Discussion
DISCUSSION

The rivers are precious natural surface water resources which is quite essential for the existance of all living beings by using water in drinking as well as is required for the economic growth for human development by using it in various ways viz. industrialization, thermal power generation, irrigation, transportation, aquatic biota and Fish production besides they are holy and related with heritage and culture.

At present entire riverine system have been badly effected by different pollution hazards and loosing their natural nature.

Having in view these problems the river Betwa is studied by taking their physical, chemical and Biological features considering required factors of every aspects. Besides the Meteorological conditions which are atmospheric temperature, rainfall, relative humidity and photo period studied as well as mean and standard deviations also calculated.

For the betterment and Management of the River the measures are also pointed out. Regarding this River Betwa was studied for the period of two years (Jan. 2004 to Dec. 2005)

Meteorological conditions

Atmospheric Temperature

The maximum Atmospheric Temperature 44.27°C. was found in the month of May and minimum 8.58°C. in winter season in the month of January, 2004 and in 2005 it was maximum 44.17°C. in the month of May and
minimum 8.55°C. in the month of December. It is directly affected to the water temperature. Photo period impacts positively on it and humidity showed negative relationship with it. Atmospheric temperature affects primary production of entire aquatic biota.

Rain fall

It depends on Monsoon and increases turbidity due to presence of decaying matter brought along with the surface run off and silting in the River water. It was highest during monsoon period 6.77 mm. in the month of September and lowest was in the month of January 1.22 mm. in 2004 and in 2005, the highest 9.62 mm. was in the month of July and lowest 1.22 mm. was in the month of April. High rain fall during monsoon along with high turbidity decreases the concentration of dissolved Oxygen as well as photo synthetic activities in River biota.

Relative Humidity

It was highest 27.02% in monsoon season in the month of July and lowest 10.87% in the month of January in 2004 and in 2005 it was maximum 26.66% in the month of July and minimum 10.51% in January. It is positively related with rain fall and atmospheric temperature impacts negatively. It increased in monsoon season and decrease in winter season. Relative humidity which increases in cloudy weather and high rains decreases the photosynthesis activities in river water as well as affects the primary productivity of biota of the River.

Photo period

It was found maximum due to high intensity of solar radiation in summer season and minimum in winter season. It was maximum 13.33 hrs in
in 2009 it was highest 15.54 hrs in the month of June minimum 10.28 hrs found in the month of Dec.

It is directly related to photosynthesis which increases concentration of dissolved Oxygen level.

**Physico-Chemical and Biological Characteristics**

For the analysis of River water physico-Chemical and Biological factors which were considered are:

**Physical Factors**- Water temperature, Turbidity, Water current and colour.


**Biological Factors**- Total coliform (MPN), Phyto and Zoo planktons, Aquatic Weeds and Fish fauna.

**Physical Factors**

**Water Temperature**

It is one of the important factor among various parameters. Water temperature plays a vital role in the breaking down of organic materials and has a major influence on the metabolic activities of organisms, it also affects the rate of chemical changes in water and pressure of dissolved gases. The Oxygen content of water in general decreases with rise in temperature. The
changes in volume and density of the water are positively related with variations in temperature. As the atmospheric temperature directly affects the water temperature.

In the present study the Betwa River water temperature ranged from 13.25\(^0\)C. to 34.25\(^0\)C. in the 1st year 2004 and between 15.54\(^0\)C. to 33.8\(^0\)C. in the IIInd year 2005 at five different sampling stations. The mean value of water temperature in study period of 2004 was 24.58\(^0\)C. to 25.28\(^0\)C. and between 25.61\(^0\)C. to 26.51\(^0\)C. in 2005. which ranged at different sampling stations. Minimum water temperature was recorded in winter season the month of December in 2004 and in 2005 the minimum temperature was recorded in the month of January. Where as the maximum was recorded in summer season (May2004) while in 2005 the month was June. Amongst all sampling stations (I to V) the water temperature was found to be comparatively higher at station II and station IV due to human activities, low water level which had high insulation from solar radiation and sewage discharges.

Water temperature showed positive Correlation with Turbidity, pH, TDS, Total alkalinity, Total hardness, Cl, C.O.D., B.O.D., CO2, NH4-N, PO4, SO4, Na, K and MPN but negative correlation was found with D.O. and relative humidity. These changes were marked by the effects of water temperature in water by various ways viz. reduction in volume of water, higher rate of organic decomposition in sewage discharges, fecal matters and much growth of coliform bacteria. Thus the above factors showed positive correlation where as only two, (D.O. and relative humidity) have negative correlation. As stated tables (4,10,7,21,27) of coefficient correlation. The observations resemble to the findings of Chacko and Srinivasan (1955) who reported hydro biological features of River Godavari and found the water temperature ranged from 27\(^0\)C. to 36.4\(^0\)C. David (1963b) observed the physico-chemical conditions of River Gandak and the average temperature of
water ranged between 19\textdegree C. to 22\textdegree C. Bhatnagar (1989) reported water temperature in the range of 19.5\textdegree C. to 38\textdegree C. in River Chambal at Kota. Agrawal (1993) analyzed the physico - chemical and biological characteristics of River Betwa from Naya pura to Vidisha and found water temperature in the range 16\textdegree C. to 35\textdegree C. Saxena (1998) reported sewage pollution in Shahpura Lake with special reference to phytoplankton and found temperature between 16\textdegree C. in the month of January and 30\textdegree C. in the month of May.

Microbial activities increase by higher temperature which decrease dissolved oxygen in water and cause asphyxiation on Fishes and it may be fatal, this results occasional Fish mortality (Jhingaran 1991)

The variations of the temperature reported by various workers marked it as the limiting factor for the aquatic biota. Increase in temperature at polluted stations may be attributed to a lot of chemical changes in domestic discharges, municipal wastes and sewage wastes in to the river water. (O’Brieh, 1974 Goldman and Horne 1983) observed changes in temperature and light are two main causes for algal pollution which vary significantly during different seasons.

Temperature is one of the limiting factors for aquatic biota along with Fishes. As all metabolic physiological activities as well as life processes viz. reproduction, feeding, movement and distribution of aquatic organisms are highly influenced by water temperature in river. Because seasonal qualitative and quantitative fluctuations occur in the planktonic populations due to variation in temperature. Pahwa (1966) reported the quantitative distribution of total macro organisms directly relate with planktonic biomas. Ganapati and Rao (1954), and Chen (1965) observed that the seasonal variations in the density of copepods and mentioned that they were influenced by temperature.
On increasing the temperature the density of planktons increases hence they show the positive co-relationship with water temperature.

The present work as regards water temperature and aquatic organisms relationship also resembles with the above work as shown in pai graphs (fig.85-104). The present work conformity with the work of Saha et al (1971), khan and Siddiqui (1974).

**Turbidity**

Turbidity of natural waters is caused by heavy foods, rains, suspended inorganic substances such as silt and clay, wind velocity, phytoplankton’s and other microscopic organism. It is a lethal factor for diatoms but in a complex with water current, act as a limiting factor for the development of plank tonic algae. Domestic wastes, sewage discharges, wasting effluents etc. cause turbidity by organic wastes. Turbidity due to profusion of plankton is an indication of rivers high fertility but that caused by silt or mud beyond a limit, is harmful to fish and fish food organism. (Jhingaran 1991). Turbidity plays an important role in determining the Portability of water.

Turbidity varies greatly with the nature of basin, certain domestic wastes may add large amount of organic and inorganic materials that produce turbidity in water. Turbid water can not be used in domestic, industrial and other purposes.

In the present study of Betwa water turbidity varied between 90 to 139 N.T.U. in 2004 and in 2005 ranged between 94 to 155 N.T.U. M inimum was recorded in the month of Dec and maximum average value was observed in the month of Aug in both the year. Higher value was in monsoon period due to silting organic matter, flow off surface run off while in summer low water level, wind velocity. The mean value of turbidity is found between 105.33

Currently Nephelometric turbidity Unit (N.T.U.) is used meter in turbidity estimation but it had been measured in J.T.U. (Jackson Turbidity Unit) traditionally. In the absence of any alternative source, the Indian standards permit turbidity up to 10 N.T.U. and the health limit for drinking water of turbidity is 5 N.T.U. recommended by W.H.O.

Jhingaran (1991) reported turbidity generally increased to maximum in monsoon due to suspended solids in the flooded waters, during the post monsoon months, turbidity values were low but increased again during the summer months with increase in tidal magnitude & intensity.

Kulshresth et al (1989) reported the biology of certain Rivers and mentioned the turbidity in the range of 20 to 2600 N.T.U.

Upadhyay (1997) reported the turbidity in ranged between 2 N.T.U. to 162 N.T.U. in Kaliasote dam.

The variations of the turbidity reported by many workers marked it as a lethal and limiting factor.

Turbidity Showed positive correlation with water temperature, total dissolved solids, PH, total Alkalinity, cl, B.O.D., C.O.D., CO2, NH4N, PO4, Na, K, Fl M.P.N., and Negative Correlation with total hardness D.O. , SO4, Photosynthetic activity. These changes ware marked by the effect of turbidity in water due to domestic waste sewage discharges, washing effluents, heavy floods, silt and clay, planktons and other aquatic organism. Thus the above factor showed positive correlationship why some have negative correlation. As stated in table (4,7,10,16 ). Roy, (1955) reported that turbidity too plays and important role as suspended matter blocks of what ever sunlight is available

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during monsoon thus giving it, status of a lethal factor. The natural turbidities are seldom if ever directly lethal to Fish (Wallen 1951) but it may affect the productivity of an aquatic biota. According to Jhingaran (1991) the suspended particles causing turbidity may also adsorb phosphate, potassium and Nitrogen in their ionic forms making them unavailable for plankton production. Turbidity decreases photosynthetic activities due to restriction of light penetration which adversely affects the productivity of aquatic biota as well as reduction of dissolved oxygen.

The observation of turbidity coincides with the observation of Roy (1955) and Jhingara (1991).

**Water current**

Water current of River water is an important factor which is closely related to the turbidity and plankton population.

Berner (1951) and Roy (1955) reported that it is a detrimental factor. The water current is reduced at and near the surface because of surface tension and is diminished at the sides and the bottom of the River bed due to frictional effects. According to Jhingaran (1991) the maximum water current of a flowing stream in its vertical section is generally found some where with in the one third of the depth of the water from the surface. It has a bearing on the rheotrophic movement of planktonic organisms, Fish young etc.

During the present study the River water current varied from 30 Cu.Cm/Sec to 1080 Cu.Cm/Sec in 2004 and in 2005 20.25 Cu.Cm/Sec to 1250 Cu.Cm./Sec. Maximum water current was observed in the month of August, 2005 due to floods in rainy season and in 2004 the month was September Whereas the minimum was recorded in winter season in the month of December in both the years. The mean value of it was ranged from
221.71 Cu.Cm./Sec. to 259.99 Cu.Cm./Sec. in 2004. While in 2005 varied between 251.53 Cu.Cm./Sec. to 281.72 Cu.Cm./Sec. Higher value was observed at stations III, IV and V in the month of August in 2005 due to flood.


Water current affected Fish productivity as well as Fishing in River water. Slow and gentle current velocity was conducive to Fish catches. While faster current of the River water proved unfavorable for spawn collection.

George et al (1966) studied the limnological survey of river kali with reference to fish mortality and found water current varied from 14 to 2,545 cfs.

During low waters transient in dry season increases the organic materials and algal blooms. But in the period of spates planktons was scanty. Jhingaran (1991) the plankton population was closely related to the flow conditions. During the period of flood, plankton presented but were rare, whereas, during the dry season the bloom form with in the standing water of the plain and also in the river channel. Besides this where flow was slowed by other hydraulic forces plankton also developed to a great degree.

According to Allen (1920) turbulence due to high current velocity is very inimical to plankton development.

Thus water current is an important factor for fish productivity as well as its fertility. This study resemble with the finding of George et al (1966) and Jhingaran (1991).
Chemical factors

Hydrogen-Ion Concentration (pH)

It is an important chemical factor to measure the concentration of hydrogen-ion Concentration of natural water by which the suitability of the water for drinking purpose and for its productivity was assessed. The pH of neutral water is seven. Generally small decrease or increase in pH was mean a considerable rise or fall in hydrogen-ion concentration. Most of the surface waters are alkaline in nature with an average pH range of 7 to 8.5. distilled water is weakly dissociated in to H+ and OH- ions, the product of which at any time is a constant K\text{w} cocking, T.T. (1953) reported that pH can be negative in very strongly acid solution and can exceed 14 in highly alkaline solutions; the lowest known pH is – 0.3 and the highest is 14.5. Logarithmic of reciprocal of hydrogen ion concentration is more convenient to denote the pH of water.

The control of pH is particularly important in the chemical flocculation of trade wastes and in the anaerobic digestion of sewage sludges and trade wastes. Hydrogen ion concentration of river water is closely related with carbon di oxide, carbonates and bicarbonates. CO2, bicarbonate buffer system is of great importance in protecting river from the harmful effects of chemical acid discharges and in preventing wide fluctuations in pH value.

In the present study the pH value was varied from 7.7 to 9.2 in 2004 where as in 2005 ranged between 8.0 to 11.4 the lowest pH value was observed in the month of January 2004 where as the highest value was found in the month of May, 2004. The maximum pH value was found in the month of August in 2005 whereas minimum value was found in the month of Dec. 2005. Mean value of pH ranged between 8.03 to 8.53 in 2004 while in 2005 it varied form 8.54 to 8.88. The observed results of pH showed significant influx
at station I (Pothia) and station III (Sewage discharge) & next to it at station IV and IIInd in (2005) due to confluence of domestic waste, city sewage and municipal wastes.

As per BIS recommendation the standard of pH for drinking water should be 6.5 to 8.5, for fish culture (6.0 to 9.0), for irrigation use 5.5 to 9.0.

