CHAPTER-4
RESULTS AND DISCUSSION

The present study was conducted in the two years i.e. from April 2011 to March 2013. Six study stations of Narmada River were selected for the present research work.

Details of observations of Physico-chemical parameters are as follows:

- **Appearance** of water is considered as first basic sign of pollution. In study point I, II and III Water was in three visible form i.e. clear (April, May) muddy (May to October) and slightly green (November to March), while at study point IV, V & VI it was brownish which reflects its polluted nature (Table 1 to 12).

- **Odour** at study point I, II and III was odourless, while at study point IV, V and VI it was stricken which reflects its polluted nature (Table 1 to 12).

[1] WATER TEMPERATURE

STATION-I:

From April 2011 to March 2012, the water temperature was recorded from 15°C to 31.6°C. The minimum water temperature recorded was 15°C in December 2011 and maximum was 31.6°C in May 2011. The average water temperature through the year was 23.9°C with a standard deviation of 5.37. During April 2012 to March 2013 this fluctuation was between 16.2°C and 32.8°C. The minimum
water temperature was recorded 16.2°C in December 2012 and maximum of 32.8°C in May 2012. The average water temperature throughout the year was 24.91°C with a standard deviation of 5.47 (Table 01, 07 & Fig 01, 02).

**STATION-II:**

In the study period from April 2011 to March 2012, the water temperature was fluctuated between 18.4°C to 31.4°C, minimum in December 2011 and maximum in May 2011 with an average water temperature of 25.04 and standard deviation of 4.11. During April 2012 to March 2013 this fluctuation was 18.8°C and 31.8°C with minimum in December 2012 and maximum in May 2012 with an average water temperature of 25.77 and standard deviation of 4.02 (Table 02, 08 & Fig 01, 02).

**STATION-III:**

In the study period from April 2011 to March 2012, the surface water temperature was fluctuated between 18.5°C to 31.5°C, minimum in December 2011 and maximum in June 2011 with an average water temperature of 25.08 and standard deviation of 4.74. During April 2012 to March 2013 this fluctuation was 19.5°C and 33.4°C, minimum in December 2012 and maximum in May 2012 with an average water temperature of 26.13 and standard deviation of 4.83 (Table 03, 09 & Fig 01, 02).

**STATION-IV:**

In the study period from April 2011 to March 2012 the water temperature was fluctuated between 18.7°C to 30.2°C, minimum in January 2012 and maximum in April 2011 with an average water temperature of 26.04 and standard deviation of 4.07. During April 2012 to March 2013 this fluctuation was 19.7°C and 32.5°C,
minimum in January 2013 and maximum in July 2012 with an average water temperature of 26.63 and standard deviation of 4.01 (Table 04, 10 & Fig 01, 02).

**STATION-V:**

From April 2011 to March 2012, the water temperature was recorded from 19.5°C to 29.2°C. The minimum water temperature recorded was 19.5°C in January 2012 and maximum was 29.2°C in July 2011. The average water temperature through the year was 25.83°C with a standard deviation of 3.02. During April 2012 to March 2013 this fluctuation was between 20.5°C and 30.5°C. The minimum water temperature was recorded 20.5°C in January 2012 and maximum of 30.5°C in April 2012. The average water temperature throughout the year was 26.83°C with a standard deviation of 2.89 (Table 05, 11 & Fig 01, 02).

**STATION-VI:**

In the study period from April 2011 to March 2012, the water temperature was fluctuated between 19.8°C to 28.5°C, minimum in December 2011 and maximum in August 2011 with an average water temperature of 25.76 and standard deviation of 2.43. During April 2012 to March 2013 this fluctuation was 20.8°C and 29.3°C with minimum in December 2012 and maximum in April 2012 with an average water temperature of 26.71 and standard deviation of 2.47 (Table 06, 12 & Fig 01, 02).

The temperature varied between 15°C to 33.4°C. The minimum temperature of 15°C was recorded at Station-I in the month of December 2011 (Table 1 & Figure 1) and the maximum temperature 33.4°C was recorded in Station-III in the month of May 2012 (Table 3 & Figure 3). During the monsoon months it started lowering; this was because of cloudy weather and reduced availability of solar
radiation and short photoperiod. Jain and Sharma (2001), Yogesh and Pendse (2001) also reported the same type of fluctuation in various freshwater bodies. Ayodele and Ajani (1999) reported that tropical freshwaters had temperature values ranging from 21°C to 32°C. Duran (2006) observed temperature value between 6.1(Winter) to 22.3 (Summer) in Behzat Stream of Turkey. George et al., (2009) observed water temperature value between 28.90°C to 34.40°C in Okpoka Creek sediments, Niger Delta, Nigeria.

Kudthalang and Thanee (2010) observed the mean of water temperature ranged from 27.3±0.9°C to 30.4±1.7°C in the upper part of the Chi Basin. Varunprasath and Daniel (2010) observed temperature variation between 22°C to 29.5°C in Bhavani river Tamilnadu, India. Saksena et al., 2008 reported the low water temperature in winter, while highest was recorded in summer. Similar seasonal variation in water temperature was recorded by Batcha (1998) in river Cauvery, Singh et al., (1999) in river Ghaghara.

[2]. pH (HYDROGEN ION CONCENTRATION)

STATION-I:

In the study period From April 2011 to March 2012 the Hydrogen ion concentration (pH) was fluctuated between 7.40 to 8.39 minimum in November 2011 and maximum in September 2011 with an average pH of 7.84 and standard deviation of 0.33. During April 2012 to March 2013 this fluctuation was 7.65 and 8.45, minimum in April 2012 and maximum in July 2012 with an average pH of 7.89 and standard deviation of 0.45 (Table 01, 07 & Fig 03, 04).
STATION-II:

In the study period from April 2011 to March 2012 the pH was fluctuated between 5.2 to 6.5 minimum in June 2011 and maximum in March 2012 with an average pH of 5.78 and standard deviation of 0.39. During April 2012 to March 2013 this fluctuation was 4.8 and 6.8, minimum in April 2012 and maximum in March 2013 with an average pH of 5.70 and standard deviation of 0.63 (Table 02, 08 & Fig 03, 04).

STATION-III:

During April 2011 to March 2012 the Hydrogen ion concentration (pH) was fluctuated between 7.2 to 8.4 minimum in May 2011 and maximum in August 2011 and November 2011 with an average pH of 7.81 and standard deviation of 0.58. During April 2012 to March 2013 this fluctuation was 7.5 and 8.9, minimum in May 2012 and maximum in January 2013 with an average pH of 8.13 and standard deviation of 0.59 (Table 03, 09 & Fig 03, 04).

STATION-IV:

In the study period from April 2011 to March 2012 the pH was fluctuated between 3.1 to 4.4 minimum in November 2011 and January 2012 and maximum in March 2012 with an average pH of 3.53 and standard deviation of 0.42. During April 2012 to March 2013 this fluctuation was 3.2 and 4.8, minimum in November 2012 and maximum in March 2013 with an average pH of 3.67 and standard deviation of 0.42 (Table 04, 10 & Fig 03, 04).
STATION-V:

In the study period from April 2011 to March 2012, the Hydrogen ion concentration (pH) was fluctuated between 5.4 to 7.5 minimum in May 2011 and maximum in August 2011 with an average pH of 6.65 and standard deviation of 0.64. During April 2012 to March 2013 this fluctuation was 5.2 and 7.4, minimum in May 2012 and maximum in August 2012 with an average pH of 6.61 and standard deviation of 0.68 (Table 05, 11 & Fig 03, 04).

STATION-VI:

In the study period from April 2011 to March 2012 the pH was fluctuated between 6.4 to 7.9 minimum in June 2011 and maximum in August 2011, December 2011 and March 2012 with an average pH of 7.43 and standard deviation of 0.45. During April 2012 to March 2013 this fluctuation was 6.6 and 8.5, minimum in June 2012 and maximum in December 2012 with an average pH of 7.78 and standard deviation of 0.57 (Table 06, 12 & Fig 03, 04).

The value of Hydrogen ion concentration of the river varied between 3.1 to 8.9. The minimum pH value of 3.1 was recorded at Station-IV in the month of November 2011 (Table 4 & Figure 10) and the maximum pH was recorded in Station-III in the month of January 2013 (Table 09 & Fig 09). It was found S-II & S-IV acidic throughout the period of investigation, due to discharge from the factory, while again at downstream the pH is normal indicates the flow of water control the pH within 200 meter and It was found alkaline throughout the period of investigation. Adoni and Vaishya (1990); Singhai et al., (1989) registered alkaline pH in lentic water in India. The pH was at its higher side during January & February and it reached its first peak in the month of April. The pH of the water
started decreasing from May and it was lowest in the month of June which corresponds to low density of phytoplankton, resulting in reduced photosynthetic activity. During monsoon month the pH of water is low because at this time density of phytoplankton were low consequently the photosynthesis was low and there was constant flow of water due to rainfall and at this time mixed the industrial effluent in the river Narmada. The pH of Narmada River is in accordance with the findings of Ghose and Sharma (1988) and Singh and Rai (1999).

