/L (April) to 25.00 ± 2mg/L (September) in village Pakka, 3.65 ± 0.05mg/L (October) to 29.50 ± 1.5mg/L(May) in village Chambeli, 5.50 ± 1.5mg/L (November) to 33.00 ± 2 mg/L (July) in village Bhana. The maximum value of alkalinity was observed in Village Bhana in July whereas minimum value of alkalinity was recorded in October from village Chambeli.Alkalinity indicates that water consists of ions, carbonates, bicarbonates and hydroxides. Rain and soil are two major sources of carbonates and bicarbonates. The alkalinity of water body mainly depends upon geology of water shed area and presence of naturally occurring limestone. According to Moyle and Alikunhi (1957), water bodies having total alkalinity above 50mg/L have been considered as productive in nature. High TA value is associated with poor quality of water.

Table 7. Variations in alkalinity in different ponds of Faridkot District

Month /Location→ ↓	Pakka	Chambeli	Bhana
June	18.00 ± 1^{ab}	15.30 ± 9.7^{ab}	24.00 ± 3^{ab}
July	13.00 ± 2^{ab}	24.00 ± 3^{ab}	33.00 ± 2^{a}
August	11.50 ± 0.5^{ab}	23.50 ± 6.5^{ab}	25.00 ± 14^{ab}
September	25.00 ± 2^{ab}	14.50 ± 5.5^{ab}	12.00 ± 1^{ab}
October	14.50 ± 2.5^{ab}	3.65 ± 0.05^{b}	16.50 ± 8.5^{ab}
November	12.00 ± 7^{ab}	16.50 ± 1.5^{ab}	5.50 ± 1.5^{ab}
December	16.50 ± 0.5^{ab}	15.00 ± 3^{ab}	11.00 ± 1^{ab}
January	10.00 ± 3.5^{ab}	12.50 ± 8.5^{ab}	9.00 ± 1^{ab}
February	8.50 ± 0.5^{ab}	4.50 ± 3.5^{ab}	10.00 ± 9^{ab}
March	10.50 ± 1.5^{ab}	12.50 ± 0.5^{ab}	12.50 ± 6.5^{ab}
April	5.00 ± 1^{ab}	8.50 ± 5.5^{ab}	12.50 ± 5.5^{ab}
May	7.00 ± 1^{ab}	29.50 ± 1.5^{ab}	23.50 ± 4.5^{ab}

Values with Mean ± SE

Value followed with different superscripts are significantly different ($p<0.05$).