During the entire Course of the study, pH of water showed positive correlation with Total dissolved solids, Total Alkalinity, T.H., B.O.D., C.O.D., CO2, Na, K, and M.P.N. whereas negative correlation with D.O., PO4, SO4, NH4N, flouride at some of the stations. (Table4,7,23)

In this field the various important water bodies were studied by different workers and recorded pH as given below; Chacko and Srinivasan (1955) observed hydrobiological features of river Godavari and recorded pH ranged from 7.2 to 8.3 and river Cauvery at Bhavani in (1949) pH ranged from 7.6 to 9.6. Ray et al (1966) and Pahwa and Mehrotra (1966) studied the hydrobiological features of river Ganga from Kanpur to Rajmahal and observed the pH of river water in the range from 7.5 to 8.3. Vass et al (1977) studied the physico-chemical and hydrobiological characteristics of river Jhelum in Kashmir and was found pH varied from 7 to 7.6. The variations of the pH in water reported by above workers shows that it always remained alkaline.

Swingle (1967a) observed, that waters having a pH range of 6.5 to 9.0 as recorded before day-break are most suitable for pond fish culture and those having pH values of more than 9.5 was unsuitable, because in the later, CO3 is not available whereas in a stream intense photosynthesis leads to alkaline condition in due to removal of carbon dioxide in sun light by green plants. Rainy water dissolves the CaCO3 and forms calcium bicarbonate which is a source of CO2 for green plants.
The present work as regards suitability and unsuitability for fish growth in river water is in conformity with the findings of Swingle (1967a) as stated above.

Fish dies at about pH 11. Acid water reduce the appetite of the fish there growth and tolerance to toxic substances. The majority of Bacteria and other micro organisms are killed by markedly acid or alkaline conditions and usually flourish best in a fairly natural media. pH value has a marked effect on the growth of bacteria. pH was 30% more important than water temperature and 50% more important than dissolved oxygen according to a recent study.

In the present observation pH was noticed higher then the permissible limit, but it was only found during flood year 2005 which showed illeffects on the fishes and aquatic biota, besides it was not suitable for the drinking purpose.

**Total Dissolved Solids (T.D.S.)**

TDS play a vital role in describing the chemical density as a fitness factor and as a general measure of edaphic relationship which contributes to the fertility as well as productivity of aquatic biota.

Total dissolved solids depend on river basin, drainage, rain fall, inflowing waters, bottom, planktons and other aquatic organisms. In natural water dissolved solids are composed of organic and inorganic components viz. carbonates, bicarbonates, chlorides, Phosphates, Sulphates, Nitrates of Ca, Mg, Na and K etc.

In the rivers presence of TDS in excess disturb the ecological balance and effect aquatic biota. It vary with the season qualitatively and quantitatively. High dissolved solids concentrations have been associated with
corresponding high level of Sulphates and or chloride which may produce distress in cattle and livestock plants are also affected by irrigation water of it.

In the present study TDS in river water ranged from 210 to 580 mg/l. in 2004 whereas in 2005 it varied between 250 to 674 mg/l.. The minimum value was observed in the month of January at station II while the maximum was in August at station III in both the years of study. The mean value of 299.17 to 451.5 mg/l in 2004 and in 2005 it varied from 328 to 507.42 mg./l. The highest value was found in the rainy season at station III and subsequently at station ISt, V and IVth in due to runoff from near by areas, drainage and sewage discharges whereas lowest was recorded in winter season at the station IInd due to low concentration of Organic and Inorganic matters and low water temperature.

A limit of 500 ppm is set by BIS for dissolved solids in suitable drinking water, however, the desirable limit has been prescribed to be 2000 mg/l in the absence of any alternative source and in water for irrigation use the limit has 2100 mg/l.

Mohoto et al (1995) studied the irrigation water quality of subarnarekha and found dissolved solids between 160 to 690 mg/l. Saxena (1998) reported TDS in surface water of Shahpura lake in the range of 134 to 547 mg./l. Sharma (1999) studied the sewage water and found TDS in the range of 220 to 1540 mg/l.

All the above workers observed variations in total dissolved solids marked it as a limiting factor. Total dissolved solids showed direct relation with conductivity.

In the present study it showed significant positive correlation with pH, total alkalinity, COD, CO2, Chloride, NH4N, Na, K, PO4, SO4, at most of the
stations and negative correlation with DO and total hardness. As stated table (13, 16,21,27)

Inorganic and organic matter sewage discharges, drainage etc. increases total dissolved solid in the water of the river. Thus the above factors showed positive correlation ship. The present work resembles with the finding of Mohto (1995) and Saxena (1998).

T.D.S enriched the nutrient status of water and results in to entrophication of the ecosystem. Sudden increase in the contents of T.D.S. is often indicate pollution which include harmful hazards and lethal heavy meals by an extraneous source.

**Total Alkalinity**

Alkaline is an important factor of water to assess its water quality. It is mainly caused by the cations of Ca, Mg, Na, K, NH4 combined either as bicarbonates or carbonates or hydroxides. Natural water bodies show a wide range of fluctuations in total alkalinites value depending up on basin, season nature of bottom and plankton population etc. Alkalinity in natural water is due to free hydroxyl ion and hydrolysis of salts. Total alkalinity is the buffering capacity of water. Quantitative capacity of total alkalinity is to neutralize a strong acid to a designated pH.

Flooded rivers in rainy season have low total alkalinites values due to waters in heavy rain fall areas and water infected with submerged weeds low rain fall areas during the summer are likely to have high total alkalinites values. Where it exceeds the hardness, the presence of basic salts generally Sodium & Potassium has been indicated. If the alkalinity has been less than the hardness salts of Ca++2 Mg++ would be present in association with Sulphate, chlorides, or nitrates.
In the course of study total alkalinity varied from 139 to 225 mg/l in 2004 whereas in 2005 it was found between 135 to 256 mg/l with a mean value of 162 to 186 mg/l in 2004 and 188.33 to 198.50 in 2005. The minimum value of alkalinity was found at St. IV in the month of August 2004 and in September 2005 where as the maximum value was observed at St. III in the month of June 2004 and station V in the month of August 2005.

Alkalinity in itself is not harmful to human being still the water supply with less than 100 mg/l are desirable for domestic use. It has little public health significance BIS has set a desirable level of alkalinity in drinking water to be 200 mg/l while its permissible value has been prescribed to be 600 mg/l in the absence of any alternative source.

In the present study alkalinity showed significant positive correction with pH, Total hardness, total dissolved solids, B.O.D., COD, CO2, NH4, Na, K and negative correlation with D.O. fluoride. These correlations showed the effect of T.A. in river water due to sewage discharges domestic wastes which enhance the level of alkalinity in river water. Table no. (4,16)

Vass et al (1977) studied the hydrology of river Jhelam and found alkalinity in the range of 22 to 94 mg/l. Alikunhi (1957) reported that in highly productive waters, the alkalinity ought to be over 100 ppm. Swingle 1967a stated that such a classification of suitability of waters for fish culture many rivers falls within the total alkalinity values equivalent to 10-50 ppm CaCO3.

The present finding as regard the suitability of water for fish culture in river water is in conformity with Alikunhi (1957).

**Total Hardness**

Total hardness of natural water is mainly caused due total of soluble Ca and Mg salts present in the water. It also includes the sulphates and chlorides.
of Ca and Mg. Permanent hardness caused due to soluble Ca and Mg hardness and salts of inorganic acids and temperature hardness caused by suitable Ca and Mg bicarbonates.

It is an important factor to assessment the portability of the water for drinking, domestic use in washing, cleaning laundering and development of aquatic organisms. It is used to assess the waters as salt or hard. Soft waters originate in areas where the top soil is thin and limestone formations are sparse and the hard waters originate in areas where the top soil is thick and limestone formations are present. For plant and animal assimilation, calcium sulfate and chloride when present in water donot serve as effective buffers for storage of CO2.

In the course of study total hardness ranged between 78 to 198 mg/l in 2004 whereas in 2005 it varied between 96 to 220 mg/l. The mean value was found from 128.56 to 142.58 in 2004 and in 2005 it was found between 144 to 164.83 mg/l. the highest value observed at Station III in the month of May and next to it at St. V, I and II in both the years and minimum at station IV in the month of August in the study period. It was directly affected by alkalinity and pH of river. WHO recommended the limit of total hardness to be 100 mg/l, while BIS has set its desirable limit for drinking purposes tobe 300 mg/l and the permissible limit for hardness is 600 mg/l in the absence of any other alternative source.

In the entire study course total hardness showed positive correlation with pH, Cl, total alkalinity, CaH, MgH, B.O.D, C.O.D., CO2, NH4, Na, K and negative correlation with turbidity, D.O. fluoride, MPN. The above factors effected total hardness in river water due to more dilution, Ca precipitation in high pH, Sewage discharges. The significant variations were found in summer and post monsoon. Table no. (4,16,25,10).
The observation resemble with the findings of Ajmat et al (1985) found that higher values of hardness were recorded during summer in the study of river Kalinandi. Siva Subramani et al (1995) reported hardness varied from 90 to 220 mg/l in Periyar river. Shukla (1996) observed the hardness of river Betwa Koare dam and upper lake respectively from 90.6 to 160.0 mg/l and 80 to 180 mg/l. The variations of the total hardness assessed by above workers marked that hardness is affected by pH and total alkalinity.

**Calcium Hardness**

Calcium is a major component of water. It is also play an important role to determining the hardness of natural water to suitability for domestic uses and development of aquatic biota of river. It is useful in the maintenance of cytoplasmic membrane and in the wall structure of algae. Higher pH reduced the concentration of calcium due to its precipitation as calcium carbonate.

Swingle (1967a) reported that a total hardness of 50 ppm CaCO₃ equivalent to be the dividing line between soft and hard waters and waters less than 5 ppm CaCO₃ equivalent cause slow growth, distress and eventual death of fish. Calcium is one of the nutrient and has no hazardous effects on human health. High concentrate of calcium is not desirable in laundering, washing and bathing owing to its suppression of formation of Lather with Soap. It Coagulates with soap and makes dirty layer on tubes, sinks etc. The utility of water decreases in breweries under these circumstances.

In the present observation calcium harness followed the trend of total hardness and varied between 73 to 164 mg/l with mean value of 115.8 to 123.75 in 2004 and 124 tp 140.5 mg/l at various stations (1 to 5) observation showed the Ca rich nature of river water. The maximum value of Ca was found at St. III in the month of May and minimum was recorded at St. IV in the month of August in the study period.
CaH was found comparatively higher at St. III and V. The significant increase of calcium hardness was found in summer due to evaporation and less dilution of water. BIS recommended desirable value of Ca as 75 mg/l in drinking water and its permissible value has been prescribed to be 200 mg/l in the absence of any other alternative. Calcium hardness showed positive correlation with pH, total alkalinity, total hardness, Cl, CO2, BOD, COD, Na, K, SO4 and negative correlation with D.O. turbidity and MPN.

The above factors effect the Ca hardness in water due to evaporation, high pH, washing activities etc. so, these above factors shows positive correlation and some (D.O. turbidity and m.p.N) have showed negative correlation. As stated tab (4,16,10,25) coefficient correlation.

The present work resemble to the work of Verma (1993) found the calcium hardness between 42 to 233 mg/l in river Betwa.

Shinha et al (1995) reported the calcium concentration in the ranged between 16.01 to 101.0 mg/l in Sai river. Shukla (1996) recorded calcium hardness varied between 54 and 114 mg/l in river Betwa.

The variations of the Ca hardness observed by above workers marked it that the value of Calcium was always found to be more than magnesium.

**Mg Hardness**

Magnesium is an important factor present in all kinds of natural water. It founds with Calcium but concentration remains generally lower than Calcium. High concentration of magnesium combined with Sulphate and acts as laxative to human and aquatic organisms. Mg Hydroxide is practically insoluble in comparison to calcium hydroxide. Mg concentration depends upon sewage discharges industrial wastes, exchange equilibrium and presence of ions is also increase its concentrations. Calcium hardness when divided by total hardness
gives magnesium hardness. In the natural water the source of mg is various kinds of rocks. In the course of study the mg hardness of river water ranged between 5.0 to 34 mg/l in 2004 and in 2005 it varied from 9.0 to 33mg/l. the maximum value was recorded at station 1 and next to it at st 3 in the month of May and minimum value was found at St. IV in 2005 in the month of August and in 2004 it was found at station II in the month of Nov. The mean value of it was varied from 13.5 to 19.17 mg/l in 2004 and 20.0 to 24.33 mg/l in 2005.

Mg hardness is direct related with CaH. BIS has set a desirable limit of 30 mg/l for drinking whereas a permissible limit of mg hardness of 100 mg/l in the absence of any alternative water source. Mg hardness showed positive correlation ship with Ca hardness total hardness, total alkalinity, total dissolved solids, SO4, Na, K, NH4-N, Cl, C.O.D., B.O.D., CO2 and negative correlation with D.O., PO4, MPN. Above changes were marked by the effect of mg hardness in water due to sewage discharges, floods and evaporation. It is a constituent of chlorophyll and is an essential requirement for pigment algae of all groups as well as aquatic biota.

Chauhan et al (1990) reported the mg content in the range of 16 to 32 mg/l in Narnda river. Present work resemble with the findings of Hosetti et al (1994) found mg hardness in the range of 13.83 to 1969 mg/l in Amarnath pond.

The variation of the mg hardness value reported by above workers marked that mg hardness is closely direct related with Ca hardness which is in confirming with the present findings.

**Chloride (Cl)**

Water is an important factor to detect the water pollution, it is found in the forms of NaCl, KCl, and CaCl2 in natural water. There sources are
domestic discharges, sewage discharges and dissolution of salt deposits. It is most constant component. The concentration changes by the chemical and biological processes which are affected by physical factors. Human and animal faecal matters have high quantity of chlorides along with nitrogenous compounds. Increase in chloride concentration serves as one of the signal of faecal pollution. The average is about 6 to 15 mg/l chlorides per person per day. High concentrations of it affect the suitability of water.