Swarnalatha and Narasingrao (1993) Observed the pH is one of the most important factors that serve as an index for the pollution. The average pH value of the lake water was 7.2 to 8.0. The pH of water was relatively high in the summer season and low in monsoon and winter season. However, when the average values for three seasons are taken into account the water body was found to be slightly alkaline. This is in accordance with earlier work by Wetzel (2001) who reported that the value of pH ranges from 8 to 9 units in Indian waters.

Saksena et al., 2008 reported The water in Chambal River was always alkaline throughout the period of study while Verma et al., 1998 have observed acidic nature of water of Subernarekha river due to discharge of copper industrial effluents in this river and it observed minimum pH value (7.60) was recorded in the month of October and maximum pH (9.33) was recorded at in the month of June. Soni et al., 2013 recorded minimum value (8.05) was noted at summer season and maximum value during winter of river Narmada.
[3]. TOTAL SOLIDS

STATION-I:

In the study period from April 2011 to March 2012, the Total Solids varied between 245mg/l. to 470mg/l, minimum in December 2011 and maximum in July 2011 with an average Total Solids of 303.83mg/l. and standard deviation of 75.33. During April 2012 to March 2013 this fluctuation was 264mg/l. and 475mg/l., minimum in February 2013 and maximum in July 2012 with an average Total Solids of 316.75mg/l. and standard deviation of 72.34 (Table 01, 07 & Fig 13).

STATION-II:

In the study period from April 2011 to March 2012, the Total Solids varied between 410mg/l. to 830mg/l, minimum in January 2012 and maximum in June 2011 with an average Total Solids of 602.67mg/l. and standard deviation of 124.08. During April 2012 to March 2013 this fluctuation was 415mg/l. and 870mg/l., minimum in January 2013 and maximum in June 2012 with an average Total Solids of 620mg/l. and standard deviation of 130.60 (Table 02, 08 & Fig 14).

STATION-III:

In the study period from April 2011 to March 2012, the Total Solids varied between 265mg/l. to 445mg/l., minimum in January 2012 and maximum in April 2011 and June 2011 with an average Total Solids of 366.58mg/l. and standard deviation of 67.15. During April 2012 to March 2013 this fluctuation was 275mg/l. and 465mg/l., minimum in January 2013 and maximum in June 2012 and August 2012 with an average Total Solids of 382.42mg/l. and standard deviation of 70.34 (Table 03, 09 & Fig 15).
STATION-IV:

In the study period from April 2011 to March 2012, the Total Solids varied between 85040mg/l. to 198644mg/l., minimum in April 2011 and maximum in January 2012 with an average Total Solids of 147793.8mg/l. and standard deviation of 91531.06. During April 2012 to March 2013 this fluctuation was 84040mg/l. and 375975mg/l., minimum in April 2012 and maximum in February 2013 with an average Total Solids of 147900.5mg/l. and standard deviation of 91490.22 (Table 04, 010 & Fig 16).

STATION-V:

In the study period from April 2011 to March 2012, the Total Solids varied between 42865mg/l. to 98495mg/l, minimum in September 2011 and maximum in November 2011 with an average Total Solids of 64553.58mg/l. and standard deviation of 21121.72. During April 2012 to March 2013 this fluctuation was 42885mg/l. and 98498mg/l., minimum in September 2012 and maximum in November 2012 with an average Total Solids of 64625.25mg/l. and standard deviation of 21101.27 (Table 05, 11 & Fig 17).

STATION-VI:

In the study period from April 2011 to March 2012, the Total Solids varied between 13456mg/l. to 36587mg/l, minimum in September 2011 and maximum in May 2011 with an average Total Solids of 22907.25mg/l. and standard deviation of 9496.92. During April 2012 to March 2013 this fluctuation was 13466mg/l. and 36597mg/l., minimum in September 2012 and maximum in May 2012 with an average Total Solids of 22929.75mg/l. and standard deviation of 9506.44 (Table 06, 12 & Fig 18).
**Total Solids** fluctuated from 245 mg/l. to 375975 mg/l. The minimum Total Solids value of 245mg/l. was recorded at Station-I in the month of December 2011 (*Table 1 & Figure 1*) and the maximum Total Solids 375975mg/l. was recorded in Station-IV in the month of February 2013 (*Table 10 & Fig 16*). Similar results was observed In river Kali total solids were represented upto 2460mg/l. George (1976) and upto 2545mg/l. and Saxena *et al.*, 2008 reported that total solids range from 322 to 4997mg/l. in river Ganga near Kanpur. Sharma and Diwan (1997) have observed total solids from 409.15 to 827.60mg/l. In river Narmada at Maheshwar.

**[4]. DISSOLVED SOLIDS**

**STATION-I:**

In the study period from April 2011 to March 2012, the Dissolved Solids varied between 200mg/l. to 268mg/l., minimum in March 2012 and maximum in July 2011 with an average Dissolved Solids of 229.92mg/l. and standard deviation of 19.20. During April 2012 to March 2013 this fluctuation was 230mg/l. and 285mg/l., minimum in June 2012 and November 2012 and maximum in February 2013 with an average Dissolved Solids of 256.66mg/l. and standard deviation of 18.59 (*Table 01, 07 & Fig 19*).

**STATION-II:**

In the study period from April 2011 to March 2012, the Dissolved Solids varied between 170mg/l. to 445mg/l., minimum in January 2012 and maximum in April 2011 with an average Dissolved Solids of 308.08mg/l. and standard deviation of 90.39. During April 2012 to March 2013 this fluctuation was 180mg/l. and 455mg/l., minimum in January 2013 and maximum in April 2012, July 2012 and
February 2013 with an average Dissolved Solids of 327.33mg/l. and standard deviation of 95.64 (Table 02, 08 & Fig 20).

**STATION-III:**

In the study period from April 2011 to March 2012, the Dissolved Solids varied between 145mg/l. to 265mg/l, minimum in January 2012 and maximum in December 2011 with an average Dissolved Solids of 208.5mg/l. and standard deviation of 37.37. During April 2012 to March 2013 this fluctuation was 147mg/l. and 268mg/l., minimum in January 2013 and maximum in December 2012 with an average Dissolved Solids of 213.67mg/l. and standard deviation of 37.45 (Table 03, 09 & Fig 21).

**STATION-IV:**

In the study period from April 2011 to March 2012, the Dissolved Solids varied between 74124mg/l. to 132457mg/l., minimum in April 2011 and maximum in February 2012 with an average Dissolved Solids of 91872.5mg/l. and standard deviation of 16503.37. During April 2012 to March 2013 this fluctuation was 47134mg/l. and 132477mg/l., minimum in April 2012 and maximum in February 2013 with an average Dissolved Solids of 91896mg/l. and standard deviation of 16519.76 (Table 04, 10 & Fig 22).

**STATION-V:**

In the study period from April 2011 to March 2012, the Dissolved Solids varied between 35915mg/l. to 92975mg/l., minimum in July 2011 and maximum in November 2011 with an average Dissolved Solids of 47492mg/l. and standard deviation of 15450.35. During April 2012 to March 2013 this fluctuation was 35975mg/l. and 92995mg/l., minimum in July 2012 and maximum in November
2012 with an average Dissolved Solids of 47532.83 mg/l. and standard deviation of 15436.89 (Table 05, 11 & Fig 23).

**STATION-VI:**

In the study period from April 2011 to March 2012, the Dissolved Solids varied between 10488 mg/l. to 32785 mg/l., minimum in September 2011 and maximum in June 2011 with an average Dissolved Solids of 19535.92 mg/l. and standard deviation of 9418.43. During April 2012 to March 2013 this fluctuation was 10788 mg/l. and 32985 mg/l., minimum in September 2012 and maximum in May 2012 with an average Dissolved Solids of 19719.25 mg/l. and standard deviation of 9408.69 (Table 06, 12 & Fig 24).

In general, Dissolved Solids showed variation 145 mg/l. to 132477 mg/l. The minimum Dissolved Solids value of 145 mg/l. was recorded at Station-III in the month of January 2012 (Table 3 & Figure 21) and the maximum Dissolved Solids 132477 mg/l. was recorded in Station-IV in the month of February 2013. (Table 10 & Fig 22) Results indicates that concentration of Dissolved solids become high in less amount of water in summer season and during the mixing with industrial effluent and in monsoon season at this site become fully loaded by rainy water so dissolved values occurred lowest. Singh (2010) observed dissolved solids was recorded highest and lowest value was fluctuated up to 310 to 390 mg/l. recorded in Jan. to April 2009-10 & 2010-11, but the value of dissolved solids showed increasing trends in month of Jan. to April. of whole studied periods and all the studied whereas (Ahmed 2004) noticed the dissolved solids were more in monsoon and less in summer. Saksena et al., 2008 recorded in Chambal river Minimum total dissolved solids (260 mg/l.) was recorded while maximum value (500 mg/l.) was recorded in the month of September. Soni et al., 2013 recorded The
TDS values varied from 228 mg/l. to 357mg/l. Its highest value was observed in monsoon season.