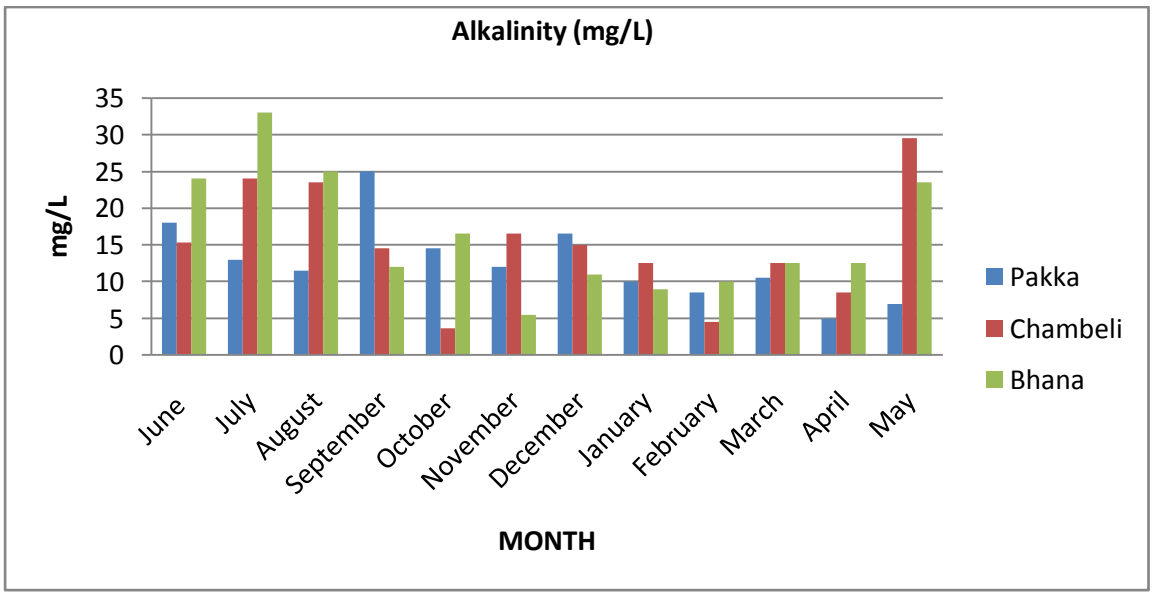

Figure7. Variations in alkalinity in different ponds of Faridkot District

viii) Biochemical Oxygen Demand (mg/L)
The details of changes in BOD at different village ponds during different months of study have been shown in Table 8 The values of BOD varied between 16.50 ± 1.5mg/L to 30.50 ± 0.5mg/L in Pakka village, 16.50 ± 7.5mg/L to 27.00 ± 1mg/L in Chambeli Village, 11.00 ± 4 mg/L to 34.50 ± 3.5mg/L in Bhana Village. The highest BOD value was recorded from village Bhana (34.50mg/L) in April whereas lowest value was observed in the month of January from village Bhana(11.00 mg/L).Figure 8 depicts variations in values of BOD in different ponds. BOD was related to changes in temperature. The maximum demand of oxygen in water was recorded during rainy season while minimum demand in winter season. The higher value of BOD during rainy season might be due to input of organic wastes. This was similar to findings of Garg *et al* (2009) in Ramsagar reservoir of Datia and Devaraju *et al* (2005) in Maddur Lake.

Table 8. Variations in BOD in different ponds of Faridkot District

Month /Location→ ↓	Pakka	Chambeli	Bhana
June	30.50 ± 0.5^{abc}	27.00 ± 1^{abc}	30.50 ± 0.5^{abc}
July	28.00 ± 1^{abc}	26.00 ± 1^{abc}	28.00 ± 1^{abc}
August	22.00 ± 7^{abc}	20.50 ± 2.5^{abc}	25.50 ± 3.5^{abc}
September	22.00 ± 2^{abc}	21.00 ± 1^{abc}	22.00 ± 2^{abc}
October	16.50 ± 1.5^{abc}	21.50 ± 6.5^{abc}	16.50 ± 1.5^{abc}
November	21.50 ± 1.5^{abc}	20.50 ± 1.5^{abc}	24.50 ± 1.5^{abc}
December	17.50 ± 1.5^{abc}	19.50 ± 0.5^{abc}	17.50 ± 1.5^{abc}
January	16.50 ± 1.5^{abc}	21.00 ± 1^{abc}	11.00 ± 4^{c}
February	26.00 ± 2^{abc}	24.50 ± 2.6^{abc}	29.00 ± 1^{abc}
March	18.00 ± 7^{abc}	26.00 ± 0^{abc}	12.50 ± 5.5^{abc}
April	16.50 ± 1.5^{abc}	16.50 ± 7.5^{abc}	34.50 ± 3.5^{abc}
May	26.50 ± 3.5^{abc}	26.00 ± 1^{abc}	26.00 ± 3^{abc}

Values with Mean ± SE
Value followed with different superscripts are significantly different ($p<0.05$).