In the present work chloride concentration was found between 25 mg/l to 73 mg/l in 2004 and in 2005 observed between 28 to 80 mg/l. The maximum concentration was found at St. III in the month of May whereas minimum concentration recorded at st. IV in the month of Aug in the entire study period. The mean value of it was found 41.25 to 48.08 mg/l in 2004 and in 2005 it varied between 42.67 to 53.50 mg/l higher concentration of chloride at st. I and III were recorded due to influence of human interference and sewage discharge and the lowest value was recorded at st. IV due to dilution in rainy season and temporary flood in 2005. Low and lower values were also found in st. II, V.

BIS has set desirable limit of chloride to be 250 mg/l for drinking water and 600 mg/l for irrigation purpose. During entire study of course chloride showed positive correlation with total alkalinity, temp, total hardness, BOD, COD, CO₂, NH₄, Na, K, SO₄, MPN whereas negative correlation was marked with D.O., PO₄ and Fluoride. These changes were noticed by the effect of chloride in river water due to washing, bothing activities, sewage discharges human faeces. Sahai and Sinha (1969) studied a direct correlation between chloride and water temperature, Phyto and zoo plankton growth and bottom biota.(4,7,10,13,16,25)
The present work resembles wish. the findings of Panda and Singh (1997) who observed drinking water quality of port city of paradip and dound chloride ranged between 11 to 52 mg/l. Nanda and Tiwari (1999) observed chloride varied from 8 to 26 mg/l in river Brahamani. Arora et al (1970) reported heavy fish mortality in Rihand reservoir due to high free chloride content (62 ppm) discharged from konaria industries.

David (1956) reported as much as 9.86 ppm of chlorine from paper mill near the confluence of Bhadra and Tunga rivers. This toxic substance adversely affected fish life to a great extent.

Above works are in conformity with the present findings.

**Dissolved oxygen**

It is a very important factor for the suitability of aquatic biota as well as portability of the water. River water receives oxygen by absorption from the atmosphere at the surface layer of the water and by the photosynthesis. It is consumed by respiration of animals as well as aquatic plants and coliform bacteria by chemical oxidation of waste substances and by putrefaction of organic matter. Dissolved oxygen volume in water depends upon concentration of dissolved salts, its temperature and the partial pressure of oxygen in the air in contact with water at the surface. It directly influences the biomagnification and bioaccumulation of the river ecology. According to Schluter and Groeneweg, (1981), it is important factor in the organic cycle of river water. Reducing dissolved oxygen concentration through high organic loading was found to be ineffective because many zooplanktons are able to survive extended periods of anoxia through physiological tolerance.

In the course of study the D.O. of river water was ranged between 4.6 to 7.9 mg/l in 2004 and in 2005 it varied from 2.4 to 6.7 mg/l. The maximum
level of it was at station IV and next to it at station II, V in the month of January in both the years and minimum was observed in the month of May at station. III, and lower was found at station I in 2004 while in 2005, August. The mean value of dissolved oxygen during the study period 4.78 to 6.58 mg/l. highest value of D.O. was observed during winter season due to much water volume, low temperature and low quantity of total coliform, which increase the oxygen holding capacity of water, where as lowest level of D.O. is observed in summer season due to low water volume, high temperature, and high quantity of zoo plankton’s and total Coliforms putrefaction of oxygen and in the course of study, D.O. showed positive correlation with photo synthesis, produced by flora. Dissolved oxygen showed Negative correlation with temp, turbidity, T.D.S., Cl, B.O.D., C.O.D., CO₂, NH₄-N, PO₄, SO₄,Na, K, MPN and zoo plankton’s. Phytoplankton directed with D.O. These changes were marked by effects of Dissolved oxygen in water by various ways and have impact on coefficient correlation. As stated table (4 to 27).

D.O. is quite important to evaluating the condition of the habitation of the flora and fauna in aquatic biota. For inland surface waters, BIS recommended the level of D.O. as > 6.0, >5.0, >4.0, >3.0 mg/l under class A to D respectively. CBPCWP (1985), reported a level of dissolved oxygen 5 mg/l or more is suitable for drinking purpose.

The observation resemble to the works of Shrivastava et al (1997) analyzed the drinking water quality of Agra U.P. and found the D.O. concentrations between 3.0 and 8.7 mg/l. Jain et al (1998) observed the water quality of river Kali and found D.O. ranged from 7.0 to 07.7 mg/l at up stream and 2.1 to 3 mg/l at down stream. Mohan and Hosetti (1998) studied the waste water of Jappinamogaru area and found D.O. varied between 3.88 to 8.78 mg/l. The variations of the D.O. reported by above workers marked that D.O. one of the most important and critical factor for aquatic biota.
Low dissolved oxygen and high carbon dioxide cause fish mortality. The unfavorable effects on the fish life are mainly caused by asphyxiation arising out of low oxygen. Venkataraman et al (1966) reported a large scale fish mortality, which was attributed to highly putrescible organic matter creating almost anaerobic conditions in the river with very low or nil oxygen. The dominance of zooplanktons over phytoplankton is responsible for depletion of oxygen, the respiratory demand of the relatively more dominant of zooplankton the presence of pollutants discharge by the various drains are the contributory limiting factors for the low or nil dissolved oxygen level. Present investigations resemble with the findings of above workers.

**Bio-chemical oxidation demand (B.O.D.)**

B.O.D. is an important factor in determining the oxidation of decomposition of organic matter or the oxygen amount utilized by micro-organism along with bacteria.

On an average basis, the demand for oxygen is proportional to the amount of organic waste to be decomposed aerobically. Obviously Bacteria use D.O. during the respiration and nitrification. Thus D.O. depletes whereas B.O.D. increases. It is a good index of organic pollution and helps in deciding potability of water for consumption. In order to assess the self purification capacity of a water body and the pollution level is essential to know the amount of bio degradable matter present and entering in it.

In the present study of B.O.D. in river water the range was found between 1.01 to 3.8 mg/l in 2004 and in 2005, it varied from 1.85 to 13.6 mg/l. The highest value was observed at station 1 and next to it higher was at station III in the month of May in 2004 and in 2005 August whereas next to it high value was recorded at station II and lower and lowest in station V & IV in the month of July 2004 and in 2005 the month was January. The mean value of
B.O.D. during the study Span was recorded 1.91 to 4.41 mg/l. The highest B.O.D. was recorded in summer season due to high temperature, purification of faecal matters, much growth of coliform, sewage discharges in the month of August 2005 the value was next to it was also higher due to flood. Whereas lower values were recorded in rainy seasons due to much water level and low decomposition of organic matter. BIS has set a limit of B.O.D. for inland surface waters is 2.0 mg/l.

In the present study of entire period B.O.D. showed positive correlation with Temp, turbidity, pH, T.A.T.H., Cl, COD, CO₂, NH₄-N, Na, SO₄ and negative correlation with water current, fluoride, D.O. These changes were marked by effects of B.O.D. in water by various ways so the above factors showed position correlation with B.O.D. as stated in table (4,7,10,13,16).

These observation resemble to the findings of Chandrashekharan et al (1997) who reported the B.O.D. in river Tikara ranged between 2.0 to 4.0 mg/l. Mohlman and his associates (1931) observed that the slug rising to the surface increased B.O.D. of the river water and lowered the dissolved oxygen content. ETTINGER (1956) reported organic compound which are readily oxidized biochemically in the river water which includes fats, carbohydrates, proteins & other substances found in domestic sewage, their effect on a stream can be assessed by the conventional B.O.D. and D.O. determinations.

**Chemical Oxidation Demand C.O.D**

It plays an important role to measure the organic matter. Carbonaceous factors of organic matter which are estimated by chemical oxygen demand. Organic substances are oxidized by a strong chemical agent in water, thus COD is the oxygen requirement. The presence of biologically resistant organic substances and toxic conditions are determined by the C.O.D. test. It is interfered by the some factors which influence B.O.D. But both these factors
do not have any corresponding correlation between them as C.O.D. indicates toxicity.

In the course of study C.O.D. value varied between 5.8 to 16 mg/l in 2004, and in 2005 it ranged between 8.0 to 88 mg/l at different sampling stations. The maximum value was observed at st.I in the month of May 2004 while in 2005 it was in the month of August. The minimum value was recorded at st. IV in the month of July 2004 and in the month of January 2005. The mean value of C.O.D. varied between 6.82 to 12.35 mg/l in 2004 and in 2005 it ranged from 24.25 to 42.58 mg/l during the study span.

The higher value was observed in summer season in 2004 at St. I and III due to low water level much organic matters and high temperature whereas in 2005 it was also high at st.V in monsoon seasons due to heavy flood, leaching of the chemical from the croplands. Lowest value was found at st. IV in broad river basin and much dilution.

C.O.D. showed positive correlation with temp., turbidity, pH, TDS, T.A., TH, B.O.D., CO₂, NH₄, PO₄, SO₄, Na, K, MPN and negative correlation with dissolved oxygen. These changes were noticed the effect of C.O.D. in water by various ways :- Low water level, much organic matters, high temperature, run off the chemicals from the crop lands, drains and inflow of ground waters. The C.O.D. values were found always greater from B.O.D. values, indicating toxicity in water. The desirable limits of C.O.D. recommended by WHO is 10 mg/l in drinking water.

The present observations resemble to the findings of Singh et al (1995) investigated the impact of river Varuna on river Ganga and found C.O.D. value varied between 7.6 to 58.4 mg/l.
Upadhyay (1997) studied kaliasote dam and recorded C.O.D. in range of 7.9 to 85.76 mg/l. The variations of the C.O.D. reported by the above workers marked it as organic pollution indicator by which toxicity in water is assessed.

**Carbon dioxide (CO₂)**

It is an important factor for the assessment of water quality. The resource of it is organic carbonaceous matter in rivers which comes from dead or living animals and plants, sewage discharge wastes and soil erosion. They are oxidized by aerobic bacteria in the presence of dissolved oxygen and form carbon dioxide. CO₂ in natural waters is also derived from atmosphere, seeping ground water and combined by basic elements chiefly calcium, magnesium and sodium to carbonates of bicarbonates. Low concentration of carbon dioxide is due to its utilization in photosynthesis and is carried out only by green plants containing chlorophyll in the presence of sunlight, it involves the formation of oxygen. Whereas in dark or nights high concentration of CO₂ is found because plants and aquatic organisms continue respiration, oxygen being taken up and carbon dioxide is given off. But in rainy season some CO₂ gets dissolved in rain water which contains about 0.6 mg/l of dissolved oxygen also. Besides, atmosphere furnishes some CO₂ to natural waters by direct contact.

High CO₂ contents of natural waters being more toxic to fish and indicates water pollution.

In the course of study the CO₂ of river water varied form 1.6 to 5.4 mg/l in 2004 and in 2005 its values fluctuated between 1.8 to 6.8 mg/l. Highest value was found at station III and at stations V, I and II though they were also high in the month of May 2004 and in month of August in 2005 the value recorded as per the sequence of stations given. Where as lowest value was observed at st. IV in the month of Jan. in both the years. The mean value of
CO₂ ranged between 3.18 to 3.84 mg/l in 2004 and in 2005 it varied from 3.31 to 6.52 mg/l. The highest value of CO₂ was found during summer in 2004 and in monsoon season in 2005 at satiation III it was marked due to decomposition of organic matter and animal excreta at high temperature in summer whereas in monsoon period due to respiration of planktons; heavy influx of discharges and leaching of soil in river.

As per the data recorded CO₂ showed positive correlation with Temp. pH Total dissolved solids, Cl, T.A., T.H, B.O.D., C.O.D., NH₄-N, PO₄, SO₄, Na, K, and M.P.N. and negative correlation with D.O. These changes were marked by various factors, which increased CO₂ concentration thus CO₂ showed positive correlation with above factors and negative correlation with D.O. as stated table (4,7,10,13,16,23,25).

The presence or absence of free carbon dioxide in the surface water is majorly regulated by due to utilization by algae during photosynthesis and also through its diffusion from air. Sreenivasan(1974). According to Jhingaran (1991) concentration of free CO₂ being detrimental to fry and fingerlings of major carps under various combinations of temperature & O₂. Ellis, M.M. (1973) considers that the concentration of free CO₂ should not exceeds 3 ml/l and that any higher value usually indicates pollution.

The present work is in conformity with the findings of the above workers.

**Ammonical Nitrogen (NH₄-N)**

Soluble inorganic nitrogen is represented primarily by four different molecules: Ammonia (NH₄), Nitrite (NO₂), Nitrate (NO₃) and nitrogen gas.
Ammonia is the principal nitrogenous byproduct of organic decomposition. The most important source of ammonia is the ammonification of organic matter. Sewage has large quantities of nitrogenous matter, thus its disposal tends to increase the ammonia content of waters.

The oxidation of ammonia by aerobic bacteria first to nitrites and then to nitrate is called nitrification. In this two step process the microbial transformation of ammonia to nitrite is much slower than the subsequent microbial transformation of nitrite to nitrate (Goldman & Horne, 1983). Occurrence of ammonia in the water is accepted as the chemical evidence of organic pollution.

In the present study the NH$_4$-N in river water ranged from 0.0345 to 1.265 mg/l in 2004 and in 2005. Its variation was found between 0.012 to 1.352 mg/l. The maximum was observed in June at station III and next to it at station V and I which was also high while minimum concentration was found in August at St. IV & II during the entire study period. The mean value was observed between 0.33 to 0.41 in 2004 and in 2005 it ranged between 0.35 to 0.43 mg/l accordingly. High concentration of NH$_4$-N is recorded in summer season due to sewage discharges animal excretae, the much decomposition of organic matter at high temperature.