[5]. SUSPENDED SOLIDS

STATION-I:

In the study period from April 2011 to March 2012, the Suspended Solids varied between 26mg/l. to 240mg/l, minimum in December 2011 and maximum in June 2011 with an average Suspended Solids of 78.08mg/l. and standard deviation of 69.87. During April 2012 to March 2013 this fluctuation was 29mg/l. and 270mg/l., minimum in December 2012 and maximum in June 2012 with an average Suspended Solids of 83.58mg/l. and standard deviation of 72.32 (Table 01, 07 & Fig 25).

STATION-II:

In the study period from April 2011 to March 2012, the Suspended Solids varied between 185mg/l. to 620mg/l, minimum in October 2011 and maximum in June 2011 with an average Suspended Solids of 336.08mg/l. and standard deviation of 11.19. During April 2012 to March 2013 this fluctuation was 190mg/l. and 630mg/l., minimum in October 2012 and maximum in June 2012 with an average Suspended Solids of 352.58mg/l. and standard deviation of 126.74 (Table 02, 08 & Fig 26).

STATION-III:

In the study period from April 2011 to March 2012, the Suspended Solids varied between 70mg/l. to 385mg/l, minimum in October 2011 and maximum in June 2011 with an average Suspended Solids of 173.33mg/l. and standard
deviation of 82.02. During April 2012 to March 2013 this fluctuation was 90mg/l. and 395mg/l., minimum in October 2012 and maximum in June 2012 with an average Suspended Solids of 184.42mg/l. and standard deviation of 81.11 (Table 03, 09 & Fig 27).

STATION-IV:

In the study period from April 2011 to March 2012, the Suspended Solids varied between 10345mg/l. to 244112mg/l, minimum in September 2011 and maximum in February 2012 with an average Suspended Solids of 65433mg/l. and standard deviation of 81777.33. During April 2012 to March 2013 this fluctuation was 10445mg/l. and 244312mg/l., minimum in September 2012 and maximum in February 2013 with an average Suspended Solids of 65583.25mg/l. and standard deviation of 81954.93 (Table 04, 10 & Fig 28).

STATION-V:

In the study period from April 2011 to March 2012, the Suspended Solids varied between 6678mg/l. to 48895mg/l, minimum in October 2011 and maximum in January 2012 with an average Suspended Solids of 17120.08mg/l. and standard deviation of 13770.22. During April 2012 to March 2013 this fluctuation was 6679mg/l. and 48898mg/l., minimum in November 2012 and maximum in January 2013 with an average Suspended Solids of 17224.42mg/l. and standard deviation of 13710.08 (Table 05, 11 & Fig 29).

STATION-VI:

In the study period from April 2011 to March 2012, the Suspended Solids varied between 2189mg/l. to 4580mg/l, minimum in February 2012 and maximum in November 2011 with an average Suspended Solids of 3324.75mg/l. and standard
deviation of 733.14. During April 2012 to March 2013 this fluctuation was 2199mg/l. and 4590mg/l., minimum in February 2013 and maximum in November 2012 with an average Suspended Solids of 3350.08mg/l. and standard deviation of 730.30 (Table 06, 12 & Fig 30).

In general Suspended Solids showed variation from 26mg/l. to 244312mg/l. The minimum Suspended Solids value of 26mg/l. was recorded at Station-I in the month of December 2011 (Table 1 & Figure 25) and the maximum Suspended Solids 244312mg/l. was recorded in the month of February 2013 (Table 10 & Fig 28). The factory effluent were flushed in the river and hence the suspended particles increase with in short duration. Mishra et al., 1999 observed range of suspended solids 182 to 375mg/l. In river Narmada at Maheshwar; Shrivastava (1999) recorded the suspended solids was ranged from 25 to 96mg/l. respectively.

[5]. CHLORIDE

STATION-I:

In the study period from April 2011 to March 2012, the Chloride varied between 11mg/l. to 27mg/l, minimum in March 2012 and maximum in July 2011 with an average Chloride of 17.8mg/l. and standard deviation of 5.34. During April 2012 to March 2013 this fluctuation was 10mg/l. and 27.4mg/l., minimum in October 2012 and maximum in August 2012 with an average Chloride of 18.3mg/l. and standard deviation of 5.63 (Table 01, 07 & Fig 31).

STATION-II:

In the study period from April 2011 to March 2012, the Chloride varied between 33mg/l. to 70mg/l, minimum in January 2012 and maximum in April 2011 with an average Chloride of 46.92mg/l. and standard deviation of 11.19.
During April 2012 to March 2013 this fluctuation was 30mg/l. and 80mg/l., minimum in January 2013 and maximum in April 2012 with an average Chloride of 45.83mg/l. and standard deviation of 13.27 (Table 02, 08 & Fig 32).

STATION-III:

In the study period from April 2011 to March 2012, the Chloride varied between 14mg/l. to 45mg/l, minimum in October 2011 and January 2012 and maximum in May 2011 with an average Chloride of 26.5mg/l. and standard deviation of 10.43. During April 2012 to March 2013 this fluctuation was 24mg/l. and 55mg/l., minimum in October 2012 and January 2013 and maximum in May 2012 with an average Chloride of 35.92mg/l. and standard deviation of 10.89 (Table 03, 09 & Fig 33).

STATION-IV:

In the study period from April 2011 to March 2012, the Chloride varied between 7410mg/l. to 14258mg/l, minimum in May 2011 and maximum in February 2012 with an average Chloride of 10328.83mg/l. and standard deviation of 2592.14. During April 2012 to March 2013 this fluctuation was 7610mg/l. and 14278mg/l., minimum in May 2012 and maximum in February 2013 with an average Chloride of 10450.5mg/l. and standard deviation of 2534.23 (Table 04, 10 & Fig 34).

STATION-V:

In the study period from April 2011 to March 2012, the Chloride varied between 6100mg/l. to 15000mg/l, minimum in May 2011 and maximum in November 2011 with an average Chloride of 8358.33mg/l. and standard deviation of 2642.13. During April 2012 to March 2013 this fluctuation was 6000mg/l. and
15400mg/l., minimum in May 2012 and maximum in November 2012 with an average Chloride of 8508.33mg/l. and standard deviation of 2814.39 (Table 05, 11 & Fig 35).

**STATION-VI:**

In the study period from April 2011 to March 2012, the Chloride varied between 3200mg/l. to 9000mg/l, minimum in March 2012 and maximum in October 2011 with an average Chloride of 5141.67mg/l. and standard deviation of 1504.82. During April 2012 to March 2013 this fluctuation was 3300mg/l. and 8500mg/l., minimum in March 2013 and maximum in October 2012 with an average Chloride of 4925mg/l. and standard deviation of 1355.88 (Table 06, 12 & Fig 36).

Chloride varied from 10mg/l. to 15400mg/l. The minimum Chloride value of 10mg/l. was recorded at Station-I in the month of October 2012 (Table 7 & Figure 31) and the maximum Chloride 15400mg/l. was recorded in Station-V in the month of November 2012 (Table 11 & Fig 35). This was due to drainage of rain water from the catchments which brought pollutants of animal origin and mixed untreated Industrial effluent and drainage of sewage by connecting nallah. During the present study increased chloride value was observed highly toxic substance in the river so it become unsuitable for the existence of fishes and it may cause skin disease in fishes. Similar kind of observations were reported by Zafar (1972) in his work conducted in Hyderabad and Wanganeo (1980) in their work conducted at Lower Lake of Bhopal.

Nandan and Jain (2002) observed 11.36 to 49.5 mg/l. of chloride content in river Mousam. Prakash (2007) noticed 11.00-26.00mg/l. of chloride in river
Narmada at Khedi Ghat (Barwaha). The chloride contents indicate domestic as well as industrial pollution. Soni et al., 2013 recorded The values of chloride contents ranged between 18 mg/l. to 26 mg/l. respectively Low level of chloride at other sites indicated no human interference similar results have been observed by Ahmad (2004).

Similar results were recorded Sisodiya and Moundiotiya (2006) chloride value between 25.79 mg/l. to 55.05 mg/l. in Kalakho Lake, Rajasthan. Duran (2007) observed Chloride value between 0.76 to 5.86 in Behzat Stream in Turkey. Sharma et al., (2008) recorded Chloride between 12.8 to 28.7 mg/l in Ningland stream, India.

[6]. DISSOLVED OXYGEN

STATION-I:

In the study period From April 2011 to March 2012 the dissolved oxygen was fluctuated between 5.2 mg/l. to 12.4 mg/l., minimum in July 2011 and maximum in November 2011 with an average DO of 8.65 mg/l. and standard deviation of 2.59. During April 2012 to March 2013 this fluctuation was 5.5 mg/l. and 11.2 mg/l., minimum in July 2012 and maximum in November 2012 with an average DO of 7.82 mg/l and standard deviation of 1.75 (Table 01, 07 & Fig 37).