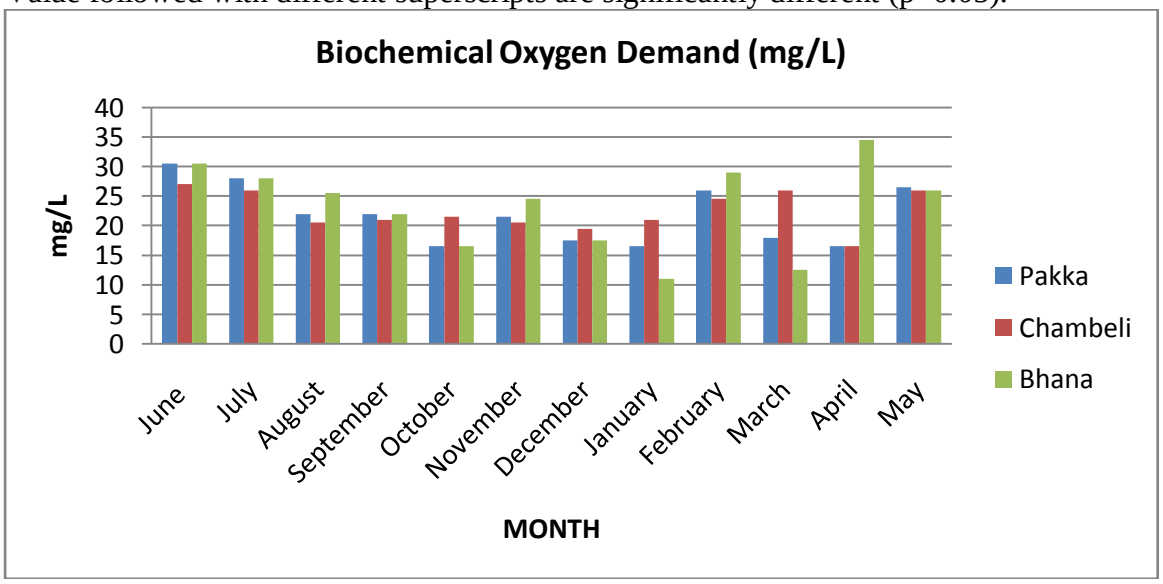

Figure 8.Variations in BOD in different ponds of Faridkot District

ix) Secchi Disc Transparency (Cm) The values of SDT recorded from June 2018

to May 2019 in three ponds have been shown in Table 9. It ranged from 8.50 ± 0.25cm (June) to 12.24 ± 0.64cm (November) in Pakka, 41.50 ± 1.5cm (June) to 67.75 ± 0.75cm (April) in Chambeli, 30.50 ± 0.5cm (June) to 46.00 ± 3cm (November) in Bhana. The maximum SDT was recorded in April from Chambeli (67.75cm) while minimum value was observed from Pakka in June (8.50 ± 0.25cm) Variations in SDT are depicted in Figure 9 in different ponds of Faridkot district. In village Pakka, SDT ranged from 8 to 12 due to presence of algae and sand particles that made it unclear. The maximum SDT was recorded in pond of village Chambeli as it was almost clear due to absence of algae. The transparency value <170 indicates higher trophic status of ponds. Similar observations were made by Kumar *et al* (2012) and Wanganeo *et al* (2011) from different water bodies of India.

Table 9. Variations in SDT in different ponds of Faridkot District

Month /Location→ ↓	**Pakka**	**Chambeli**	**Bhana**
June	8.50 ± 0.25^{k}	41.50 ± 1.5^{fghi}	30.50 ± 0.5^{j}
July	10.90 ± 0.5^{k}	41.75 ± 1.25^{fghi}	$36 .00 \pm 2^{hij}$
August	11.05 ± 1.05^{k}	44.00 ± 3^{fghi}	34.50 ± 1.5^{abc}
September	12.24 ± 0.64^{k}	45.50 ± 2.5^{defgh}	38.50 ± 0.5^{ghij}
October	12.00 ± 0.6^{k}	57.00 ± 0^{abc}	45.50 ± 0.5^{defgh}
November	12.00 ± 0.3^{k}	66.00 ± 6.5^{ab}	46.00 ± 3^{defgh}
December	11.40 ± 0.1^{k}	55.50 ± 2.5^{bcd}	38.00 ± 1^{defgh}
January	11.55 ± 0.05^{k}	49.00 ± 2^{cdefg}	34.50 ± 2.5^{hij}
February	12.37 ± 0.12^{k}	55.50 ± 0.5^{bcd}	38.50 ± 1.5^{abc}
March	10.95 ± 0.05^{k}	54.50 ± 3.5^{cde}	43.75 ± 1.73^{fghi}
April	10.45 ± 0.05^{k}	67.75 ± 0.75^{a}	40.50 ± 0.5^{fghij}
May	9.20 ± 0.8^{k}	51.00 ± 1^{cdef}	36.00 ± 2^{hij}