It showed positive correlation with Temp, Turbidity, TDS, Cl, B.O.D., C.O.D., CO$_2$, PO$_4$, SO$_4$, Na, K, MPN and negative correlation with water current and D.O. These changes were by marked effects on NH$_4$-N in water by various reasons and have impact on correlation as stated above. Table no. (4,7,10,13,16).

A level of 0.15 mg/l of free ammonia for fish culture has been recommended by BIS. Upper permissible limit of Ammonical nitrogen for drinking and irrigation water is 1.5 & 5.0 mg/l.
The present findings are in the conformity with the observations of joy et al (1990) studied the river periyar and reported the NH₄-N in the range between nil to 0.0625 mg/l. Baruah et al (1995) studied the jhanji river of Assam and found NH₄-N in the range of 0.21 to 0.82 mg/l. Upadhyay (1997) assessed the Ammonical nitrogen ranged between nil to 0.99 mg/l in the kaliasote dam.

According to Goldman and Horne (1983) Ammonia is preferred for plant growth because the incorporation of nitrate requires additional metabolic energy and enzymatic activity. Ammonia play an important role for algal growth. Higher concentration of it is harmful to fish and other aquatic biota. Algae and bacteria both incorporate ammonia very rapidly.

**Nitrite- Nitrogen (NO₂-N)**

Ammonia is oxidized and nitrite is formed besides reduction of nitrate. During denitrification, nitrates are reduced to nitrites in the presence of carbonaceous matter and of limited amounts of oxygen. As an intermediate stage in the nitrogen cycle, nitrite is a very unstable ion and appears in the water mainly as a result of biochemical oxidation of ammonia: presence of a small quantity of nitrite indicates the fecal pollution in water body and the availability of partially oxidized nitrogenous matter. The high content of nitrite causes blue baby (methamoglobinemia) disease in infants.

In the course of Study the nitrite value ranged between 0.010. to 0.120 mg/l in the year 2004 and in 2005 it ranged between 0.021 to 0.122 mg/l. Highest value was found at station III and next to it at st. V, I, II in the month of June whereas lowest value was recorded at St IV in the month of Aug in the entire study span. The mean value of NO₂-N was observed in river water between 0.04 to 0.22 mg/l in year 2004 and in 2005 it varied from 0.05 to 0.11 mg/l.
The Nitrite nitrogen showed positive co relationship with NH₄-N, NO₃-N, CO₂, Cl, PO₄, SO₄, Na, K, MPN and negative correlation with water current D.O. and Fluoride. These changes were marked by effects of NO₂-N in water by various ways viz : decomposition of nitrogenous matter by bacteria, sewage discharges animal excretae. USEPA (1996) has set a desirable limit of nitrite and nitrate together to be 10 mg/l.

The work was in conformity with the observations of Rao et al (1994) who studied the sewage pollution of Ooty lake and found nitrite between 0.01 to 1.23 mg/l. Abdul et al (1996) found nitrite concentration varied from 0.022 to 0.022 mg/l in kuttiadi lake.

Joy et al (1990) recorded the NO₂-N ranged between nil and 0.48 mg/l in Periyar river. The variation of the NO₂-N reported by above workers marked that the value were found corresponding to that of Ammonical nitrogen.

**Nitrate nitrogen (NO₃-N)**

The most important source of nitrate is biological oxidations of organic nitrogenous matters which comes from sewage discharges, domestic sewage wastes the seepage of sewage and runoff from crop lands. Nitrate is an important plant nutrient and normally present in many plants, often at levels that cause poisoning of livestock, self purifying capacity of the water body is affected by Nitrate.

Nitrate usually occurs in trace quantities in surface water. This water quality parameter is related with human health. Human infants have been especially susceptible, not only because of their high gastic pH but also due to their high fluid intake relative to body weight. Its poisoning brings "methemoglobinemia" condition which resulting from changes in the hemoglobin of the red blood cells that reduce their capacity to carry oxygen.
In the present study the nitrate in river water varied from 0.72 to 5.15 mg/l in the first year 2004 and in second year (2005) between 0.758 to 5.58 mg/l. The maximum value was recorded at st III in the month of June where as minimum value was found at st IV in the month of August during entire study span. The mean value was found from 1.78 to 2.48 mg/l in 2004 and 1.95 to 2.66 mg/l in 2005. Highest value of nitrate was observed in summer and in pre monsoon season due to much excreatory matter, domestic sewage. It showed distinct seasonal variation.

The nitrate showed positive correlation with Temp, pH, T.A. Cl, B.O.D., C.O.D., CO₂, SO₄, NH₄, Na, K, MPN and negative correlation with turbidity, water current, TDS D.O. These changes were marked by effects of nitrate nitrogen in water by various ways viz decomposition of organic nitrogenous substances, high water temp, domestic sewage discharges and high excretory matter, Thus the above factors showed positive correlationship NO₂-N where as some factors (turbidity TDS, D.O.) showed negative correlation. As state Table (4,7,10,1,21).

BIS has set a desirable limit of nitrate in drinking water as 45.0 mg/l and a permissible limit of 100 mg/l in the absence of any other alternate source.

The present work coincide with the findings of Mitra (1995) who studied the tributaries of Mahanadi and reported nitrate between 0.73 to 1.84 mg/l. Sharma et al (1998) reported the sewage waters of Gwalior region and found nitrate in the range of nil to 3.33 mg/l. Pande and sharma (1999) studied the river Ramganga and found nitrate ranged from 3.0 to 9.5 mg/l, Tanaka M, (1953) reported that during the autumn the dissolved oxygen content of the bottom Layers of lake kizakiko is greatly decreased, and this favours reduction of Nitrate by bacteria and the formation of nitrite and hydroxylamine (NH₂OH).
Phosphate (PO₄)

It is an important and one of the major nutrient responsible for phytoplankton growth which are consumed by zooplankton and later by fishes. So its role is in water productivity. Phosphates also have wide uses in domestic and industries. But higher concentration of phosphate causes eutrophication which causes pollution. They are formed mainly during certain biological process of trains formation of organic substances to inorganic phosphates. There is no common atmospheric source for phosphorous. Synthetic detergents, domestic sewage, dead microorganisms, waste water, agriculture run off and runoff water from the catchments areas are the major sources of phosphorus in water bodies. Phosphates after once being introduced in to a aquatic habitat, have been continually recycled in the green plants and algae. When the plants and algae die the phosphate get released and used again by other plants. Large amount of phosphorus get stored in the bottom muds of water bodies in the form of slightly soluble salts of calcium, magnesium and Iron. Phosphates are found in all photoautotrophes where they are synthesized enzymatically and constitute part of phosphate pool. Phosphates lies in the ability to increase the growth of nuisance algae and aquatic weeds, if phosphate were removed it could be made the limiting factor. Natural waters having a phosphorous content of more than 0.2 ppm PO₄ are likely to be quite productive whereas excess of PO₄ in surface waters is a sign to heavy organic pollution.

In the present study the PO₄ of river water was found between 0.0438 to 0.625 mg/l in 2004 and in 2005 it ranged between 0.0435 to 0.620 mg/l. The maximum level of phosphate content was recorded at st V in the moth of Aug. and minimum concentration was noticed at St IV in the month of Feb in the entire study period. The mean value of phosphate content ranged between 0.11
to 0.29 mg/l in 2004 and in 2005 it varied between 0.07 to 0.53 mg/l highest value of PO₄ was observed during monsoon season in both the years due to run off water from catchment areas and cultivated crop lands, storms and sewage, whereas minimum concentration was recorded in winter season due to lack of run off and storm.

The PO₄ showed positive correlation with Sulphate TH, TDS, Na, K and negative correlation with D.O. at most of the monitoring stations. (4 to 27).

BIS and USEPA have not set any standard value for phosphate in drinking water but the critical level for inorganic phosphates has been established 0.005 mg/l.

The present work is in conformity with the findings of Sarwar et al (1991) who studied the fresh water pond of Shrinagar and found phosphate ranged between 0.005 to 0.043 mg/l. Baruah et al (1995) observed the phosphate varied from negligible amount to 0.20 mg/l in river Jhanji. Pande and Sharma (1999) found phosphate ranged between 0.5 to 0.85 mg/l in Ramganga at Muradabad. The variations of PO₄ noticed by the above workers and reported that it is a limiting factor.

**Sulphate (SO₄)**

The most abundant form of sulphur is the anion sulphate (SO₄⁻⁻) occurring in combination with Ca, mg, and Fe, cations in fresh waters. It is also found in water as hydrogen sulphide. In natural waters, H₂O is produced as a result of reduction of sulphates by certain bacteria under an aerobic conditions and also as a result of bacterial decomposition of proteins containing reduced sulphur. Sulphate is an essential and impart permanent hardness to the water. The supply of sulphate in surface, ground and under ground water under natural conditions is due to the reaction of rain water with
sulphate containing rocks of the catchments area. Sulphate is ecologically important for growth of plants, plankton development and in protein metabolism. It is an important consideration in determining water potability for public and industrial supply because of its cathartic effect upon human, when it is present in excessive amounts. Sulphate is directly associated with odour and corrosion problem because high concentration of sulphate contaminates the water body.

In the present study the SO$_4$ concentration varied from 2.16 to 6.95 mg/l in 2004 where as in 2005 its concentration ranged form 2.25 to 7.85 mg/l. The higher concentration was found at St. III and st. V in the month of May and lower values where observed at St. II and IV in the month of July In entire study period. The mean value was observed between 3.89 to 4.4 in 2004 whereas in 2005 it was found between 4.47 to 4.71 mg/l. highest value was found in summer season primarily due decomposition of organic wastes and discharges of sewage and lowest concentration was observed in monsoon season mainly due to much dilution and much water volume. The SO$_4$ showed positive correlation with Temp pH, T.A. TH, cl, B.O.D. C.O.D., CO$_2$, PO$_4$, Na, K, and negative correlation with turbidity, water current, T.D.S. and D.O. These changes were marked by the effects of SO$_4$ in water. BIS has set the limit of Sulphate in drinking water to be 200 mg/l where as its permissible limit is 400 mg/l in the absence of any other alternative source. (Table-4-27).

The present observations resemble with findings of sharma (1998) who observed the sewage water in Gwalior region and found sulphate 1.749 m.e.q. Raman et al (1994) observed the sulphate in the range of 25.0 to 35.0 mg/l in Tungabhadra river. The bacterial sulfur cycle is an important in connection with problems of river pollution & the treatment of sewage Heukelekian (1948) reported that sewage contains only a few sulphate reducing bacteria but much larger numbers occurs in sewer growths and in sewage sludges.
SODIUM (Na)

In natural waters sodium occurs as halide (NaCl). Sodium letraborate (Na$_2$B$_4$O$_7$) and sodium sulphate. Its concentration in natural fresh water is generally lower than the calcium and magnesium. Sodium is essential to sustain biological life. It is metabolized only by blue green algae. High concentration of Na is harmful to human physiology. In natural waters weathering of various rocks is the major source of sodium, thus sea water is rich in this element due to which sea water is unsuitable for drinking, domestic, irrigation or industrial uses. According to Hedge and Kale (1995) this elements is also harmful in irrigation due to its effect on soil structure, in filtration and permeability rates.

Sodium salts are highly soluble in water. During natural softening of water, sodium is exchanged by ca++ and mg++ and thus gets increased in concentration in some ground waters. Sodium associated with chlorides and sulphates make the water salty and renders it unsuitable.

In the present study the value of sodium in river water varied between 02 to 26mg/l in 2004 and in 2005 it fluctuated between 05 to 28 mg/l. The highest value was found at St. III and next to it was higher at st I & V in the month of August and lower was found at St. II and lowest concentration was recorded at St. IV in the month of January in the entire study span. The mean value was Observed between 11.92 to 17.17mg/l in 2004 and 11.33 to 17.08 mg/l in 2005.

Highest value of Na was recorded in rainy season due to more drainage of domestic waste and sewage discharges runoff from nalas and adjoining river storm whereas lowest was found in winter season due to less discharges etc.
The sodium showed positive correlation with temperature, pH, TA, T.H., Cl, B.O.D., C.O.D., CO₃, NH₄, PO₄, SO₄ M.P.N. and negative correlation to with D.O. These changes were marked by effects of sodium concentrate in water. As shown in tables (4-27).

The BIS who has prescribed a limit of 200 mg/l of Na for suitable water. A high percentage of exchangeable sodium in dispersion restricts water movement and effects plant growth. Under the WHO limits so the Betwa river water is soft and suitable. The present observations are in conformity with the other findings of Mohan and Hosstti (1998) reported sodium from 18.98 to 49.62 mg/l in waste water of Jappinamogaru area. Mitra (1997) reported sodium in the range from 18.98 to 49.62 mg/l in river Brahmani.

The variations of the Na reported by above workers marked that its salts impart water with softener against hardness.

**Potassium (K)**

It is an important element occurring naturally and plays a vital role in the metabolism of fresh water organisms and acts as enzyme activator. The concentrations of it remain quite lower than calcium, magnesium and sodium. Potassium is a necessary requirement for all algae, under low potassium concentration, growth and photosynthesis of algae are poor and respiration high. The quantity increased in polluted waters by disposal of waste water, like sodium. Potassium also enter the exchange equilibrate of the observed actions. According to golterman (1967), Potassium fixed in minerals is not always easily exchangeable. Concentration is high in summer because K is adsorbed by mud during winter and released during summer. In the course of study the potassium was found in river water. Varied from 01.0 to 12 mg/l in 2004 and ranged between 02 to 13 mg/l. The maximum nature was found at St. III and next to it at station 1and V in the month of August whereas minimum value
was recorded at St IV in the month of January and mean values was observed in range of 4.42 and 8.17 mg/l highest value was recorded in rainy season due to leaching from soil, sewage etc. and lowest was found in winter season due to low concentration of organic wastes in discharges and also low temp. Potassium shared positive correlation with temp, turbidity, pH, T.A. T.H. Cl, BOD, COD NH₄, Na and negative correlation with D.O. and SO₄ at some stations, These changes were marked by effects of varied concentration in discharges of K.as shown in tables (4,7,10,19,25).

