

## Seasonal variation in physico-chemical and biological properties of river Panar (Bihar)

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### Abstract

A base line study was conducted to determine the impact of anthropogenic activities on the physico-chemical and biological factors of the river Panar. The result revealed well defined seasonal variation. On the basis of physico-chemical and biological parameters the river appears to be polluted. On the basis of Moyle's classification, the river water appeared to be hard type. Likewise on the basis of phosphorous and nitrogen, the investigated water body may be categorized as moderate trophic level. The bulk of phytoplankton was shared by Chlorophyceae (9), Myxophyceae (8), Bacillariophyceae (9) and Euglenophyceae (1). Many of algal species out of the total 27 reported from the river like *Euglena*, *Microcystis*, *Anabaena*, *Chlamydomonas*, and *Spirulina* were recognized as pollution indicator. The zooplankton population comprised of Rotifera (19), Cladocera (5) and Copepoda (3). The zooplankton also comprised some pollution tolerant species like *Brachionus*, *Keratella*, *Moina*, *Mesocyclops*, *Cypris*, *Ceriodaphnia*, *Polyarthra* etc. The study clearly revealed that the aquatic environment of the river has undergone degradation and is not suitable for human use. The main sources of river pollution in the present study were recognized as:

- a) discharge of domestic sewage from near by villages
- b) agricultural run off
- c) burning of corpses on the bank of river
- d) bathing habits of human as well as cattles
- e) washing of clothes and utensils
- f) soil erosion
- g) retting of Jute.

Proper remedial measures should be taken immediately in order to restore it from further deterioration. There must be alternate waste disposal system away from the river and disposal of solid and liquid waste must be stopped forth with. Indiscriminate fishing practices and retting of jute should be stopped, Planting of some toxicant reducing macrophytes should be done on both sides of the river. There is urgent need to take up widespread conservation and education programme in this area to highlight the problem of pollution.

**Key Words** Seasonal Variation, Physico-Chemical Characteristics, Phytoplankton, Zooplankton, Water Quality.

### Introduction

Fresh water is the most precious resource on the earth, which is becoming scarce. Rivers, streams, ponds and lakes have been the major source of water. But these days, due to industrialization, urbanization and anthropogenic activity, most of the rivers have become a matter of great concern over period of last few decades because of their vital importance in several human uses, all over the world. Due to the unplanned industrialization and population explosion of the country, the rivers have become today one of the most

heavily polluted water sources of India .

Of all the earth's ecosystems, rivers are the most dynamic having as their primary function the transportation of water. They also carry the load of the dissolved and particulate output of crystal weathering and erosion from land to the sea. Rivers have been studied for many years with inputs from many disciplines of science and humanity. Engineering hydrologists, geographers, economists, biologists, chemists, geologists and social scientists have produced a vast body of literature on regional, hydrographical, chemical and historical aspects (Livingstone, 1963; Barnes and Mann, 1980). From data available with UNESCO 1979 and UN 1981 on twenty-nine of the larger rivers of the world, the inter annual variance of discharge is found to be between 6 and 33 percent.

In most of the developing countries, the disposal of sewage and industrial wastes is often conducted without critical appraisal of the impact upon their receiving waters . There are numerous sources of domestic and industrial effluents leading to heavy metal enrichment of water and sediments. The rapid urbanization and industrialization, which are, advanced tool and tips of modern civilization have cultivated pollution problems into water, air and land.

The quality of water resources is usually described according to its physical, chemical and biological characteristics. The use of water in any region for different purposes like domestic, industrial, agriculture and fish culture depends on its physico-chemical and biological characteristics. Hence the present work was undertaken which deals with the seasonal variation in physico-chemical and biological properties of river Panar.

### Materials and Method

The present investigation was carried out in the river Panar at five sampling stations selected in the stretch of the 15 km.(Fig-1) The water samples were collected at the monthly intervals between Jan'2003 to Dec'2003 from each sampling station in a polythene bottle of 3 ltrs capacity . Water temperature was recorded with an ordinary mercury thermometer graduated from 0° to 50° C. The analysis of p<sup>H</sup>, dissolved oxygen, free carbon dioxide, BOD, COD, carbonate, bicarbonate, chloride, nitrate, phosphate and sulphate was done according to the methods of APHA (1975) and Trivedy and Goel (1984) .

For the planktons, 50 ltrs of river water was taken and filtered through the boiling silk plankton net (No.30) with 77 mesh/sq cm. The samples were taken from different areas of the stations regularly. The plankton concentrate on the plankton net was preserved with 5% formalin. Separation and counting the plankton was done by taking 1 ml of sub-samples into a Sedgwick Rafter Plankton Counting chamber of 1 ml capacity. All organisms were counted according to the procedure described by Welch (1952).