STATION-II:

In the study period From April 2011 to March 2012 the dissolved oxygen was fluctuated between 4.8 mg/l. to 7.4 mg/l., minimum in October 2011 and maximum in June 2011 with an average DO of 5.83 mg/l. and standard deviation of 0.82. During April 2012 to March 2013 this fluctuation was 4.3 mg/l. and 7.0
mg/l, minimum in February 2013 and maximum in June 2012 with an average DO of 5.53 mg/l and standard deviation of 0.80 (Table 02, 08 & Fig 38).

**STATION-III:**

In the study period From April 2011 to March 2012 the dissolved oxygen was fluctuated between 6.5 mg/l. to 11.2 mg/l., minimum in September 2011 and maximum in June 2011 with an average DO of 8.04 mg/l. and standard deviation of 1.43. During April 2012 to March 2013 this fluctuation was 6.0 mg/l. and 10.2 mg/l., minimum in September 2012 and maximum in June 2012 with an average DO of 7.53 mg/l and standard deviation of 1.33 (Table 03, 09 & Fig 39).

In general, **Dissolved Oxygen** showed variation between 4.3 mg/l. to 12.4 mg/l. The Dissolved Oxygen totally absent in just after the discharge by factory S-IV, S-V and S-VI. The zero level of DO is very significant and it makes the water unsuitable for any existence of biological life. The minimum Dissolved Oxygen value of 4.3 mg/l. was recorded at Station-II in the month of February 2013 (Table 8 & Figure 38) and the maximum Dissolved Oxygen 12.4 mg/l. was recorded in Station-I in the month of November 2011 (Table 01 & Figure 37). The value of DO in river was lowest in the month of January & February and from March it started increasing & reached its first peak in the month of April, but started declining gradually from the month of May and reached the lowest value in the month of June. Then from the month of August the value of DO started increasing gradually and reached its second peak in the month of November & December. Whenever there was an increase in the photosynthetic activities of phytoplankton, a corresponding increase in the values of DO was observed. Ganapati (1960) has also reported that the increased photosynthetic activity is the main source for the increase in DO. This present result was in conformity with Mohan *et al.*, 2013 in
River Tawi in vicinity of Udhampur city (J & K) India. Verma and Shukla (1978) observed that at high temperature the dissolved oxygen was low. This might be due to the low solubility of oxygen at a high temperature. In the present investigation there is direct relation between temperature and DO.

In the present study it is reported the minimum value of dissolved oxygen was recorded as 4.86 mg/l. in the month of August and maximum recorded as 14.59 mg/l. in the month of November. This level of oxygen in the river should be able to support good fauna and flora. Similar observation was recorded by Singh and Rai (1999) in river Ganga, Hiware and Jadhav (2001) in river Manjar.

[7]. BIOLOGICAL OXYGEN DEMAND

STATION-I:

During April 2011 to March 2012 the biological oxygen demand was fluctuated between 2.4 mg/l. to 13.4 mg/l., minimum in January 2012 and maximum in June 2011 with an average BOD of 5.03 mg/l and standard deviation of 3.67. During April 2012 to March 2013 this fluctuation was 2.6 mg/l. and 12.4 mg/l. with minimum in January 2013 and maximum in June 2012 with an average BOD of 4.92 mg/l. and standard deviation of 3.25 (Table 01, 07 & Fig 40).

STATION-II:

During April 2011 to March 2012 the biological oxygen demand was fluctuated between 6.9 mg/l. to 18.5 mg/l., minimum in January 2012 and maximum in April 2011 with an average BOD of 11.34 mg/l. and standard deviation of 4.31. During April 2012 to March 2013 this fluctuation was 5.4 mg/l. and 19.5 mg/l. with minimum in October 2012 and maximum in April 2012 with
an average BOD of 12.02 mg/l. and standard deviation of 4.39 (Table 02, 08 & Fig 41).

**STATION-III:**

During April 2011 to March 2012 the biological oxygen demand was fluctuated between 3.7 mg/l. to 14.2 mg/l., minimum in October 2011 and maximum in April 2011 with an average BOD of 8.23 mg/l. and standard deviation of 4.08. During April 2012 to March 2013 this fluctuation was 4.7 mg/l. and 15.2 mg/l. with minimum in October 2012 and maximum in April 2012 with an average BOD of 9.39 mg/l. and standard deviation of 4.09 (Table 03, 09 & Fig 42).

**STATION-IV:**

During April 2011 to March 2012 the biological oxygen demand was fluctuated between 12000 mg/l. to 75100 mg/l., minimum in August 2011 and maximum in June 2011 with an average BOD of 36583.33 mg/l. and standard deviation of 18622.17. During April 2012 to March 2013 this fluctuation was 13500 mg/l. and 77100 mg/l. with minimum in August 2012 and maximum in June 2012 with an average BOD of 37541.67 mg/l. and standard deviation of 18768.23 (Table 04, 10 & Fig 43).

**STATION-V:**

During April 2011 to March 2012 the biological oxygen demand was fluctuated between 6000 mg/l. to 33000 mg/l., minimum in August 2011 and maximum in February 2012 with an average BOD of 15850 mg/l. and standard deviation of 8912.15. During April 2012 to March 2013 this fluctuation was 7300 mg/l. and 33600 mg/l. with minimum in April 2012 and maximum in February 2013 with an average BOD of 16175 mg/l. and standard deviation of 9048.67 (Table 05, 11 & Fig 44).
STATION-VI:

During April 2011 to March 2012 the biological oxygen demand was fluctuated between 11000 mg/l. to 16580 mg/l., minimum in March 2012 and maximum in April 2011 with an average BOD of 13962.5 mg/l. and standard deviation of 1629.91. During April 2012 to March 2013 this fluctuation was 11990 mg/l. and 15860 mg/l. with minimum in September 2012 and maximum in February 2013 with an average BOD of 14285 mg/l. and standard deviation of 1666.38 (Table 06, 12 & Fig 45).

**Biochemical Oxygen Demand** varied between 2.4 mg/l. to 59800 mg/l. The minimum BOD value of 2.4mg/l. was recorded at Station-I in the month of January 2012 (Table 1 & Figure 40) and the maximum BOD 59800mg/l. was recorded in Station-IV in the month of February 2013. (Table 10 & Fig 43). The high value of BOD indicate pollution in the water and number of Zooplankton is increased in this particular stretch in the river. it means due to dilution BOD again reduced to normal. The values of BOD were also reported by many other workers such as Pathak and Mudgal (2005), Khanna and Bhatia (2003). The high level of BOD might have been attributed to the discharge of pollutants into the river through washing, sewage contamination, industrial affluent and a like. This present result was in conformity with Sisodiya and Moundiotiya (2006) in Kalakho Lake, Rajasthan; Balachandran *et al.*, (2012) in Bangalore Lake at Karnataka; Efe Ogidiaka (2012) recorded in Ogunpa River at Bodija, Ibadan, Oyo state and Prabhakar *et al.*, (2012) in Palar River, Vellore district Tamilnadu.
[8]. CHEMICAL OXYGEN DEMAND

STATION-I:

During April 2011 to March 2012 the Chemical oxygen demand was fluctuated between 10mg/l. to 47mg/l., minimum in January 2012 and maximum in June 2011 with an average COD of 18.75 mg/l. and standard deviation of 10.34. During April 2012 to March 2013 this fluctuation was 12 mg/l. and 49 mg/l. with minimum in January 2013 and maximum in June 2012 with an average COD of 20.83 mg/l. and standard deviation of 10.19 (Table 01, 07 & Fig 46).

STATION-II:

During April 2011 to March 2012 the Chemical oxygen demand was fluctuated between 34mg/l. to 70mg/l., minimum in August 2011 and maximum in April 2011 with an average COD of 52.92mg/l. and standard deviation of 12.42. During April 2012 to March 2013 this fluctuation was 45mg/l. and 80mg/l. with minimum in June 2012 and November 2012 and maximum in April 2012 with an average COD of 59.25 mg/l. and standard deviation of 11.83 (Table 02, 08 & Fig 47).

STATION-III:

During April 2011 to March 2012 the Chemical oxygen demand was fluctuated between 22mg/l. to 65mg/l., minimum in August 2011 and November 2011 and maximum in April 2011 with an average COD of 33.37mg/l. and standard deviation of 15.07. During April 2012 to March 2013 this fluctuation was 15.5mg/l. and 75mg/l. with minimum in October 2012 and maximum in April 2012 with an average COD of 36.54mg/l. and standard deviation of 16.44 (Table 03, 09 & Fig 48).
**STATION-IV:**

During April 2011 to March 2012 the Chemical oxygen demand was fluctuated between 5000mg/l. to 95000mg/l., minimum in July 2011 and maximum in November 2011 with an average COD of 63359.17mg/l. and standard deviation of 36936.69. During April 2012 to March 2013 this fluctuation was 7000mg/l. and 160000mg/l. with minimum in July 2012 and maximum in February 2013 with an average COD of 76742.5mg/l. and standard deviation of 42329.73 (Table 04, 10 & Fig 49).