BIS, WHO an USEPA has not set any standard of K for drinking water. The observations resemble to the findings of krishnomerthy et al (1994) reported potassium variation from 1.2 to 10.3 mg/l. Raju et al (1999) found the potassium in range of 0.9 to 10.0 mg/l in pulang river basin. Schaperclaus (1961) reported that K is adsorbed to the mud during winter and released during summer. Golterman (1967) concluded that potassium is fixed in minerals is not always easily exchangeable.

### Fluoride

It is the most electronegative and reactive element. It exists either as inorganic fluorides or organic fluoride compounds major natural source of fluorid in environment is natural weathering of rock and increasing in the atmosphere due to various industrial effluents, leaching or chemical fertilizer from croplands iron, steel plants, phosphate fertilize units, coal powering etc. fluoride is considered as a serious pollutant and its toxicity is harmful to aquatic biology as well as potability of water . In the course of study the fluoride of river water varied between 0.001 to 1.20 in year 2004 and in 2005 ranged from 0.02 to 1.71 mg/l. The maximum value was recorded at station 3 and subsequently at station II & I in the month of August whereas the minimum value was found at St IV & Lowest at st.5 in the month of Feb
throughout the study span the mean value was recorded in the range of 0.18 to 0.35 mg/l in 2004 and in 2005 it varied between 70.19 to 0.35 mg/l. The highest value was found in rainy season due to floods which carry more chemicals elements from adjoining areas.

Fluoride showed positive correlation with Temp., Turbidity total dissolve solids, CO₂, NH₄, Na, K and negative correlation ship with pH, T.A., T.A., T.H., Cl, D.O., B.O.D., C.O.D, & SO₄ as stated in tables (4,7,10,16).

1.0 ppm concentration has been recommended, with a permissible operating range of 0.8 to 1.2 ppm and above 1.2 ppm mottling of the teeth or enamel fluorsis occurs. Higher level of fluoride in drinking water has been reported to cause various physiological disturbances in human beings as well as aquatic animals.


In the present investigation fluoride concentration was noticed higher than the possible limit but it was only found during the flood year (2005) which showed all effects on the aquatic biota along with fishes, besides it was also not suitable for the drinking purpose. Thus the present findings were in the conformity of the above mentioned work reported by different workers.
Atmospheric Temperature (°C)

2004

Fig 1

2005

Fig 2
Relative Humidity (%), Rain Fall (mm) & Photo Period(Hrs.)

2004

2005
Fig 5

Station II
Year 2004

Fig 6

Station I
Year 2004
Water Temperature (°C), Turbidity (N.T.U.), & Chloride (mg/l)

Station V
Year 2004

Station I
Year 2005

Fig 9

Fig 10
Water Temperature (°C), Turbidity (N.T.U.), & Chloride (mg/l)

Station II
Year 2005

Station III
Year 2005

Fig 11

Fig 12
Water Temperature (°C), Turbidity (N.T.U.), & Chloride (mg/l)

**Station IV**
Year 2005

**Station V**
Year 2005

Fig 13

Fig 14
Hydrogen – ion concentration (pH), Total Alkalinity (T.A.) & Total Hardness (T.H.)

Station I
Year 2004

Station II
Year 2004
Hydrogen – ion concentration (pH), Total Alkalinity (T.A.) & Total Hardness (T.H.)

Station V
Year 2004

Fig 19

Station I
Year 2005

Fig 20
Hydrogen – ion concentration (pH), Total Alkalinity (T.A.) & Total Hardness (T.H.)

Station II
Year 2005

Station III
Year 2005

Fig 21

Fig 22
Total Hardness (T.H.), Calcium Hardness (Ca.H.) & Magnesium Hardness (Mg.H.)

Station I
Year 2004

Fig 25

Station II
Year 2004

Fig 26
Total Hardness (T.H.), Calcium Hardness (Ca.H.) & Magnesium Hardness (Mg.H.)

Station III
Year 2004

Fig 27

Station IV
Year 2004

Fig 28
Total Hardness (T.H.), Calcium Hardness (Ca.H.) & Magnesium Hardness (Mg.H.)

Station V
Year 2004

Station I
Year 2005

Fig 29

Fig 30
Total Hardness (T.H.), Calcium Hardness (Ca.H.) & Magnesium Hardness (Mg.H.)

Station II
Year 2005

Station III
Year 2005

Fig 31

Fig 32
Total Hardness (T.H.), Calcium Hardness (Ca.H.) & Magnesium Hardness (Mg.H.)

Station IV
Year 2005

Station V
Year 2005

Fig 33

Fig 34
Dissolved Oxygen (D.O.), Biochemical Oxygen Demand (B.O.D.) & Chemical Oxygen Demand (C.O.D.)

**Station I**
Year 2004

**Station II**
Year 2004

Fig 35

Fig 36
Dissolved Oxygen (D.O.), Biochemical Oxygen Demand (B.O.D.) & Chemical Oxygen Demand (C.O.D.)

Station III
Year 2004

Fig 37

Station IV
Year 2004

Fig 38
Dissolved Oxygen (D.O.), Biochemical Oxygen Demand (B.O.D.) & Chemical Oxygen Demand (C.O.D.)

Station V
Year 2004

Fig 39

Station I
Year 2005

Fig 40
Dissolved Oxygen (D.O.), Biochemical Oxygen Demand (B.O.D.) & Chemical Oxygen Demand (C.O.D.)

Station II
Year 2005

Fig 41

Station III
Year 2005

Fig 42
Dissolved Oxygen (D.O.), Biochemical Oxygen Demand (B.O.D.) & Chemical Oxygen Demand (C.O.D.)

Station IV
Year 2005

Station V
Year 2005

Fig 43

Fig 44
Ammonical Nitrogen (NH₄-N), Nitrite Nitrogen (NO₂-N) & Nitrate Nitrogen (NO₃-N)

Station I
Year 2004

Station II
Year 2004

Fig 45

Fig 46
Ammonical Nitrogen ($\text{NH}_4$-$\text{N}$), Nitrite Nitrogen ($\text{NO}_2$-$\text{N}$) & Nitrate Nitrogen ($\text{NO}_3$-$\text{N}$)

**Station III**
**Year 2004**

**Station IV**
**Year 2004**
Ammonical Nitrogen (NH₄-N), Nitrite Nitrogen (NO₂-N) & Nitrate Nitrogen (NO₃-N)

Station V
Year 2004

Station I
Year 2005
Ammonical Nitrogen (NH₄-N), Nitrite Nitrogen (NO₂-N) & Nitrate Nitrogen (NO₃-N)

Station II
Year 2005

Station III
Year 2005

Fig 51

Fig 52
Ammonical Nitrogen (NH$_4$-N), Nitrite Nitrogen (NO$_2$-N) & Nitrate Nitrogen (NO$_3$-N)

Station IV
Year 2005

Station V
Year 2005

Fig 53

Fig 54
Ammonical Nitrogen (NH₄-N), Phosphate (PO₄) & Sulphate (SO₄)

Station I
Year 2004

Station II
Year 2004

Fig 55

Fig 56
Ammonical Nitrogen (NH₄-N), Phosphate (PO₄) & Sulphate (SO₄)

Station V
Year 2004

Station I
Year 2005
Ammonical Nitrogen (NH₄-N), Phosphate (PO₄) & Sulphate (SO₄)

Station II
Year 2005

Station III
Year 2005

Fig 61

Fig 62
Sodium (Na), Potassium (K) & Fluoride

Station I
Year 2004

Station II
Year 2004

Fig 65

Fig 66
Water Current, Total Dissolved Solid (T.D.S.), Carbon di Oxide (CO2) & M.P.N.

Station I
Year 2004

Station II
Year 2004

Fig 75

Fig 76
Water Current, Total Dissolved Solid (T.D.S.), Carbon di Oxide (CO2) & M.P.N.

Station V
Year 2004

Station I
Year 2005

Fig 79

Fig 80
Water Current, Total Dissolved Solid (T.D.S.), Carbon di Oxide (CO2) & M.P.N.

Station II
Year 2005

Station III
Year 2005

Fig 81

Fig 82
Station I
Phytoplankton
2004

Jan
-4 8 3 6 6 10 18 16 Jan 16 17 14 17 12 4 8 17 20 14 8 4
Jan 6 6 10 -

Feb
4 7 10 12 6 8 8 14 22 25 Feb 14 3 15 12 14 10 4 7 15 18
12 10 6 Feb 10 9 6 12 2

Mar
9 14 12 14 4 12 6 10 3 19 20 3 Mar 9 8 14 10 13 9 3 6 13 16
10 8 6 Mar 13 10 16 10 16 4

Apr
15 8 17 7 4 12 17 16 18 6 Apr 8 10 12 8 10 8 4 10 14 10 6
8 Apr 16 17 36 8 18 6

May
18 7 15 20 10 3 14 13 18 18 10 May 6 11 10 8 8 5 - 8 12 9 6
5 May 18 24 58 14 19 6

Jun
21 9 18 22 12 2 18 16 12 16 18 Jun 6 8 6 9 8 4 Jun 22
28 60 6 22 3

Jul
26 10 20 25 16 10 20 22 18 19 12 Jul 6 4 - Jul 4 8 13 -

Aug
20 - 16 18 - 12 5 18 16 12 8 8-Aug 6 4-Aug 8 13 -

Sep
18 18 17 4 8 4 13 12 4 10 Sep 4 5 5 - 8 4 2 5 9 5 3 - Sep
4 14 38 2 -

Oct
- 6 10 - 5 12 6 15 6 7 8 6 Oct 9 8 6 3 11 6 4 4 7 12 6 5 3 Oct 6
18 30 4 8 6

Nov
- 8 12 - 8 10 8 16 10 12 10 5 Nov 12 9 12 6 14 9 6 3 10 14 8 5
4 Nov - 12 18 - 6 3

Dec
- 4 6 - 6 5 12 8 12 14 12 - Dec 14 6 13 8 15 13 8 4 15 18 10 6
6 Dec - 6 15 - 4 -

Fig 85
Station III
Phytoplankton
2004

- Jan - 6 9 - 4 8 - 7 12 20 18 - Jan 18 - 19 15 18 13 6 10 19 22 17
  10 6 Jan - 8 - 7 12 -
- Feb - 6 8 12 13 8 10 - 10 17 24 28 - Feb 15 4 17 13 16 12 6 9 17 21
  13 13 8 Feb 13 10 - 8 14 4
- Mar - 10 16 14 16 6 13 9 11 22 20 25 4 Mar 11 10 16 12 15 11 4 7
  14 19 12 10 7 Mar 15 13 19 12 17 6
- Apr - 16 10 15 18 - 8 6 14 19 18 21 8 Apr 10 13 13 10 13 9 - 5 13
  16 12 8 10 Apr 18 18 38 10 20 8
- May - 19 10 17 21 - 11 4 16 17 14 20 13 May 8 15 12 11 10 7 - 10
  15 10 7 8 May 20 26 60 17 22 8
- Jun - 23 12 19 24 - 13 3 20 19 13 19 9 Jun - 8 10 - 9 12 9 5 6 Jun
  24 30 62 9 24 5
- Jul - 28 13 22 26 - 18 13 21 24 20 21 14 Jul - 9 - 7 - Jul 9 18 30 -
- Aug - 22 - 18 21 - 14 8 20 18 14 10 6 - Aug - 7 - 6 - Aug 5 10 16 -
- Sep - 19 - 20 18 5 10 6 15 15 6 7 12 Sep 5 5 7 5 - 9 6 3 3 4 10 7 4 -
  Sep 6 16 40 4 -
- Oct - 7 11 - 7 13 8 16 9 10 11 8 Oct 8 10 7 5 13 8 6 9 12 9 8 5
  Oct 8 20 32 6 11 9
- Nov - 9 13 - 9 11 11 19 12 14 13 7 Nov 14 12 14 8 16 12 8 4 12 15
  10 7 6 Nov - 14 20 - 8 5
- Dec - 6 8 - 7 7 13 10 14 16 14 - Dec 17 8 16 11 18 15 11 6 18 18
  12 8 8 Dec - 9 17 - 5 -

Fig 87
Station IV
Phytoplankton
2004

Fig 88

xlvi
Station II
Phytoplankton
2005

- 2 3 1 2 - 2 5 1 2 1 0 - Jan 1 2 - 1 4 9 1 6 2 4 1 0 1 6 9 3 2 1 2 3 5 -
- 1 2 - 4 1 3 - 3 7 1 5 1 7 - Feb 1 0 2 1 1 6 6 5 1 3 8 1 2 7 3 3 Feb 7 5 - 1 8 1
- 4 6 5 9 1 6 2 5 1 4 1 0 1 3 1 Mar 4 3 1 2 5 8 5 1 3 9 1 1 6 2 4 Mar 8 5 1 2 1 0 2
- 8 4 7 1 2 - 3 2 7 1 2 1 3 1 4 3 Apr 4 6 9 5 5 3 - 2 7 9 4 2 3 Apr 1 1 1 2 3 0 5 1 2 2
- 1 1 3 1 2 1 4 - 4 1 1 0 9 1 0 1 6 6 May 3 5 7 3 4 2 - 4 6 4 1 2 May 1 2 1 8 4 9 4 1 3 3
- 1 5 2 1 0 1 4 - 6 1 1 3 1 2 8 1 4 3 Jun - 2 4 - 3 4 3 1 1 Jun 1 5 2 2 5 3 8 1 5 1
- 1 5 2 1 0 1 4 - 6 1 1 3 1 2 8 1 4 3 Jul - 3 - 2 2 - Jul 2 8 2 0 2 -
- 6 - 3 6 3 - 2 3 - 4 - Aug - 2 - 1 - Aug 2 3 7 -
- 1 2 - 4 1 3 1 2 1 4 6 1 2 6 Sep 1 1 2 - 2 1 1 1 5 1 - Sep 2 1 0 3 0 -
- 1 4 - 1 5 2 1 3 3 Oct 5 4 3 1 6 2 1 1 3 7 2 1 1 Oct 3 1 2 2 1 4 1
- 1 5 - 3 6 4 7 2 7 3 2 Nov 7 5 8 2 9 3 2 5 1 1 2 1 Nov - 7 1 1 1 2 2
- 1 2 - 2 5 3 3 1 1 4 Dec 8 2 1 0 4 1 1 1 0 3 1 8 1 2 5 1 1 Dec - 3 1 0 - 1 -