### Results and Discussion

#### Temperature :

It is a well known fact that the water temperature exerts direct as well as indirect influence on many abiotic and biotic compositions of aquatic ecosystem. Temperature has variable effects, it may kill some organisms and may stimulate the growth of the other (Kotpal and Bali, 1989). The water temperature regulates various

physico-chemical as well as biological activities (Raney and Menzel, 1969) and its values and variations have a great bearing upon its productivity (Jhingran, 1982). It also reflects on the dynamics of living organisms (Chandler, 1942). All organisms possess well defined limits of temperature tolerance. All metabolic and physiological activities are greatly influenced by water temperature. Temperature also affects the speed of chemical changes in soil and water. Temperature showed diurnal as well as seasonal variations. In the present investigation, the water temperature followed more or less similar trend of the air temperature. The water temperature varied between 18.9 to 36.9°C (Table-1). Dale and Gillispie (1977) have reported the influence of macrophytes on the water temperature.

#### **pH:**

pH is a general physico-chemical parameter and indicates the fate of chemical constituents. It is one of the most important environmental factor of natural water. pH is also reported to play an important role in the formation of algal bloom (Anderson, 1961 and King, 1972). Decreasing volume of water often accompanied by progressive change in pH (Adoni, 1975). The variation of pH is often linked with the species compositions and life processes of animal and plant communities inhabiting them. In the present investigation, the pH varied between 7.3 - 8.6 (Table-1). Thus the river water was alkaline throughout the year. The highest pH value during winter appeared to be influenced by water level, large number of phytoplanktons and highest value of dissolved oxygen (Sunder, 1988 and Pandey *et al.*, 1992a). The pH is associated with high photosynthetic activity (Roy, 1955). The low pH value during monsoon might be due to high turbidity and elevated water temperature, which stop photosynthetic activity leading to accumulation of free CO<sub>2</sub> which lowers the pH of water during monsoon (Adebisi, 1980).

#### **Transparency**

Turbidity restricts the penetration of sunlight and hence reduces photosynthetic activity which in turn is related to the productivity of water mass. The suspended particles causing turbidity may also absorb considerable amount of nutrient element like phosphorus, nitrogen and potassium in their ionic forms making them unavailable for planktonic production. Turbidity makes the water unfit for domestic purpose. In the present study the turbidity varied from 31.5 to 72.8 cm (Table-1). The high turbidity during rainy season may be attributed to the land drainage contributing to increase in particulate suspended matter; Roy (1955) reporting on the hydrology of an irrigation tank from Bangalore, Karnataka opines that high turbidity adversely affects primary production. The highest transparency during winter season was due to close competition between macrophytic vegetation and phytoplanktons. Kaul *et al.*, (1972) and Wetzel (1975) found that macrophytes were capable of storing nutrients, suspended in water in more quantity than the phytoplankton could do. Zutshi and Vass (1973) have similar observations while studying the limnology of Kashmir lakes.

### Dissolved Oxygen

The dissolved oxygen content plays a vital role in supporting aquatic life in running waters and is susceptible to environmental changes (Jameson and Rana, 1996). Dissolved oxygen affects the solubility and availability of the nutrients and the productivity of the ecosystem (Wetzel, 1975). Dissolved oxygen is one of the most important parameters in the water quality assessment and reflects the physical and biological process prevailing in the water. The volume of oxygen dissolved in water is dependent upon (i) Its temperature (ii) the partial pressure of oxygen in the air in contact with the water at the surface, and (iii) the concentration of dissolved salts. The water receives oxygen mainly through two sources (i) by absorption from the atmosphere at the surface, and (ii) by the photosynthesis of chlorophyll bearing organisms inhabiting the water body. Any water polluted by organic wastes suffers from decline in dissolved oxygen (Butcher, 1947). In the present investigation the dissolved oxygen varied from 6.8 - 9.9 mg/L (Table-1). The higher value of oxygen was observed during winter season when temperature was low. It supports findings of Rao (1975), Bharti and Kori (1975), Mishra and Yadav (1978), Singhal *et al.*, (1985), Saxena and Mishra (1991). The low value of oxygen during rainy season might be due to higher growth of bacteria which utilizes oxygen for metabolic activities. However, Madhyastha *et al.*, (1999) have reported increased level of dissolved oxygen during monsoon leading to super saturation, which may be due to rainwater. Higher value of  $O_2$  during summer has been reported by Vijaykumar (1992,99) due to increased solar radiation. There should be adequate dissolved oxygen in all the seasons. The river with self-purification capacity could assimilate the existing load (Lester, 1967).