**STATION-V:**

During April 2011 to March 2012 the Chemical oxygen demand was fluctuated between 4700mg/l. to 56000mg/l., minimum in June 2011 and March 2012 and maximum in February 2012 with an average COD of 36580mg/l. and standard deviation of 19550.2. During April 2012 to March 2013 this fluctuation was 4800mg/l. and 57000mg/l. with minimum in March 2013 and maximum in February 2013 with an average COD of 37588.33mg/l. and standard deviation of 19780.34 (Table 09, 11 & Fig 50).

**STATION-VI:**

During April 2011 to March 2012 the Chemical oxygen demand was fluctuated between 1000mg/l. to 4200mg/l., minimum in January 2012 and March 2012 and maximum in June 2011 with an average COD of 2266.67mg/l. and standard deviation of 1176.54. During April 2012 to March 2013 this fluctuation was 1200mg/l. and 4400mg/l. with minimum in January 2013 and March 2013 and maximum in June 2012 with an average COD of 2450mg/l. and standard deviation of 1174.35 (Table 06, 12 & Fig 51).
**Chemical Oxygen Demand** varied between 10 mg/l. to 160000 mg/l. The minimum COD value of 10mg/l. was recorded at Station-I in the month of January 2012 ([Table 1 & Figure 46](#)) and the maximum COD 160000mg/l. was recorded in Station- IV in the month of February 2013 ([Table 10 & Fig 49](#)) Quantity of COD increased many folds in polluted water.

Mishra and Saxena (1998) reported COD as a reliable parameters for judging the extent of pollution in water. Verma and Dalela (1975) and Ajmal et al., 1985 have reported maximum value of COD in Kainadi during summer, while Dakshini and Soni (1979) observed maximum COD at 45.20mg/l. in Rajghat drain entering Yamuna at Delhi.

Mahadevan and Krishnaswamy (1983) found COD upto 108.6mg/l. in river Vaigai. Shah and Pandit (1988) observed minimum and maximum COD values in April and December respectively with moderate values. Ghose and Sharma (1988) have recorded 10.0 t 45.0mg/l. COD in river Ganga at Patna. Mishra and Saxena (1998) in Morar river (Gwalior) reported maximum value of COD 182.0mg/l. in April and minimum value 16.0mg/l. in November. In river Narmada at Maheshwar COD value ranged between 18.0 to 64.0mg/l. Shrivastava (1999).

[10]. **POTASSIUM**

**STATION-I:**

During April 2011 to March 2012 the Potassium was fluctuated between 0.28mg/l. to 0.85mg/l., minimum in July 2011 and maximum in June 2011 and December 2011 with an average Potassium of 0.65 mg/l. and standard deviation of 0.21. During April 2012 to March 2013 this fluctuation was 0.35mg/l. and 0.95 mg/l. with minimum in July 2012 and maximum in September 2012 with an
average Potassium of 0.64 mg/l. and standard deviation of 0.18 (Table 01, 07 & Fig 52).

**STATION-II:**

During April 2011 to March 2012 the Potassium was fluctuated between 2.7 mg/l. to 8.5 mg/l., minimum in November 2011 and maximum in June 2011 with an average Potassium of 5.28 mg/l. and standard deviation of 2.02. During April 2012 to March 2013 this fluctuation was 2.2 mg/l. and 8.0 mg/l. with minimum in February 2013 and maximum in June 2012 with an average Potassium of 4.92 mg/l. and standard deviation of 2.03 (Table 02, 08 & Fig 53).

**STATION-III:**

During April 2011 to March 2012 the Potassium was fluctuated between 1.2 mg/l. to 4.5 mg/l., minimum in December 2011 and maximum in May 2011 with an average Potassium of 2.49 mg/l. and standard deviation of 1.18. During April 2012 to March 2013 this fluctuation was 1.3 mg/l. and 3.5 mg/l. with minimum in December 2012 and maximum in May 2012 with an average Potassium of 2.19 mg/l. and standard deviation of 0.86 (Table 03, 09 & Fig 54).

**STATION-IV:**

During April 2011 to March 2012 the Potassium was fluctuated between 5700 mg/l. to 8500 mg/l., minimum in March 2012 and maximum in February 2012 with an average Potassium of 7287.5 mg/l. and standard deviation of 688.91. During April 2012 to March 2013 this fluctuation was 5900 mg/l. and 8600 mg/l. with minimum in March 2013 and maximum in February 2013 with an average Potassium of 7512.5 mg/l. and standard deviation of 677.60 (Table 04, 10 & Fig 55).
**STATION-V:**

During April 2011 to March 2012 the Potassium was fluctuated between 4500mg/l. to 6900mg/l., minimum in March 2012 and maximum in November 2011 with an average Potassium of 5800mg/l. and standard deviation of 748.33. During April 2012 to March 2013 this fluctuation was 5500mg/l. and 7000mg/l. with minimum in September and March 2013 and maximum in November 2012 with an average Potassium of 6250mg/l. and standard deviation of 509.01 (Table 05, 11 & Fig 56).

**STATION-VI:**

During April 2011 to March 2012 the Potassium was fluctuated between 1000mg/l. to 4200mg/l., minimum in March 2012 and maximum in June 2011 with an average Potassium of 2322.5mg/l. and standard deviation of 1169.97. During April 2012 to March 2013 this fluctuation was 1100mg/l. and 4100mg/l. with minimum in March 2013 and maximum in June 2012 with an average Potassium of 2422.5mg/l. and standard deviation of 1111.96 (Table 06, 12 & Fig 57).

Potassium of the river varied between 0.28mg/l. to 8600mg/l. the minimum Potassium value of 0.28mg/l. was recorded at Station-I in the month of July 2011 (Table 1 & Figure 52) and the maximum Potassium 8600mg/l. was recorded in Station- IV in the month of February 2013 (Table 10 & Fig 55). Dakshini and Soni 1979 observed potassium from 3.75 to 31.80 mg/l. in sewage drains entering into Yamuna at Delhi. Somashakhar and Survama (2000) in river Cauvery reported sodium as 3.75mg/l. Shyamsunder (1988) has recorded maximum potassium as 1.04mg/l. in Jhelum river, while Shah and Pandit (1988) observed maximum value as 10.48mg/l. Mishra and Saxena (1998) reported highest value of potassium as 18.8mg/l. Shrivastava (1999) reported potassium value varied from 0.35 to 9.44mg/l. in river Narmada at Maheshwar.
Studied of Limnochemical characteristics in river Ghaghara in U.P. Singh et al., 1999. Physicochemical properties of water samples from Manipur river system, India reported Singh et al., 2010. Distillery units producing alcohol are major revenue-earning enterprises. Alcohol is produced from sugarcane molasses. The molasses is fermented with yeast and alcohol is distilled from fermented wash, leaving behind a large volume of foul-smelling coloured waste water, generally known as spent wash or distillery effluent. The proportion of spent wash is nearly 14–15 times the total alcohol production. As there are large number of distilleries spread all over the world, large quantities of this effluent are produced (Manonmani et al., 1990, Arindam and Prasad 1999; Raghukumar et al., 2004). The disposal of large quantities of distillery effluent poses environmental problems, as it contains a considerable amount of organic material and has high biological oxygen demand (BOD) and chemical oxygen demand (COD). Due to the high BOD of raw spent wash, the application of an anaerobic treatment technology with biogas recovery has been reported to be highly effective (Nandy et al., 2002 and Yusuff & Sonibare 2004). Study on Limno-chemistry of river Ganga and some of its major tributaries Singh et al., 1999 and Water Quality Assessment of surface and sub-surface water of Damodar river basin, India reported Singh (2002).

Impact of distillery effluents on water quality of river Gelabil Assam reported Ayyasamy et al., 1993. Narmada river water no comprehensive treatment has yet been elaborated Panday et al., 2007. Even with the best available waters is black, foul-smelling and has very high levels of BOD, COD, TDS and soluble salts. This shows that distillery at Barwaha is not following proper treatment of the effluent. Thus, an urgent attention of the factory management authority, local
administration and pollution control board is needed to save the Narmada River from pollution.

**Correlation between Temperature with D.O. and BOD (Table 43 & Table 44)**

Correlation between Temperature and D.O. (2011-12) at station-I was observed as $r = -0.8794$. Thus D.O. showed high negative correlation with Temperature. Correlation between Temperature and D.O. at station-II was observed as $r = 0.5335$. Thus D.O. showed moderate positive correlation with Temperature. Correlation between Temperature and B.O.D. at station-I was observed as $r = 0.5942$. Thus B.O.D. showed moderate positive correlation with Temperature. Correlation between Temperature and B.O.D. at station-II was observed as $r = 0.6565$. Thus B.O.D. showed moderate positive correlation with Temperature. Correlation between Temperature and B.O.D. at station-III was observed as $r = 0.5762$. Thus B.O.D. showed moderate positive correlation with Temperature. Correlation between Temperature and D.O.(2012-13) at station-I was observed as $r = -0.7753$. Thus D.O. showed high negative correlation with Temperature. Correlation between Temperature and B.O.D. at station-I was observed as $r = 0.5751$. Thus B.O.D. showed moderate positive correlation with Temperature. Correlation between Temperature and B.O.D. at station-II was observed as $r = 0.6678$. Thus B.O.D. showed moderate positive correlation with Temperature. Correlation between Temperature and B.O.D. at station-III was observed as $r = 0.5457$. Thus B.O.D. showed moderate positive correlation with Temperature.