Fig 91

xlix
Station IV
Phytoplankton
2005

Volvox Ankistrodesmus Scenedesmus Endorina Actinostrum
Chlorella Chlorococcus Pandorina Zygnaema Ulothrix Spirogyra
Chlosterium Acmaesthes Astrotionella Cyclotella Diatoma
Navicula Syndra Stauroneis Gomphonema Nitschia Melosira
Cymbella Cocconeis Fragillaria Microcystis Anabaena
Oscillatoria

- Jan - 2 4 1 2 3 6 13 1 Jan 13 15 10 13 8 2 5 12 17 11 3 3 Jan 4 6 -
- Feb 2 3 5 6 2 4 4 10 17 18 16 Feb 12 2 13 7 2 4 10 14 9 4 3 Feb 8 6 2 9 1
- Mar 5 8 7 10 1 8 3 6 16 12 15 2 Mar 6 4 13 7 9 6 1 3 11 12 7 3 4 Mar 10 7 13 2 12 4
- Apr 9 5 8 13 4 2 9 1 4 1 1 15 4 - Apr 5 7 11 6 6 4 2 7 11 6 2 4 Apr 12 13 3 3 7 1 5 3
- May 13 3 12 15 6 2 10 12 12 16 7 - May 4 7 8 4 5 2 - 5 8 6 2 2 May 13 2 0 5 2 5 1 6 3
- Jun 17 3 12 16 8 1 14 13 9 1 4 5 - Jun 3 6 4 5 5 1 2 Jun 16 24 54 10 18 1
- Jul 21 4 15 18 1 2 6 1 5 1 8 1 4 1 5 8 - Jul 4 2 2 4 1 2 0 10 2 3 -
- Aug 8 4 7 4 3 4 - 5 Aug 3 1 1 - Aug 2 4 9 -
- Sep 14 5 1 4 2 3 1 4 7 1 2 7 - Sep 2 2 3 4 2 1 1 2 6 2 1 - Sep 2 12 3 -
- Oct 1 6 1 6 3 7 1 3 4 4 Oct 6 5 4 1 7 3 1 7 3 1 1 4 8 3 2 1 Oct 4 13 2 5 1 5 2
- Nov 2 7 4 7 5 8 3 8 3 Nov 9 6 9 3 1 1 4 3 2 7 1 1 5 2 1 Nov 8 13 1 3 2
- Dec 1 3 3 3 7 4 4 1 2 6 - Dec 1 0 3 1 0 6 1 2 1 1 4 2 1 0 1 4 7 3 2 Dec 4 1 1 2 -

Fig 93
Station V
Phytoplankton
2005

Volvox Ankistrodesmus Scenedesmus Eudorina Actinostrum
Chlorella Chlorococcomat Pandorina Zygnema Ulothrix Spirogyra
Chlosterium Achnanthes Astorioniella Cyclotella Diatoms
Navicula Synedra Stauroeis Gomphonema Nitschia Melosira
Cymbella Cocconeis Fragillaria Microcystis Anabaena
Oscillatoria

- Jan: 12 1 13 10 8 - Jan: 10 12 8 10 4 1 3 9 13 7 2 2 Jan: 2 4
- Feb: 11 3 1 2 5 12 16 - Feb: 8 1 8 4 3 1 2 6 10 5 2 2 Feb: 5 3 1 6 1
- Mar: 3 3 8 1 4 2 4 12 9 11 - Mar: 2 2 9 3 6 3 1 1 8 1 1 3 1 3 Mar: 7 4 1 0 1 8 1
- Apr: 7 2 5 10 1 2 1 5 10 12 13 2 Apr: 2 3 7 2 4 1 1 4 7 2 1 2 Apr: 9 1 0 2 8 4 1 0 2
- May: 10 2 10 12 3 1 9 8 8 1 4 4 May: 1 3 4 1 2 2 5 2 1 1 May: 1 1 5 4 6 3 1 2 2
- Jun: 13 1 8 1 1 5 1 2 12 1 0 6 1 2 1 1 Jun: 1 2 2 1 2 2 May: 1 2 7 1 4 1 1
- Jul: 18 3 1 2 1 5 8 3 1 3 1 4 1 1 1 2 Jul: 1 1 1 Jul: 1 4 1 9 5 0 6 1 4 1 1
- Aug: 4 2 3 2 1 2 3 Aug: 1 Aug: 1 2 4
- Sep: 1 0 3 1 1 1 3 5 1 2 4 Sep: 1 1 2 2 1 1 Sep: 2 7 2 8 5
- Oct: 1 3 1 4 1 5 1 2 1 2 Oct: 4 2 3 1 4 1 1 1 Oct: 2 1 0 2 0 4
- Nov: 1 4 2 5 3 6 1 6 2 2 Nov: 6 4 5 2 6 2 1 1 3 2 1 1 Nov: 5 1 0 1
- Dec: 2 1 1 4 2 3 1 1 Dec: 2 8 1 1

Fig 94
Station I
Zooplankton
2004

Fig 95

Amoeba, Arcella, Euglena, Metopus, Paramecium, Vorticella,
Amoeba, Rotaria, Philodina, Branchionus, Keratella, Daphnia, Bosmina, Oxyurella, Culeops, Mesocyclops,
Macrocyclops, Ergasilus

Jan 4 4 3 - 6 3 Jan 12 5 18 - Jan 4 8 10 5 Jan 9 - 8 7
Feb 9 3 7 - 7 5 Feb 9 7 7 12 - Feb 6 10 21 8 Feb 12 - 8 5
Mar 12 8 14 - 9 9 Mar 10 9 14 - Mar 8 15 29 8 Mar 16 - 10 6
Apr 15 9 15 4 10 10 Apr 14 12 10 19 - Apr 8 18 38 10 Apr 25 12 13 8
May 18 12 18 6 12 12 May 15 14 13 22 - May 12 19 46 13 May 32 10 16 10
Jun 21 15 20 8 15 14 Jun 18 16 17 25 6 Jun 5 6 9 15 Jun 24 7 9 6
Jul 12 7 - 6 - Jul 8 7 8 7 Jul 3 - 7 10 Jul 22 - 8 -
Aug 2 - - - - Aug 6 5 5 4 6 Aug 6 - 5 Aug 6 - 4 -
Sep 4 3 4 - 4 - Sep 9 8 6 8 4 Sep 10 4 - 6 Sep 8 6 7 4
Oct 8 5 8 - 7 - Oct 11 10 8 10 15 Oct 12 7 8 8 Oct 7 15 6 7
Nov 5 4 7 - 13 5 Nov 10 9 8 14 4 Nov 10 7 16 5 Nov 10 11 9 10
Dec 3 2 - 5 4 Dec 11 10 6 16 - Dec 6 6 10 4 Dec 6 - 6 7
Station II
Zooplankton
2004

Amoeba, Arcella, Euglena, Metopus, Paramecium, Vorticella,
Anurea, Rotaria, Philodina, Branchionus, Keratella, Alona,
Bozmina, Daphnia, Oxyurella, Cyclops, Mesocyclops,
Macrocylops, Ergasilus

- Jan 3 2 2 - 4 1 Jan 8 6 3 16 - Jan 3 6 8 3 Jun 6 - 4 4
- Feb 6 2 5 - 4 4 Feb 6 5 5 10 - Feb 4 8 18 10 6 Feb 8 - 6 3
- Mar 9 6 10 - 5 5 Mar 7 6 6 11 - Mar 6 11 25 6 Mar 13 - 7 4
- Apr 11 7 12 2 6 7 Apr 10 8 8 15 - Apr 5 14 3 2 8 Apr 22 8 1 0 6
- May 16 9 1 5 4 1 0 9 May 12 1 0 9 1 8 - May 8 1 7 4 2 1 0 May 3 0 6 1 3 6
- Jun 19 1 2 1 7 5 1 1 0 Jun 1 4 1 3 1 3 2 2 3 Jun 2 3 6 1 3 Jun 2 0 5 6 4
- Jul 8 5 - - 4 - Jul 4 3 5 6 5 Jul 1 - 5 Jul 1 6 - 4 -
- Aug 2 1 - - Aug 2 2 1 1 3 Aug 3 - - 3 6 Aug 4 - 3 -
- Sep 2 2 2 - 2 - Sep 7 5 2 4 2 Sep 7 2 - 3 Sep 5 3 5 2
- Oct 5 3 6 - 4 - Oct 8 7 5 6 1 1 Oct 8 5 6 5 Oct 5 1 4 4
- Nov 3 2 4 - 1 0 3 Nov 6 5 5 1 1 2 Nov 6 4 1 1 3 Nov 7 8 6 6
- Dec 2 1 - - 3 2 Dec 8 7 3 1 2 - Dec 4 3 7 2 Dec 3 - 3 4

Fig 96
Station III
Zooplankton
2004

Amoeba, Arcella, Euglena, Metopus, Paramecium, Vorticella, Anurea, Rotaria, Philodina, Branchionus, Keratella, Alona, Bosmina, Daphnia, Oxyurella, Cyclops, Mesocyclops, Macrocylops, Ergasilus

Jan
6 5 4 – 8 4 Jan 14 12 8 22 – Jan 6 10 13 7 Jan 12 – 10 8

Feb
10 4 9 – 9 6 Feb 11 10 10 16 – Feb 9 12 23 10 Feb 18 – 12 8

Mar
14 10 16 – 11 10 Mar 12 13 12 18 – Mar 10 16 32 11 Mar 18 – 12 8

Apr
17 12 17 5 14 13 Apr 16 15 13 20 – Apr 11 21 40 14 Apr 28
15 16 11

May
20 13 21 9 15 15 May 18 17 17 24 – May 13 23 48 17 May 35
13 19 14

Jun
23 18 22 12 18 17 Jun 22 19 19 27 8 Jun 7 8 12 18 Jun 28 10
12 8

Jul
14 8 – 8 – Jul 10 9 10 11 9 Jul 4 – 9 Jul 25 – 11 –

Aug
43 – – Aug 8 7 6 7 8 Aug 8 – 6 Aug 9 – 7 –

Sep
7 5 6 – 6 – Sep 11 10 9 9 6 Sep 12 5 – 8 Sep 12 9 10 6

Oct
9 7 10 – 9 – Oct 13 12 11 12 16 Oct 13 9 10 11 Oct 10 18 8 10

Nov
6 6 8 – 15 8 Nov 12 11 10 15 6 Nov 12 8 18 7 Nov 14 13 11
12

Dec
43 – – 7 5 Dec 13 12 8 18 – Dec 8 8 11 6 Dec 8 – 8 9

Fig 97

Iv
Station IV
Zooplankton
2004

Amoeba, Arcella, Euglena, Metopus, Paramecium, Vorticella, Anura, Rotaria, Philodina, Branchionus, Keratella, Alona, Bosmina, Daphnia, Oxyurella, Cyclops, Mesocyclops, Macrocylops, Ergasilus

Jan 3 3 2 – 5 2 Jan 10 8 4 17 – Jan 3 7 9 4 Jan 8 – 6 6
Feb 7 6 – 6 4 Feb 8 7 6 12 – Feb 5 9 19 7 Feb 10 – 7 4
Mar 11 7 12 – 7 7 Mar 9 8 8 12 – Mar 7 13 27 7 Mar 14 – 8 5
Apr 13 8 14 3 8 9 Apr 12 11 9 17 – Apr 6 16 35 9 Apr 24 10 12 7
May 17 10 17 5 11 11 May 13 12 11 20 - May 10 18 45 12 May 30 8 15 8
Jun 20 13 19 6 13 12 Jun 16 15 15 24 5 Jun 4 4 7 14 Jun 22 6 8 5
Jul 10 6 – 5 - Jul 6 5 7 7 6 Jul 2 – 6 8 Jul 20 – 6 -
Aug 2 1 - - Aug 4 4 3 2 4 Aug 4 – 4 Aug 5 – 3 -
Sep 3 3 3 – 3 – Sep 8 6 4 6 3 Sep 9 3 – 4 Sep 7 4 6 3
Oct 6 4 7 – 6 – Oct 9 9 7 8 13 Oct 10 6 7 7 Oct 6 13 5 5
Nov 4 3 5 – 12 4 Nov 8 7 6 13 3 Nov 8 5 13 4 Nov 8 10 7 8
Dec 2 2 – 4 3 Dec 10 9 5 14 – Dec 5 4 8 3 Dec 4 – 4 5

Fig 98

Ivi
Station V
Zooplankton
2004

Amoeba, Arcella, Euglena, Metopus, Paramecium, Vorticella,
Anura, Rotaria, Philodina, Branchionus, Keratella, Alona,
Bosmina, Daphnia, Oxyurella, Cyclops, Mesocyclops,
Macrocylops, Ergasilus