Values with Mean ± SE

Value followed with different superscripts are significantly different ($p<0.05$)

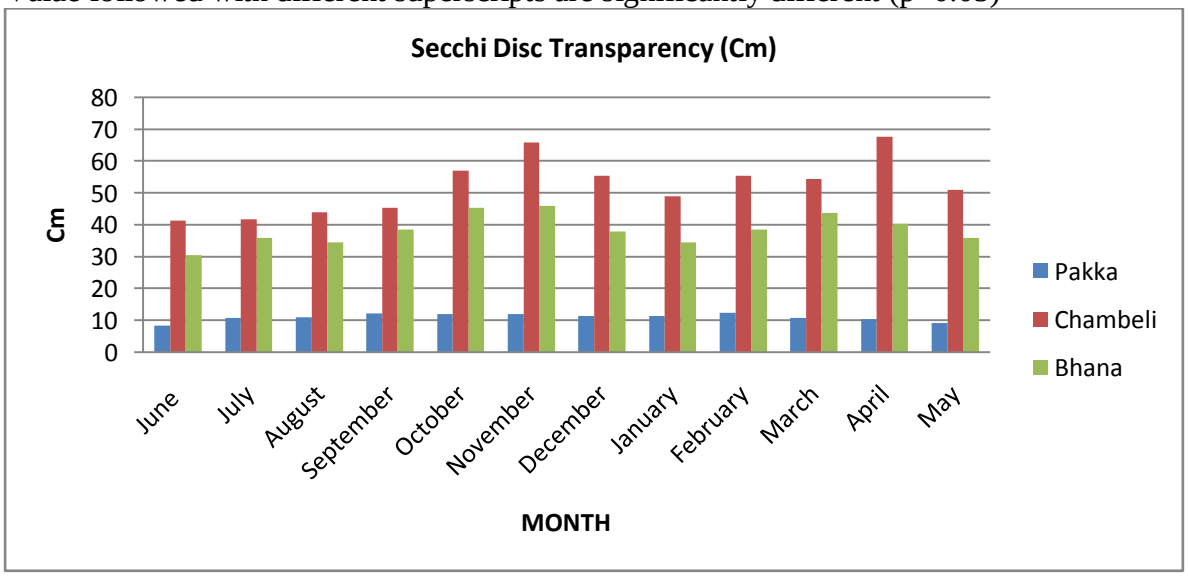

Figure9. Variations in SDT in different ponds of Faridkot District

x) Correlation of abiotic parameters with different insect orders of different village ponds: Table 10 depicts positive correlation of Odonates with EC and free CO_2,

Coleoptera with free CO_2, Diptera and DO while Hemiptera with EC and free CO_2 in Village Pakka. In Village Chambeli significant correlations was seen between Odonates and air and water temperature, Diptera and free CO_2as shown in Table 11. There was significant correlation of Odonates with free CO_2 and SDT, Diptera with EC and Hemiptera with SDT in village Bhana as shown in Table 12.The findings of Mishra and Singh (2018) indicated that order Hemiptera and Diptera were positively correlated with alkalinity whereas DO was negatively correlated with orders Ephemeoptera, Odonata, Coleoptera and Hemiptera.According to study conducted by Oku *et al* (2014) there was positive correlation of BOD with orders Plecoptera and Ephemeroptera while order Hemiptera was correlated with temperature and Diptera with pH. In general, aquatic insect diversity was positively correlated with pH, BOD and electrical conductivity values (Arimoro and Ikomi 2008).