Roy (1955); Lakshminarayan (1965); Lewkowicz (1974) and Wanganeo (1980) observed a good correlation between phytoplankton and oxygen concentration, and explained this on the basis of photosynthetic activity.
BIOLOGICAL ANALYSIS:-

Planktons:- In the present study planktons were represented by Phytoplankton and Zooplankton.

PHYTOPLANTON:-

Phytoplankton is a fundamental component of aquatic ecosystem and major source of biologically important and labile organic carbon, located at the base of the food chain. The density and productivity of the phytoplankton are greatly influence by different physico-chemical characteristics of water. In the present study the phytoplankton population was found comprising of four major groups; Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae. In the present investigation 30 species of phytoplankton have been recorded of which 14 belong to Chlorophyceae, 9 to Bacillariophyceae, 6 to Cyanophyceae, and 1 to Euglenophyceae. The percentage of Phytoplankton is given in (Table 45).

DISTRIBUTION OF PHYTOPLANTON

In year 2011-12 the total number of phytoplankton recorded at this river was 54474 No./l. while During 2012-2013 the total phytoplankton recorded was 44794 No./l. The phytoplanktons were represented by four groups i.e. Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae. Overall the group Chlorophyceae dominated in the present study. The order of dominance was as:-

Chlorophyceae>Bacillariophyceae>Cyanophyceae>Euglenophyceae
**Chlorophyceae:**

The green algae were represented by highest number of genera during summer season and total fourteen sp. was present out of which dominant species were *Cosmarium sp.*, *Scenedesmus sp.*, *Chlorella sp.* and *Spirogyra sp.* These constituted 46 to 47% of the total population. During 2011-2012 this group contributed total 25445 Unit/l. to the total phytoplankton. The range of minimum 786 Unit/l. at sampling station S2 to maximum 8965 Unit/l. at sampling station S1. In the 2012-2013 this group contributed total 20730 Unit/l. to the total phytoplankton. The range varied from minimum 6058 Unit/l. at sampling station S3 to maximum 7684 Unit/l. at sampling station S1. Chlorophyceae illustrated peak in summer months and *Cosmarium sp.*, *Scenedesmus sp.*, *Oedogonium sp.*, *Spirogyra sp.*, and *Chlorella sp.* were the most dominant amongst Chlorophyceae (Table 13, 17, 21 & 25, 29, 33). Similar results was reported earlier by Bhowmick and Singh (1985) in river Ganga. Mehra (1986) observed maximum growth of chlorophyceae during warmer months of the year. This view was agreed in the present studies of river Narmada.

During the study period This group was dominated by *Cosmarium sp*. These genera are pollution tolerating genera (Palmer 1980). The ability of chlorophycean algae to withstand against the pollution load has been reported by Palmer (1969). Sharma *et al.*, 2013 observed The Chlorophyceae (green algae) will the dominant group among the phytoplanktons recorded during the study period river Narmada at Omkareshwar. However, this group dominated during winter and summer months and considerably were very low in number during rainy months of the both years.
**Bacillariophyceae:**

The group Bacillariophyceae constitutes the diatoms and it characteristics of lentic water bodies specially the river. Diatoms were represented by nine genera. These constituted 29 to 30% of the total population. During 2011-12 Bacillariophyceae contributed total 15987 Unit/l. to the total phytoplankton. This group ranged between minimum 4660 Unit/l. at sampling station S2 to maximum 5767 Unit/l. at sampling station S1. In the year 2012-13 this group contributed total 13658 Unit/l. to the total phytoplankton. The range varied from minimum 4073 Unit/l. at sampling station S2 and maximum 5352 at sampling station S1. This result of Bacillariophyceae indicated that they were more in numbers in summer seasons and low in numbers during rainy seasons. *Fragilatia sp.*, *Cymbella sp.*, *Noviculla sp.*, *Synedra sp.* and *Pleurosigma sp.* were the most dominant amongst Bacillariophyceae (*Table 14, 18, 22 & 26, 30, 34*). However two peaks of monthly distribution of diatoms reported by Pahwa and Mehrotra (1966) in river Ganga, Dad (1981) in river Chambal. Minimum number of diatoms were recorded in monsoon months probably due to high water flow in the river. *Fragilaria sp.*, *Synedra sp.*, *Cymbella sp.* and *Naviculla sp.* among diatoms were dominant. *Navicula sp.* was very common at polluted stations.

**Cyanophyceae:**

Cyanophycean algae possess ability to grow in polluted waters. In present study blue green algae contributed 22% of the total phytoplankton and come third in order of dominance. Blue greens were represented by six genera and *Oscillatoria sp.*, *Merismopedia sp.*, *Spirulina sp.*, and *Microcystis sp.* in Cyanophyceae were the most dominant. In the 2011-12 the group Cyanophyceae contributed total 12227 Unit/l. to the total phytoplankton. This group ranged
between minimum 4660 Unit/l. at the sampling station S3 to maximum 5767 Unit/l. at the sampling station S2. In the year 2012-13 this group contributed total 9773 Unit/l. to the total phytoplankton. The range varied from minimum 1475 Unit/l. at sampling station S1 to maximum 4275 Unit/l. at sampling station S2. These groups were more common during summer seasons and minimum in rainy season (Table 15, 19, 23 & 27, 31, 35). during the study period These groups were more common during summer seasons and minimum in rainy season. Similar observations have been made by Biswas and Konar (2000); Nandan and Jain (2002), Verma (2006) and Sharma et al., (2011). George (1962) has observed that high temperature is the principal factor for the growth of cyanophyceae. The blue green algae were less in winter as also observed by Hutchinson (1967). Sharma et al., (2013) observed in the Narmada river During the study period, 9 species of family Cynophyceae were recorded. The maximum diversity of this group was recorded in February to April months in both years due to abundance in food. The diversity of this group was minimum from July to September months due to rainfall and heavy floods, poor water quality and less food availability.

**Euglenophyceae:**

In the 2011-12 Euglenophyceae contributed total 765 Unit/l. to the total phytoplankton at this river. The range varied from 130 Unit/l. at sampling station S1 to maximum 359 Unit/l. at sampling station S3. In the year 2012-13 this group contributed total 633 Unit/l. to the total phytoplankton. The range varied from minimum 110 Unit/l. at sampling station S1 to maximum 282 Unit/l. at sampling station S3 (Table 16, 20, 24 & 28, 32, 36). Euglenophyceae contributed 2% only of the total phytoplankton. during the study period maximum number was occurred in Summer season and minimum number was occurred in monsoon.
Similar observation has been made by Palharya and Malviya (1988) in river Narmada. According to Hosmani and Bharti (1985) Lower population of euglenoids in river Narmada might be due to lower concentration of organic matter. Cetinic et al., 2006 observed Phytoplankton Seasonality in a highly stratified Karstic estuary (Krak, Adriatic Sea) similar results observed Khanna et al., 1993; Rao (2004); Sindhu and Sharma (2007); Pritchard et al., 2008; Reddy et al., 2009; Hulyal & Kaliwal 2009; Pejman et al., 2009; Kudela & Peterson 2009; Hassan et al., 2010 During the study period Sharma et al., 2013 only one species of family Euglenophyceae was recorded. Its diversity was maximum in winter and summer seasons. This group was totally absent during the rainy season.

**Correlation between Physico-chemical parameters and Phytoplankton:**

*(Table 46 to 49)*

No significant correlation was found between Temperature and Phytoplankton *(Table 46).*

**Correlation between pH and Phytoplankton:**

Correlation between pH and Chlorophyceae (2011-12) at station-I was observed as \( r = -0.6393 \). Thus Chlorophyceae showed moderate negative correlation with pH. Correlation between pH and Cyanophyceae at station-I was observed as \( r = -0.5522 \). Thus Cyanophyceae showed moderate negative correlation with pH. Correlation between pH and Euglenophyceae at station-I was observed as \( r = -0.5003 \). Thus Euglenophyceae showed moderate negative correlation with pH.

Correlation between pH and Chlorophyceae (2012-13) at station-I was observed as \( r = -0.60767 \). Thus Chlorophyceae showed moderate negative correlation with pH. Correlation between pH and Bacillariophyceae at station-I
was observed as $r = -0.4306$. Correlation between pH and Cyanophyceae at station-I was observed as $r = -0.59919$. Thus Cyanophyceae showed moderate negative correlation with pH. Correlation between pH and Euglenophyceae at station-I was observed as $r = -0.6364$. Thus Euglenophyceae showed moderate negative correlation with pH.