Jan 2 1 - 3 1 Jan 7 5 2 14 - Jan 2 4 6 2 Jan 5 - 3 2
Feb 4 2 4 - 3 2 Feb 4 3 3 8 - Feb 3 6 1 5 4 Feb 7 - 4 2
Mar 8 5 8 - 4 4 Mar 5 5 4 1 0 - Mar 5 9 2 2 4 Mar 1 1 - 6 3
Apr 9 5 1 0 1 5 5 Apr 8 7 7 1 3 Apr 3 1 3 0 5 Apr 2 0 6 8 4
May 1 4 8 1 3 3 8 7 May 1 1 9 7 1 5 - May 6 1 4 0 8 May 2 9 5 1 0 5
Jun 1 8 1 0 1 5 4 9 8 Jun 1 3 1 2 1 1 2 0 2 Jun 1 2 4 1 0 1 7 Jun 1 7 4 4 3
Jul 6 4 - 3 - Jul 3 2 4 4 Jul 1 - 4 5 Jul 1 4 - 3 -
Aug 1 1 - - - Aug 2 1 1 1 2 7 Aug 2 - 1 3 Aug 3 - 2 -
Sep Sep 2 1 1 - 1 - Sep 5 3 1 3 1 Sep 5 1 - 2 Sep 4 2 4 1
Oct 4 2 4 - 2 - Oct 6 5 4 4 8 Oct 7 3 4 4 Oct 3 9 3 2
Nov 2 1 3 - 8 2 Nov 5 3 4 9 1 Nov 5 3 9 2 Nov 5 6 4 5
Dec 1 1 - - 2 1 Dec 6 5 2 1 0 - Dec 3 2 5 1 Dec 2 - 2 3

Fig 99
Station I
Zooplankton
2005

Amoeba, Arcella, Euglena, Metopus, Paramocium, Vorticella,
Anurea, Rotaria, Philodina, Branchionus, Keratella, Alona,
Bosmina, Daphnia, Oxyurella, Cyclops, Mesocyclops,
Macrocyclops, Ergasilus

Jan
3 3 2 – 4 2 Jan 10 9 3 15 – Jan 3 6 6 4 Jan 6 – 7 5
6 2 6 – 4 3 Feb 8 7 5 8 – Feb 4 8 18 6 Feb 9 – 8 4

Feb
8 5 12 – 6 6 Mar 8 7 7 12 – Mar 6 12 26 6 Mar 15 – 8 4

Mar
12 5 12 2 7 8 Apr 11 8 7 16 – Apr 6 15 35 8 Apr 22 9 10 6

Apr
16 7 15 4 7 9 May 12 8 12 19 – May 9 16 42 10 May 28 8 13

May
18 9 18 5 10 10 Jun 14 12 15 22 5 Jun 3 4 7 11 Jun 20 5 6 3

Jun
8 3 – 4 – Jul 5 3 4 4 4 Jul 2 – 4 6 Jul – 6 –

Jul
Aug
1 – Aug 3 2 1 4 Aug 4 – 3 Aug 5 – 3 –

Aug
3 2 2 – 2 – Sep 6 4 3 4 2 Sep 5 3 – 4 Sep 12 4 5 3

Sep
Oct
5 3 6 – 5 – Oct 8 6 5 8 10 Oct 8 5 6 6 Oct 18 12 5 5

Oct
Nov
3 2 6 – 8 3 Nov 9 6 6 12 3 Nov 8 5 14 3 Nov 30 10 8 8

Nov
Dec
2 1 – 2 3 Dec 9 7 4 13 – Dec 4 4 8 3 Dec 32 – 4 6

Dec
Station IV
Zooplankton
2005

Amoeba, Arcella, Euglena, Metopas, Paramecium, Vorticella, Anurea, Rotaria, Philodina, Branchionus, Keratella, Alona, Bosmina, Daphnia, Oxyurella, Cyclops, Mesocyclops, Macrocyclops, Ergasilus

Jan 3 2 2 - 3 2 Jan 9 8 2 13 - Jan 2 5 4 3 Jan 5 - 5 4
Feb 5 2 4 - 3 2 Feb 6 6 4 6 - Feb 3 6 1 5 5 Feb 6 - 6 3
Mar 7 4 1 0 - 5 5 Mar 7 5 5 9 - Mar 5 1 0 2 3 4 Mar 1 2 - 7 2
Apr 1 0 5 1 1 2 6 6 Apr 1 0 6 6 1 5 - Apr 6 1 2 3 3 7 Apr 1 9 7 9 4
May 1 5 6 1 3 3 6 8 May 1 0 8 1 1 7 - May 8 1 3 9 8 May 2 6 6 1 2 3
Jun 1 6 7 1 5 4 8 9 Jun 1 2 1 0 1 4 2 0 3 Jun 2 3 5 1 0 Jun 1 8 5 4 2
Jul 6 3 - - 3 - Jul 3 2 3 3 2 Jul 1 - - 3 Jul 1 6 - 4 -
Aug - 1 - - - - Aug 5 2 2 1 3 Aug 3 - - 2 Aug 4 - 2 -
Sep 2 2 1 - - Sep 6 3 2 3 2 Sep 3 2 - 2 Sep 8 2 3 2
Oct 4 3 4 - 3 Oct 7 5 4 6 8 Oct 5 3 5 4 Oct 1 6 1 0 4 3
Nov 3 2 4 - 6 2 Nov 8 5 5 1 0 3 Nov 5 4 1 2 3 Nov 2 7 7 6 5
Dec 1 1 - - 2 2 Dec 7 6 3 1 1 - Dec 3 2 6 2 Dec 3 0 - 3 5

Fig 103

lxi
Station V
Zooplankton
2005

Amoeba, Arcella, Euglena, Metopus, Paramecium, Vorticella,
Anurea, Rotaria, Philodina, Branchionus, Keratella, Alona,
Bosmina, Daphnia, Oxyurella, Cyclops, Mesocyclops,
Macrocyclops, Ergasilus

Jan 1 1 2 1 6 5 1 10 1 Jan 1 2 2 1 Jan 2 2 2
Feb 3 2 2 1 8 3 2 4 Feb 1 3 1 0 3 Feb 3 4 1
Mar 4 2 7 3 2 1 0 3 2 5 Mar 2 5 2 0 2 Mar 8 5 2
Apr 6 3 9 1 5 3 Apr 1 2 4 3 1 0 Apr 3 8 2 7 4 Apr 1 5 5 7 2
May 1 0 3 9 2 4 5 May 1 3 5 9 1 3 May 4 1 0 3 3 6 May 2 1 6 9 1
Jun 1 2 4 1 1 4 6 Jun 1 5 8 1 0 17 Jun 1 2 3 5 Jun 1 3 3 2 1
Jul 3 2 1 1 Jul 5 1 2 2 Jul 1 1 1 Jul 1 3 2 1
Aug 4 1 1 Aug 1 1 Aug 2 4
Sep 2 1 1 Sep 3 3 1 1 Sep 1 1 1 Sep 4 1 1 1
Oct 2 1 1 Oct 4 2 2 3 Oct 3 1 2 1 Oct 1 4 6 3 2
Nov 1 1 2 3 1 Nov 6 3 2 5 Nov 2 2 8 2 Nov 2 2 4 3 3
Dec 1 1 1 Dec 3 4 1 8 Dec 1 1 3 1 Dec 2 7 1 3

Fig 104

lxii
BIOLOGICAL FACTORS

Total coliform (MPN)

Bacteriological examination is most important to the proper judgment to assess the purity of water. Presence of the bacteria in water cause deleterious effects and is a cause of pollution which is hazardous for human health. The presence of bacteria is detected in faecal matters. Thus it is indicative of sewage contamination. When faecal pollution is found the water is considered to be potentially dangerous to health. The bacteria used as indicators have been described as coliform organism which are found in the intestine of many vertebrates. The origin of these micro organisms has been generally the result of surface runoff precipitation that carries micro organisms attached to dust particles to earth or by addition addition of waste water to water ways, Lakes etc. In aquatic ecosystem of bacterial communities considered as indicators of eutrophication as well as water pollution.

In natural waters micro organisms carry out the decomposition of plant and animals residus by aerobic, anaerobic and facultative decomposition. However river waters are contaminated by sewages and other pollutants containing several bacteria capable of causing diseases such as typhoid fever colic problems dysentery diarrhea and cholera As Phosphate is utilized by all growing organisms. So this task is reliable for the quality of any water supply as well as detection and identification of inn crop organisms.

In the present study the MPN of coli form organisms was recorded between the range of 120 to 1400/100 ml in the first year where as in the second year it varied form 190 to 1650/100ml. The minimum concentration was found in the month of January at St. IV in both the years while maximum
was recorded at St I in the month of September in 2004 & in the month of August 2005.

The highest range of MPN was noticed during monsoon season by the entrant of runoff water from cultivated crop land and organic matters by areas and by leaching of soil. Next to it in summer due to much of putrification of organic matters domestic, sewage discharges in low water volume with low water current and high temperature. Total coliform showed positive correlation with Turbidity, Water temperature, T.D.S, T.A., Cl, B.O.D., C.O.D., CO₂ NH₄, N, PO₄ Na, K and negative correlation with T.H., D.O., SO₄ these relationships were marked by the desity of total coliform which are related with the quantity of organic matters disposal and water temperature as shown in tables (4,7,10,16).

W.H.O. has set a desirable limit of coli form is Zero number /100 ml in drinking water. The actual number of coli form is difficult to report therefore they are reported as an approximate count most probable number. On this basic in the present investigation the river Betwa water was not found portable. The present work is also in conformity with findings of Doctor et al (1998) noticed MPN between 300/100 ml to 1600/100 ml in river Bhadar.

**PLANKTON**

Every water body has micro flora and fauna in the forms of phyto and zooplankton. Their density varies according to the nature of water. The useful aspects are that they play an important role in trophic relationship as they are consumed by a number of fishes. Plankton is defined as free floating minute plant and arrival organisms. They are capable of fixing atmospheric nitrogen in their bodies. Upon liberation nitrogen is usable form increases soil fertility and enhances the growth of plants. Few algae is a source of antibiotics small green
algae is also used as converting the dangerous and expensive sewage waste in to an odourless and valuable fertilizer. Agar- agar is an important algae product forms a base for many kinds of medicines used as laxatives. The algae are of negative value as well. Water blooms of algae impart unpleasant odours, oily and fishy taste to the drinking water. Some of the blue green algae produce toxic protein products which are poisonous to fish, cattle and other aquatic and domesticated animals. In water body, there usually occur seasonal qualitative and quantitative fluctuations in the planktonic population in temperate as well as tropical climate.

**Phytoplankton (Micro flora)**

Phytoplankton trap the sun’s energy during photosynthesis and release oxygen in water which is taken by fishes and other organism also increase D.O. in water. The phytoplanktons are found up to the depth where light can penetrate. They are the producers in the aquatic food chain. Seasonal bloom of phytoplankton provided various colours as yellow, green, brown, blue green in water. Algae have the principal growth products of eutrophication. Eutrophication as a result of which there is excessive growth of phytoplankton due to nutrient enrichment.

In the present study phytoplankton were noticed qualitatively and quantitatively, which belong to the group of chlorophyceas, Bacillariophyceae (MXo physical) Discharge of sewage warts drastically change the quality of water the conqsequently the composition of phytoplankton (Patric, 1953 Laxmi narayan 1965, Venkatswarlu 1969 verma et al 1984).

Munawar (1974) has observed an increased phytoplomkton population in sewage contaminated rivers and ponds according to him the density of phytoplankton population at peak development during summer and minimum
in rains. Goldman and Herne (1983) studies changes in temperature and light are two main causes for algal production to vary significantly

**Group A: Chlorophyceae**

In Betwa River water this group of phytoplankton varied form 17 to 173 org/l in 2005 where as in 2004 it ranged between 14 to 220 org/l, it was abundant during summer and then in rainy season, its density was lesser in the winter season. These variations were marked in summer season due to higher value of dissolved organic matter, low amount of water, high temperature pH and high photosynthesis due to high radiation of Sun But in 2005 its density was lesser in rainy season due to floods which cause turbidity dilution of nutrients, high water current. Turbidity also affects the photosynthetic activity due to hindrance of sunlight.

During the present observation population of chlorophyceal gradually raised from Feb onwards and touched a peak level in April to July. Work of Jha (1982) The present findings are in conformity with the who has reported primary maxima during summer secondary during winter & Lowest during monsoon. Kant and Kachroo (1977) and Kant and Anand (1978) reported a gradual rise in temperature from February on wards as optimal condition for growth and preproduction of chlorophyceae.

**Group B: Bacillariophyceae**

These are diatoms, which are generally yellow, brown, olive green and they are basic food of aquatic animals. These are autotrophic and utilize organic substances. They show a wide range of adaptability but could not develop in abundance.
In the present observations their range was 01 to 155 org/l in 2005 while in 2004 it was recorded 04 to 173 org/l during seasonal variations they grow quite during winter season and touched a peak level in November to march in the entire study span. The minimum density was recorded in the rainy season. The maximum density was noticed due to low water temperature, medium water current and pH presence of organic wastes which stimulate the growth of diatoms while lowest concentration was found due to dilution of nutrients strong water current and turbidity. The present observation are in conformity with the findings of Saha et al (1971) who studied the seasonal fluctuations of various groups of phyto & zooplanktons in a fishpond of cutter and found the composition of phyto and zooplankton’s in a fish pond of cuttak and found the composition of phytoplanktons in second year mainly consisted of chlorophyceae, followed by diatomaceae and cyanophyceae.

According to Rishi (1983), strong current velocity resulted in low plankton population. High Turbidly produces an injurious blanketing effect on the phytoplankton and kills them (welch, 1952, Roy 1955 and chakrabarty et al 1959). During the entire study period Melosira was most dominant genus of diatoms whereas navicula, Nitschia, Cyclotella, Achranthes cymbell appeared as the second dominant genus of Bacillariophyceae.