Table 10. Correlation of abiotic parameters with different insect orders in village Pakka

WATER PARAMETERS→ ORDERS ↓	Air temp (^{0}C)	Water temp (^{0}C)	pH	EC (µS/ Cm)	DO (mg/L)	FREE CO2 (mg/L)	Alkalinty (mg/L)	BOD (mg/L)	SDT (Cm)
Odonata	0.20	0.18	0.15	0.37*	-0.45	0.25	0.24	0.10	-0.06
Coleoptera	0.16	0.17	-0.006	0.12	0.03	0.43*	-0.04	-0.10	0.04
Diptera	-0.55	-0.53	-0.11	-0.23	0.48*	-0.19	-0.24	-0.40	0.23
Hemiptera	0.33	0.32	-0.10	0.44*	-0.37	0.43*	0.11	0.03	0.25

*Values are significantly different ($p<0.05$).

Table 11. Correlation of abiotic parameters with different insect orders in village Chambeli

WATER PARAMETERS→ ORDERS ↓	Air temp (^{0}C)	Water temp (^{0}C)	pH	EC (µS/ Cm)	DO (mg/L)	FREE CO2 (mg/L)	Alkalinty (mg/L)	BOD (mg/L)	SDT (Cm)
Odonata	0.47*	0.45*	-0.018	0.006	-0.21	0.08	0.23	0.06	-0.61
Coleoptera	0.20	0.21	-0.062	0.21	-0.06	0.03	0.25	-0.31	-0.09
Diptera	-0.19	-0.18	-0.56	0.10	-0.52	0.51*	-0.22	-0.020	0.008
Hemiptera	0.05	0.09	0.06	-0.04	0.07	-0.23	0.010	-0.13	0.20

*Values are significantly different ($p<0.05$).

Table 12: Correlation of abiotic parameters with different insect orders in village Bhana

WATER PARAMETERS→ ORDERS ↓	Air temp (^{0}C)	Water temp (^{0}C)	pH	EC (µS/ Cm)	DO (mg/L)	FREE CO2 (mg/L)	Alkalinty (mg/L)	BOD (mg/L)	SDT (Cm)
Odonata	0.063	0.063	-0.231	0.186	-0.338	0.372*	-0.122	-0.003	0.519*
Coleoptera	0.030	0.043	0.195	-0.234	0.133	0.035	0.052	-0.311	0.122
Diptera	-0.158	-0.149	-0.477	0.487*	0.331	0.053	-0.004	-0.175	0.228
Hemiptera	0.133	0.130	-0.163	0.056	-0.094	-0.086	-0.208	0.232	0.356*

*Values are significantly different ($p<0.05$).

CONCLUSION

Water quality parameters like temperature, pH, EC, alkalinity, free CO_2, DO, BOD, SDT were observed at fortnightly intervals. Maximum air temperature was recorded in month of June (42^0C) from all three villages while minimum air temperature of 14.5^0C was recorded from village Bhana in the month of January. The highest water temperature was observed in month of June (40^0C) and minimum in month of December and January (13^0C) from all the three ponds. pH fluctuated between 7 to 9 in all three village ponds being highest in Chambeli (8.83) and minimum in Pakka (6.92) in May. Village Bhana had highest EC (9.01 µS/cm) in May whereas lowest EC (1.06 µS/cm) was recorded from Chambeli in month of February. The DO values were increased in March (14.90 mg/L) and decreased in October(0.85 mg/L) in village Pakka. The observed free CO_2 highest in September (93.50mg/L) in Pakka while it was absent in most of the months in different village ponds. Maximum alkalinity was recorded from village Chambeli in May (29.50 mg/L) while minimum was recorded in April (5.00 mg/L) from Pakka. The BOD values were increased in village Bhana (34.50mg/L) in April whereas decreased in the month of January in village Bhana(11.00 mg/L). SDT ranged from 8-12cm in village Pakka, 40-68 cm in village Chambeli and 30-49 cm in village Bhana. It was observed that there were slight variations in the water quality parameters in three ponds and most of the parameters had great influence on abundance of aquatic insects.

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