Prowse and falling (1958) show Cyanophyceae shows positive correlation with temperature and pH. and negative correlation with DO. The negative correlation ship with diatoms density Phosphate and similar studied Whipple and Parker (1932) Pearsall (1923) and Lind (1938), Rao (1955), Singh (1960), and Zafar (1967).

**Diversity Index:**

Several types of indices are used. In the present study, Shannon and Weaver diversity index (1963) ($H'$) were used.

**Shannon and Weaver Index ($H'$)**

<table>
<thead>
<tr>
<th>Status of water.</th>
<th>3 and above</th>
<th>1 to 3</th>
<th>1 and less than 1.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean water.</td>
<td></td>
<td>moderately polluted.</td>
<td>Heavily polluted.</td>
</tr>
</tbody>
</table>

The value of Shannon and Weaver Index theoretically range from 0.00 to 4.00. Value less than 1.00 indicates poor water quality, value from 1.00 to 3.00 indicates moderate water quality and value above 3.00 indicates good water quality.
Diversity index (Shannon and Weaver diversity index, H’) of Phytoplankton:

According to Wilhm and Dorris (1966) species diversity (S-W) index (H’) value ranged from >3 indicates clean water, 1.00 to 3.00 indicates moderately and <1.00 indicates heavily polluted condition of water. Shannon and Weaver diversity Index is based on community concept (Wilhm and Dorris 1966) which is determined by the quality of water. The water quality of a river system is mainly related to its physico-chemical parameters. This characteristic of a river leads into the development of specific limnological habitats. The use of Shannon and Weaver Index has gained a wide acceptance and has become an important tool of water quality studies Adeogun and Fafioye (2011).

In the present study the Diversity indices for phytoplankton were derived by the application of Shannon and Weaver Index (H’) for three sampling stations and shown in Table 45. The values of H’ at station I were 2011- 2012 (1.139) and 2012-2013 (1.129); This indicates that station-I has moderately polluted; at station II were 2011-2012 (0.979) and 2012-2013 (0.974); This indicates that station-II has heavily polluted; at station III were 2011-2012 (1.132) and 2012-2013 (1.155); This indicates that station-III has moderately polluted (Table 50). In the present investigation results show the Station-II and III is heavily polluted because at this site mixed industrial effluent at time to time and make at this point heavily polluted and not acceptable for growth of flora and fauna.

POPULATION DYNAMICS OF ZOOPLANKTON:

In the present investigation the zooplankton population was found to be composed of five major groups; Protozoa, Rotifera, Cladocera, Copepoda, and Ostracoda and total 15 species of zooplankton have been recorded of which 5
belonging to Protozoa, 4 to Rotifera, 3 to Cladocera, 2 to Copepoda, and 1 to Ostracoda. The percentage of Zooplankton is given in (Table 51). The order of dominance was as:-

**Rotifera>Copepoda>Cladocera>Protozoa>Ostracoda**

**DISTRIBUTION OF ZOOPLANKTON:-**

When the Oxygen concentration was recorded zero there was no presence of zooplankton at sampling sites S4, S5 and S6. During the study period the 2011-12 the number of zooplankton recorded at S1, S2 and S3 sampling points is total 5736 Unit/l. During year 2012-13 the total number of zooplankton recorded is 5200 Unit/l.

Monthly variation in Zooplankton in sampling sites of Narmada river are given in (table 37 to 42).

**Protozoa:-**

In the 2011-12 this group contributed total 1091 Unit/l. to the total zooplankton. The group ranged between minimum 304 Unit/l. at sampling station S3 and maximum 428 Unit/l. at sampling station S1. During year 2012-13 this group contributed total 929 Unit/l. to the total zooplankton. This group varied from minimum 224 Unit/l. at sampling station S3 to maximum 390 Unit/l. at sampling station S1. The maximum number of protozoans were reported in March and the minimum during August, September and October. The percentage of protozoans in total Zooplankton population was 18 to 19%. Only five genera of protozoans were recorded namely *Amoeba sp.*, *Arcella sp.*, *Actinophrys sp.*, *Paramecium sp.* and *Diffugia sp.* the *Paramecium sp.* abundance in group. Sharma *et al.*, (2010) observed The protozoan population in Narmada river contributed only 14.8% of total Zooplankton and represented by 10 species. The maximum average density
has been reported in March (101.8 den/l.) and minimum in August (7.2 den/l). Protozoan species are not recorded during monsoon months. Chouhan and Kanhere (2013) observed some species of Protozoan are *Arcella* sp., *Actinophrys* sp., *Euglepha* sp., *Epistylis* sp., *Lacrmaria* sp., *Opercularia* sp., *Prorodon* sp., *Vorticella* species in Barwani Tank of West Nimar, M.P. India. Chaurasia (1996) observed Protozoa maximum recorded in summer month. Similar observation made by Mahor (2011); Thirupathaiah *et al.*, 2012; Vasisht and Jindal (1980), Jindal & Vasisht (1985) and Datta *et al.*, (1990) reported low production or complete absence of protozoans during monsoon period.

**Rotifera:**

In the present study Rotifers formed the most dominant group and were found with appreciable quantities throughout the period of investigation. The major portion of the Zooplankton population was shared by rotifers. In the 2011-12 this group contributed total 1913 Unit/l. to the total zooplankton. The group ranged between minimum 283 Unit/l. at sampling station S1 to maximum 884 Unit/l. at sampling station S2. During year 2012-13 this group contributed 2004 Unit/l. to the total zooplankton. This group varied from minimum 606 Unit/l. at sampling station S3 to maximum 736 Unit/l. at sampling station S2. The population of rotifers was maximum in March and was minimum in August. The percentages of rotifers in total zooplankton were 33% to 39% unit/l. The four species of rotifers were recorded and the common genus was *Brachionus* sp. and *Keratela* sp. was found throughout the year and it was recorded in majority of the month. The dominance of rotifers has been described by Kofoid (1908), Allen (1920), Hynes (1970), Kar *et al.*, (1987), Pahwa and Mehrotra (1966); Dad (1981) and Vandysh (2004); Krishnamoorthy *et al.*, 2007. During the study period Sharma *et al.*, 2010 observed rotifers second in order to abundance and exhibiting a bimodal pattern.
with the minor peak (51.3 den/l.) in the month of August and the major peak (344.3 den/l.) in the month of March. Chaurasia (1996) reported that the diversity of rotifers in Burha tank water, Raipur and their species diversity are higher in eutrophic condition. Rotifers are Branchionus caudatus, Branchionus falcatus, Horaella sp., Keratella tropica, Monostyla sp., pseudodiaptomus sp., Nauplii species.

**Copepoda**

The present study recorded copepodan as the second dominant group of Zooplankton in Narmada river. They exhibited a biomodal pattern with a first peak in November and Second prominent in March. In the present study 2011-12 this group contributed total 12493 Unit/l. to the total zooplankton. This group ranged between minimum 345 Unit/l. at sampling station S3 to maximum 546 Unit/l. at sampling station S1. During year 2012-13 this group contributed 1119 Unit/l. to the total zooplankton. This group varied from minimum 298 Unit/l. at sampling station S3 to maximum 520 Unit/l. at sampling station S1.

Copepods were represented in the sample by the genera Cyclops sp. and Nauplius sp. This group thriven well from March to April The maximum number was recorded in March. Similar peaks of copepods population in summer were reported by Kofoid (1908) from Illinois river, Ray et al., (1966) and Shah and Pandit (1988) from Ganga river, George (1987) in the upstream of Tawa river and Dad (1981) from clear water area of Chambal river. The percentage of Copepods in total Zooplankton population was 22% to 23% in Narmada river. The living copepods constitute an essential link in the aquatic food chain. Though they are not as important element in fish diet as the Cladoceran Species however they are in intermediate trophic level among bacteria, algae and protozoa on one hand and small and large plankton predators on the other. Kulshreshtha et al., (1989)
reported second dominant copepoda zooplankton from rivers Kshipra and Chambal. Sharma et al., 2010 observed The Copepods population ranked third in order of dominance during the study period in Narmada river. The group exhibited two peaks, the major peak in April and the minor peak in January.