### BOD

The Biochemical Oxygen demand (BOD) is a parameter which enables the determination of relative oxygen requirements especially of waste waters, polluted waters and effluents. BOD in water showed a very critical situation. The value ranged from 19.6 — 29.8 mg/l (Table-1). Higher value were observed and presented seasonal fluctuation in monsoon and lower values in post monsoon. The overall increase in BOD values can be attributed to the discharge of organic wastes and animal excreta in to the water from domestic sources and animals of the villages located near the rivers. Kaur *et al.*, (1996) have reported increase in BOD value in river water due to deposition of animal excretory wastes.

### COD

COD values were also very high in the river water, which ranged from 59.5 – 92.8 mg/l (Table 1). High COD values were due to algal biomass and other organic matter (Patel and Sinha, (1998). The peak of COD was observed in monsoon. The highest value of BOD and COD in rainy season are due to higher concentration of dissolved solid (Jameel, 1998). High COD value show that a large amount of chemically oxidizable matter is present.

### Free $CO_2$

Free carbon-dioxide is an extremely necessary constituent in an aquatic ecosystem (Welch, 1952). The

respiratory activity by aquatic organisms produce considerable amount of  $\text{CO}_2$  in the water, which remains dissolved partly in water as carbonic acid and part of it diffuses to atmosphere. The free  $\text{CO}_2$  value of the river ranges from 0.8 – 1.2 mg/l (Table-1). The low value of  $\text{CO}_2$  during winter season might be due to increased photosynthetic activity by phytoplanktons. The high value of  $\text{CO}_2$  during summer season suggests active decomposition of organic matter. High carbon dioxide content is indicative of high organic pollution (Todda, 1970 and Cole, 1979).

Vyas and Kumar (1968) showed a direct relationship of free carbon dioxide with transparency, temperature and pH, while an inverse relation with dissolved  $\text{O}_2$ . According to Bohra and Bharagava (1977) high concentration of  $\text{CO}_2$  results in to low pH and high carbonate values. Present observation of high  $\text{CO}_2$  in summer are in line with similar studies done earlier by Vyas and Kumar (1968). In summer with an increase in atmospheric temperature there was corresponding rise in water temperature and subsequent increase in biological oxidation of organic matter that might have caused and elevation in the level of  $\text{CO}_2$  (Singh and Srivastava, 1988 Michael, 1966).

#### Chloride

Natural water normally contains low chloride than bicarbonate and sulphates. Large contents of chloride in fresh water is an indication of organic pollution (Thrash *et al.*, 1944). Chloride is generally undertaken as major factor to equalize cation - anion balance of ecosystem. The most important source of chloride in the water is the discharge of domestic sewage. Man and other animals excrete very high quantities of chloride together with nitrogenous compounds. The chloride contents in the river under investigation was found highest during summer and lowest during winter season (Table-1). The higher value of chloride during summer months may be due to the gradual decrease in the amount of water. Mishra and Yadav (1978) have also reported increased values of chloride in summer months and have correlated this with gradual decrease in the amount of water. Moreover, the increased amount of excreta laid by various aquatic fauna may also account for the increased values of chloride during summer months. The finding of Cole, 1979; Pandey and Mishra, 1990 and Swarnalatha, 1994 are also similar with the observations made in the present study in this regard. Munawar (1970) has suggested that high value of chloride is an indication of pollution of animal origin. It has been also suggested that chloride contents also increased with degree of eutrophication (Sinha, 1986).

#### Alkalinity

Alkalinity of water is the capacity to neutralize a strong acid and is characterized by the presence of all hydroxyl ions capable of combining with hydrogen ion. The role of alkalinity in the determination of productive capacity of aquatic environment has been described by Philipose (1959), according to whom inland waters are categorized into three types, further according to the same author waters with low alkalinity are comparatively low in production. The alkalinity in natural waters is mainly due to the presence of bicarbonates and carbonates. Rai (1980) has reported that waters rich in free  $\text{CO}_2$  are comparatively less alkaline whereas waters deficient in this gas are more alkaline. Similar observations have been made by

Roy (1955), Zafar (1964) and Munawar (1970). But on the contrary, Singh (1965) has claimed that the alkalinity of water does not seem to be affected either by oxygen or carbon dioxide alkalinity below 500 mg/l indicate low photosynthetic rate (Das, 2002).

In the present investigation carbonate alkalinity was absent throughout the year. Bicarbonate alkalinity ranged from 50.1 - 99.0 mg/l (Table-1). Bicarbonate alkalinity was highest during summer and lowest during rainy season. On the basis of alkalinity values the river water can be classified under high category of nutrient type after the classification of Philipose (1959) as the alkalinity value is > 100 mg/L. On the basis of Moyle's (1946) classification, the river may be termed as hard water type. The low value of alkalinity during monsoon indicated degradation of water quality due to flooding from intensive agricultural zones. The effect of alkalinity in river water is responsible for the increased algal productivity. On the basis of pH, free CO<sub>2</sub> and alkalinity, the river water may be considered moderately alkaline giving support to the observations of Vass *et al.*, (1977) of river Jhelum.