**Group C: Cyanophyceae**

It includes the blue green algae which are the only brown oxygen producing prokaryotes. Many filamentous blue greens possess specialized cells of disputed function known as the heterocyst Fay et al (1968) reported that heterocyst are the sites where atmospheric nitrogen is fixed. Blue greens are also useful for photosynthetic ability and chemotropic capabilities According to Carr whilton (1973) Blue green algae flourish in all aquatic ecosystems because they have an extra ordinary functional structure heterogenicity. These
were the third dominant group. The abundance of blue greens marked at all stations in summer season when temperature was high.

In the course of study it varied from 06 to 152 org./l during the period of 2005 where as in 2004 it ranged from 12 to 154 org/l. The abundance of blue greens during summer season rise in the population form February and touched a peak level in April to June. Ociuatoria was most dominant while anabaena, Microcystis appeared as the second dominant genus of cyanophyceae during the entire study span. Nostoc was the third dominant member in the total stretch of the river. High alkalinity and buffering capacity resulted in growth of blue green algae. The abundance of Blue greens are due to high temperature, pH, dissolved organic matter phosphate nitrogen and relatively high values of dissolved oxygen during the study Rich phosphate and silicate coupled with moderate nitrogen contents were responsible for high blue greens yields in summer and winter season.

The work is in conformity with the finding of Rai and Kumar (1977) who reported that high nutrient concentration was required for peak development of cyanophyceae. High temperature and cyanophyceae are directly correlated (Chakrabarti, (1989).

Blue greens are capable of utilizing first of all ammonical nitrogen directly. The blue green algae furnish food for fish and other aquatic animals. According to chacko (1970) Oscillatoria is the most favored blue green algae consumed by 56 species of fishes. Verma (1970) observed that the blue greens form is an important group of soil organisms which are of great agricultural importance because of ability of some of them to synthesize organic substances as well as to fix atmospheric nitrogen. Blue green are chief agents for nitrogen fixation in rice fields. So it is an organic fertilizer.
The above discussion showed that the blue green algae were found at all stations with low qualitative and quantitative observations in comparison of chlorophyceae and bacillariophyceae having high temperature, much concentrations of phosphate and ammonia nitrogen with low D.O. condition.

**Zooplankton (Micro fauna)**

Zooplanktons feed on phytoplankton and are the primary consumers in the food chain. They occupy the central position between the auto trophs & heterotrophs and are used as food by some plankton feeder fishes. Zooplanktons especially the copepods, cladocera and rotifers, exhibit diurnal vertical migration. They are very important in fisheries. Excessive growth of it form the swarms in fresh water and impart characteristics colour in the region. Zooplanktons are preferred by fry as they are easily digested. Singh and Singh (1985) stated that zooplankton favor less light and moderate temperature and are directly related with dissolved oxygen. Reducing dissolved oxygen concentration through high organic loading was found to be ineffective because many zooplanktons are able to survive extended period of anoxia through physiological tolerance (Schluter and Groeneweg 1981). In the course of study protozoa were observed qualitatively and 6 genera were found their density was also recorded which was from 02 to 110 org/l during the period of 2004 whereas in 2005 it ranged between 01 to 76 org/l. During the entire study density of protozoan was observed higher than all other zooplanktons. Their maximum number was seen subsequently at station I and III in the month of June which was due to much decomposition of organic matter and high temperature by which more nitrates were produced. Pokkie, (1968) reported that protozoans increased gradually from spring to summer but in winter it was sporadic. Protozoan showed a direct relationship their nitrate constants and D.O. Rotifera were observed 5 genera. They were noticed in the range of 07
org/l to 95 org/l in 2004 whereas in 2005 they ranged from 05 to 77 org/l. Mostly they were also seen in summers their maximum density was found in the month of June which was due to more concentrated sewage discharges and high simultaneously. According to Michael (1964), Rotifers co-related with higher alkalinity and temperatures condition O’Brien and De Noyelles (1972) reported that pH values of 10.5 to 11 were fatal to zooplankton in naturally entropic pond.

In crustaceans, cladoceran and copepoda four genera of each were observed. Cladoceran varied between 03 org/l to 101 org/l in 2004 and in 2005 ranged between 03 to 90 org/l where as copepoda ranged from 05 to 71 org/l in 2004 while 02 65 org/l in 2005 Lee (1979) observed waste water algal cultures of cladocerans in rising the pH to 9.5 cladocerans and copepods were maximum found in the month of May in the entire study spent due to high temperature much decomposition of sewage discharges with the result increased alkalinity. According to Anthony et al (1979) copepod and diocesans indicate the incidence of organic pollution.

In the present work the summer season peak of zooplanktons were observed. Due to high temperature, pH, alkalinity, nitrate contents and other valuable nutrients which stimulate the reproduction and favored the development of zooplanktons density in the river. This is in conformity with the observation of Vasisht & Dhir (1970) besides the various group zooplankton variation recorded in this work also resemble the works of different workers as stated above.
AQUATIC WEEDS (Macroflora)

These are mostly aquatic angiosperms in the form of free floating. Submerged and marginal weeds. Free floating weeds have their leaved freely floating on the surface of the water and roots Hanging underneath viz Enchorial, Lemma, Marselia, Spirodella.

Submerged weeds grow under the water surface and may or may not be rooted viz: Hydrolyte vallisneria, Potamogeton ceratophyllum Ninjas manor whereas mariginal weeds were not observed in river Betwa in the entire study period. Muencher (1944) stated that aquatic plants are those species which normally stand in water and must grow for at least a part of their life cycle in water, either completely submerge or emerged

Aquatic weeds are undesirable plants which grow in water due to rich phosphorus and ammoniacal nitrogen. Water productivity is reduced by the excessive growth of aquatic weeds and prevents effective utilization of water as well as hindrances of fish movement, navigation, fishing and human activities. According to Dutta and Gupta (1976), the human activity spot on the rivers become heavily infected with a variety of aquatic weeds which cause interference with a variety of aquatic weeds with the religions ablution of the pilgrim.

In the present study spon (2004-2005), it was observed that free floating special were Eichhornia crassipes, Lemna Pemcicostata spiradella polyshiza, and floating level speciy, were Nymphoides Cristalum are found. Flowering & Fruiting of Lemna, sprrodella were seen from Jan to May their flowers are enclosed in a membranous spathe within the reproductive pouch while enchoria is known as water hyacinth which in habits near river banks, canals and pools. Because of its luxuriant growth they lateron cover the entire surface of the water and thus chocks water courses and greatly hamper navigation &
fishing. The seeds germinate during the rainy seasons and they bear flowers in Sept and Oct. The seeds remain dormant from Nov to June. Some times Lemma and Spirodella occur mixed.

Nymphoides is a small plants with floating leaves. It usually flowers and fruits in winter seasons from Oct to Feb. These free floating forms predominate and their colinize are found at such places where river forms side poalse they were observed at St. I, II and III.

Submerged specie ceratophylum flowering from Jan to March and fruiting later on. They lack cutile, stomata & roots and are completely adapted to an aquatic mode of life. It forms an association with Hydrilla and another submerged plant. Hydrilla flowers during winter season from Oct to Jan. It is eaten by some fishes and as it is a goods oxygenator vallisnenia flowering and fruiting from Oct to March Chopra et as (1956) reported that it is used as a stomachic & foleucorrhoea. Hydrilla & vallischenia are also cultivates in aquaria mostly these plants are also used as manure. They were most abundant at station III and IV where river form side pockets. Occasionally Najas, Hydrilla & vallizneria also grow in pure formations or in a mixed occurrence of all the three .Potamogeton perfoliatus and P. Pectinatus are aquatic herbs with a stout dichotomously branched stems and their flowering and fruiting were observed through out the year Ninjas minor is a small fragile dichotomously branched and it glowers & fruits during all seasons of the year. It is rarely seen totally submerged but is found at shallowest part of the river which are stations IV and II excessive growth of macro vegetation appear with the arrival of rainy season due to large amount of runoff from cultivated croplands, domestic sewage & city sewage which are responsible for enrichment. Of minerals organic matters and silt these act as promotors for the growth of aquatic weeds. Their prolifically growth chocke many lakes rivers and irrigation canals.
Betwa is not a shallow river in comparison of river ken and river Mandakini. As the shallow rivers are favorable for the excessive growth of aquatic weeds as it was observed in the river Mandakini (Chitrakoot, Satna) and Ken (Banda). Mandakini is more shallow river than Ken. Whereas the Betwa river is more deeper than the above two rivers. In this river the growth of aquatic weeds were found lesser during the study period than the said two rivers. Besides the Canals, nalas, Small water pockets around the river the excessive growth of aquatic weeds was also observed. During the flood period these weeds are also drifted in the river which later on proliferates which causes weed in festation near by river banks water, weed infestation is a great problem. The present work is in conformity of the above work presented by Dutta and Gupta (1976).

**Fish Fauna (Macro Fauna)**

Fishes are the main resources of proteinous food which are found in water, their growth reproduction and production depend up on water quality. Suitable water has a fair amount of dissolved oxygen, sufficient amount of phosphate sulphate nitrate, carbonates, organic compounds as well as planktons besides temperature variation, light, pH and water flow, their optimum values are required for fish biology. At present almost all the rivers are polluted which adversely affect all aquatic affect all aquatic organisms including fish growth, domestic waste, sewage discharges and industrial effluents are causing pollution of water. The waste products and discharges of sewage extremely change the physical, chemical & Biological properties of river water, these changes cause depletion of fish population thus they are the primary indicator for nature of water. Fishes are most economically important group of vertebrate fish diet provide rich protein fats and vitamins A, D and E. phosphorous and other elements are also present in it and they are easily
digestable. Besides fishes provide several useful byproducts by which fish industries are developed. They are used as fish manure for fields which contains a high percentage of nitrogen & phosphate, fish meal is an important artificial food for poultry, pig and cattle. As the skin of several fishes are used for making polishing and smoothing material. Fish oil is also important fishery by product. Fishes are also used in fish Glue, Isinglass Artificial pearl industry, sports & Games and many other products.

Fishes & birds are very large in number than other vertebrate obviously these are numerous genera and species of fresh water fishes besides their multiplication productivity is also very high. Various ichthologists have reported fishes as Gunther(1880) recorded 26 families of fishes in India. Day (1985) observed 87 genera in Indian fresh water and zoological survey of India, (1991) has published that about 400 spp of fishes of India.

In the present observation found that a number of economically important fishes are present in Betwa river 14 families, 28 genera and 33 species were investigated in river Betwa. But of major economic important fishes are during the study period (2004-2005) Labeo rohita, L. calbasu, Cirrihinus mrigala, Catla catla Mystus seghla, wallago attu Heteropneustes fossilis channa punctatus, Mastacembelus armatus and they were in abundance also.

In Betwa river the bed is composed of fine brown and the banks of the river has muddy with vegetation at some places. St. IV which is down stream near Ramaini Pump canal is more shallow than others at southern side of the river a less number of fisher are found here whereas St. II which is Betwa ghat and St I Pothia village have more fishes than all the selected stations due to enrichment of nutrients, deepness of river and vast water level.
The Macro fauna of Betwa River is characteristics in having a large number of fishes.

The minimum river water quality standard which is acceptable to river Authorities which are also fishery authorities in one that requires the river to support a fishery

KEN-BETWA LINK PROJECT

The national water policy, adopted by the Government of India in 1987, emphasized, the need for inter basin transfer of water.

Inter linking of Ken with Betwa is a central Government project.

The Government of Madhya Pradesh formulated proposal for Ken Multi Purpose Project (KMPP) on the Ken river which is also known as Greater Gangau Dam and accordingly a detailed project report (1982) had been prepared. The project envisaged construction of a dam across the Ken river. About 210 mtr down stream of the existing Gangau weir. This project was expected to provide annual irrigation to 3.23 lakh ha. in Chhatarpur and Laundi tehsil of Chhatarpur District and Ajaigarh tehsil of Panna district. In this proposal hydro power generation was also envisaged through construction of two power houses.

As per the studies carried out by National Water Development Agency (NWDA) in the context of the Ken-Betwa link, it was proposed earlier that the above said Gangau reservoir would be utilized as the head works for the link. Under the KBLP the great Gangau dam is proposed on the border Panna and Chhatarpur district of M.P. on Ken river and to divert water from there though a link canal Betwa river. The proposed link canal is taken of on the left bank of the Ken river at 245.5 meter from the tailrace of power house – 10 f GGD. The GGD site is covered by hillocks with dense forest.
The main justification of this scheme is that Ken has surplus water and Betwa is a deficit basin both rivers originate from MP and flow parallel through similar geographical area and merge with Yamuna in U.P.

The proposed link canal would submerge thousands of hectare cultivable land at Chhatarpur, Tikamgarh and Jhansi. The irrigated area will get seriously affected due to the proposed link. People from scores of villages near Dhaudhan would be displaced due to proposed dam. A major part of world fame Panna tiger reserve would also be submerged due to the reservoir. The Gangau dam is the feeder dam for Bariyarpur weir, which will receive lesser or no water from the Ken river during non monsoon months. Even in monsoon, while the great Gangau dam would be filling, there will be no water either for Gangau dam or for the Bariyarpur weir and its command area. If all the water in the Ken river is stored in the GGD and is diverted to Betwa basin then Gangau & Bariyarpur reservoir may become dry for most of the year. Besides the excess water in Betwa basin could create water logging in Hamirpur & Jalaun districts. Obviously it could also make Hamirpur & Jalaun districts flood prone. The proposal is based on basic fallacies of surplus and deficit basins based on manipulated water balance. If looked at carefully can basin does not have any surplus water and Betwa basin has many unexplored local options. Thus river link project has not shown how drought from flood prone basin to a drought affected one. Bundelkhand water parliament is also against it.

So the Ken-Betwa link proposal is not beneficial for Bundelkhand region as well as unlivable.