**Cladocera:**

The cladocera constitute one of the important group of the zooplankton community of each fresh water bodies. In the 2011-12 this group contributed total 1263 Unit/l. to the total zooplankton. The group ranged between minimum 348 Unit/l. at sampling station S3 to maximum 526 Unit/l. at sampling station S1. During year 2012-13 this group contributed total 1020 Unit/l. to the total zooplankton. This group varied from minimum 224 Unit/l. at sampling station S3 to maximum 514 Unit/l. at sampling station S1. The Cladocera were generally abundance from January to April. The maximum number was recorded in March with decline from April to onwards. From time to time these attracted the attention of fisher biologist due to their importance as food for both fry and adult (Welch 1952 and Pennak 1978). *Daphnia* and *Moina sp.* is common genera. The percentage of Cladocera in total zooplankton population was 19% to 22% in Narmada river. Sharma et al., 2010 reported in river Narmada Among the total Zooplankton population, Cladocera Species is reported as second in order of abundance in Narmada river. In the present study the peak in Cladoceran Species population during March month showed the preference of the group towards the increasing temperature along with increase in alkalinity, pH, Ca and chlorides.
**Ostracoda:**

The role of fresh water ostracods in an aquatic ecosystem is well established. In the present study 2011-12 this group contributed total 176 Unit/l. to the total zooplankton. The group ranged between minimum 36 Unit/l. at sampling station S1 to maximum 80 Unit/l. at sampling station S2. During year 2012-13 this group contributed 128 Unit/l. to the total zooplankton. This group varied from minimum 14 Unit/l. at sampling station S1 to maximum 59 Unit/l. at sampling station S2. The percentage of Ostracoda in total zooplankton population was 2% to 3% in Narmada river. In the present study in river Narmada maximum number of Ostracods was recorded as March and April. similar results recorded Shah and Pandit (1988) reported occurrence of ostracoda population during summer months in river Ganga. Chouhan and Kanhere (2013) concluded Zooplanktons are economically important large group of tiny animal. The role of planktonic organism in aquatic environment is an essential link in food chain. Chouhan and Kanhere (2013) were recorded Protozoan (33.82%), Rotifers (35.56%), Cepepoda (14.76%) and Cladocera (15.88%). A number of rotifers are higher than other groups but species diversity of Protozoan in higher than Rotifers. it was found Protozoan and Rotifers similar and Copepod and Cladocera are similar in the Barwani tank of West Nimar (M.P.). The study on zooplankton Diversity of Pravara river, Near Sangamner city, Dist. Ahmednagar, Maharashtra Pandit *et al.*, 2007.

No significant correlation was recorded between Temperature and Zooplankton (*Table 52 & 53*).
Correlation between pH and Zooplankton (Table 54 to 55)

Correlation between pH and Protozoa (2011-12) at station-I was observed as \( r = -0.517015 \). Thus Protozoa showed low negative correlation with pH. Correlation between pH and Rotifera at station-I was observed as \( r = -0.6117 \). Thus Rotifera showed moderate negative correlation with pH. Correlation between pH and Copepoda at station-I was observed as \( r = -0.63189 \). Thus Copepoda showed moderate negative correlation with pH.

Correlation between pH and Protozoa (2012-13) at station-I was observed as \( r = -0.5297 \). Thus Protozoa showed moderate negative correlation with pH. Correlation between pH and Rotifera at station-I was observed as \( r = -0.5781 \). Thus Rotifera showed moderate negative correlation with pH. Correlation between pH and Rotifera at station-II was observed as \( r = -0.0588 \). Thus Rotifera showed low negative correlation with pH. Correlation between pH and Copepoda at station-I was observed as \( r = -0.6652 \). Thus Copepoda showed moderate negative correlation with pH. Correlation between pH and Copepoda at station-II was observed as \( r = -0.5072 \). Thus Copepoda showed moderate negative correlation with pH. Vasisht and Jindal (1980) reported the period of abundance of zooplankton coincided with optimum values of pH and it showed positive correlation with water temperature and phytoplankton. Rai & Sharma (1986) Noticed a positive correlation with protozoan count and chemical factor pH, DO etc.

Hussainy (1967) noted that at low temperature the amount of oxygen is always low. its observed the water temperature had an inverse correlation with the dissolved oxygen. Allen (1920) stated that temperature is the determining factor for the seasonal distribution of fauna and flora. its reported the highest number of
phytoplankton was in April and second peak was in December thus there is no definite correlation between temperature and distribution of phytoplankton.

Sharma et al., 2010 recorded positively correlated between Temperature with Zooplankton group Protozoa, Rotifera, Cladocera and Copepoda and it observed Negative correlation between BOD; Phosphate with Zooplankton group Protozoa, Rotifera, Cladocera and Copepoda. Its recorded copepod population shows positive correlation with temperature, pH, dissolved oxygen and chloride and it reported protozoan population dynamic is positively correlated with pH and chloride. Similar studied was observed Singh (2002), Neves (2003), Vandysh (2004) and Pandit et al., 2007.

**Correlation between Phytoplankton and Zooplankton**

There was no significant correlation between Phytoplankton and Zooplankton (Table 56).

**Diversity index (Shannon and Weaver diversity index, H’) of Zooplankton**

In the present study the Diversity indices for zooplankton were derived by the application of Shannon and Weaver Index (H’) for three sampling stations and shown in Table 34. The values of H’ at station I were 2011-2012 (1.432) and 2012-2013 (1.400); This indicates that station-I has moderately polluted; at station II were 2011-2012 (1.417) and 2012-2013 (1.398); This indicates that station-II has moderately polluted; at station III were 2011-2012 (1.412) and 2012-2013 (1.403); This indicates that station-III has moderately polluted (Table 57). Hajan (1988) observed Deteriorating nations rivers in ecology and pollution of Indian rivers. According to Krishnamoorthy and Sarkar (1997) there has been a great thrust for
developing water quality criteria based on quantitative enumeration of ecological data, which are called as biological indices of water quality or pollution.

**FISH AND THEIR BEHAVIOUR:**

During the study the presence of 21 fish species were observed, belonging to 4 order and including under 6 families, Cypriniformes contributed by 15 species; Clupiformes-2 species; Ophiocephaliformes-2 species and Siluriformes-2 species respectively (Table 58). Chouhan et al., 2013 observed during the study period in river Narmada 59 fish species, 34 genera, 17 families and 7 orders were recorded in the three stations respective Viz. Maheshwar, Khalghat and Barwani.

Various studies have been done on fish biodiversity and its conservation issues in river systems. The study was executed by the Department of Fisheries, Govt. of M. P. in the year 1967-71 of the river Narmada which covers the stretch from Jabalpur to Khalghat reporting 46 species belonging to 27 genera, 14 families and 7 orders in the stretch (Anon 1971). Rao et al., (1991) have undertaken pre-impoundment survey at Punasa (Khandwa district), Omkareshwar (Khandwa district), Mandleshwar (Khargone district), Maheshwar (Khargone district) and Barwani (Barwani district) pertaining to the river and have enlisted 84 fish species belonging to 45 genera, 20 families and 6 orders. Another survey of fish fauna on river Narmada was carried out and reported 21 fish species belonging 16 genera, 6 families and 4 orders (Balapure 2001). In India, there are about 2,500 species of fishes, of which 930 freshwater and 1,570 marine, are estimated Kar (2003).

Bakawale and Kanhere (2013) recorded during the study period the fish diversity in the river Narmada. 51 Species of fish belonging to 7 orders and included under 15 families were collected in Narmada where Perciformes
contributed by 4 species, while ophiocephaliformes came thire in contribution and counted 3 species and rest species were from Clupiformes, Beloniformes, Siluriformes and Mastacembleformes (3,1,1, and 2 species respectively). Similar results was observed Hora & Nair 1941; Karamchandani et al., (1967); Rao (1991); Rao et al., (1992); Rao (2004); Bakawale & Kanhere (2006) and Verma & Kanhere (2007).

**Impact on Fish Fauna:**

Fish fauna was studied at three stations there was fluctuation in fish species diversity. During the study period 21 species were found in upstream (S1) and in downstream (S3) 12 species were reported, while at the point of confluence (S2) 6 species was observed. Absence of some species of fishes at the station S2 shows there pollution tolerance limitation and irregular opening and closing of the gate as per the requirement of electric generation form Omkareshwar dam site the water level is irregular changed and it is effecting the habitat and breeding sites of fishes, when the water level is low and effluent are discharge in river Narmada instant fish mortality is reported from the site.

**Impact on Fish behavior :**

(a) **At Upstream (S1):** Fishes were observed showed normal behavior.

(b) **At Confluence (S2):** at the point of Confluence the Fishes were affected by the pollution and showed change in their normal behavior as- movement towards surface, Imbalance, Increased respiration activity and slime secretion.

(c) **At Down stream (S3):** at the S3 point there fish behavior normal.
In the past physico-chemical characteristics of industrial effluents as well as their impacts on plants and animals have been out extensively (Mishra et al., 1999; Avasn and Rao 2000; Kumar and Gopal 2001). The dilution level (more than 5%) of distillery effluents has been reported as toxic by Sharma et al., (2011), and they also recommended the use of distillery effluent for irrigation purpose after proper dilution. Our results clearly show that the different lower dilution levels were growth inhibitory and toxic while higher dilution levels were within tolerance limits. Hence the results obtained in our experiment are also in resemblance to the findings of Sharma et al., (2011). These results are also in resemblance to the findings of Rajannan et at., (1998), Kumar (1999) and Kumar and Prasad (1999), who showed the industrial effluent impact on fishes and noticed its inhibitory effects on fish growth.