### Nitrate

Nitrogen occurs in natural waters in elemental state and as organic as well as inorganic nitrogenous compounds. The elemental nitrogen in water is derived mostly from the atmosphere. The other source is the bacterial denitrification of nitrates, nitrites and ammonia. Nitrate parameter is an excellent parameter to judge organic pollution. Thrash *et al.*, (1944) have attributed the nitrogen richness of fresh water body to the pollution of animal origin. In aquatic system nitrogen level is regulated through precipitation, atmosphere solution and volatilization under meteorological process; sedimentation influence effluent and ground water movement under geologic process, nitrogen fixation, denitrification, uptake, growth, decay, hydrophytes pumping and fish and weed removal under biological process (Toetz, 1976). The level of the total nitrogen concentration in an index of carbon budget of fresh water body (Munawar, 1970; Pillai and Sreenivasan, 1975). In the present study the nitrate value ranged from 0.38 to 0.64 mg/l. The low value of nitrate during winter season might be due to high macrophytic and phytoplankton production. Lee *et al.*, (1975) have indicated that during winter, the decrease in nitrogen is probably associated with entire uptake of this element by these plant communities. The high value of nitrate during rainy season might be attributed to rain showers, decomposition of organic matters and influx of flood water (Rao and Govind, 1966).

### Phosphate

The phosphate in natural water occurs in very small quantities. It is necessary for fertility and is generally recognized as a key nutrient in the productivity. The phosphate more than 2 mg/l in open water gives a sign of organic pollution (Pomeroy *et al.*, 1965). Among the various micro-nutrients phosphorous is found to play an important role in governing the primary productivity of any ecosystems (Hutchinson, 1957). The primary concern to phosphorous lies in its ability to increase the growth of nuisance algal and eutrophication. Butler and Liss (1972) stated that any change in phosphate content may affect the plankton community. Phosphate is the main nutrient responsible for eutrophication in water bodies. Excess of phosphate is

reported to be present in the domestic sewage. According to Arceivala (1981) raw domestic water may contain an average of 10mg/l of phosphate.

Phosphorus is available in water combined with a number of ions. Phosphate or iron and calcium are very common. In the present investigation the phosphate value was usually low, the minimum being 0.08 mg/l (Table-1). The minimum value of phosphate during winter may be due to advance phytoplanktons which utilizes it. Such findings have also been reported by Kataria *et al.*, (1996). The maximum value of phosphorous during rainy season might be due to agricultural run off which brings phosphate from the catchment areas. Cattle dung and night soil also add to the phosphorous content of water.

#### **Sulphate**

Sulphate, a common anion has a very important role in the soft water systems where certain organic chelate or complex metal ions prevent those ions reacting with other substances (Hutchinson, 1957 and Wetzel, 1975). The increased value of sulphate during monsoon (Table-1) might be due to surface run off which brings more suspended solids along with organic and soluble salts (Sinha, 1986). The low value of sulphate during winter might be due to higher phytoplankton population. Sulphate is ecologically important for growth of plants and its short supply may inhibit the development of plankton. Sulphur is also important in protein metabolism.

#### **Phytoplankton**

Phytoplankton is an important aquatic flora. They play a key role in maintaining proper equilibrium between abiotic and biotic components of the aquatic ecosystem. Phytoplankton have been regarded as the chief primary producers of natural ecosystems. Being an index of trophic status, phytoplankton reflects the over all environmental condition of the system and its potentiality (Agarwal *et al.*, 1993). Phytoplankton are the fundamental components of aquatic ecosystem as they are the major source of biologically important and labile organic carbon, located at the base of food chain. The magnitude and dynamics of phytoplankton population have become an essential tool to assess the general health of an aquatic eco-system. Phytoplankton can be used in the treatment of waste water and either heavy scale deposition or corrosiveness of water and making it potable (Mahadev and Hosmani, 2002). Their density have been reported to be effected by the quality of water (Bilgrami and Dutta, 1979: 1985).

The phytoplankton communities of the river were presented mainly by four groups comprising 38.71% species of Chlorophyceae, 38.96% Myxophyceae, 15.06% Bacillariophyceae and 7.27% Euglenophyceae (Table-2 and Fig 2).

#### **Chlorophyceae**

This group was represented by *Spirogyra sp.*, *Volvox sp.*, *Ulothrix sp.*, *Closteridium sp.*, *Chara sp.*, *Pandorina sp.*, *Zygnema sp.*, *Chlorella sp.* and *Chlamydomonas sp.*

#### **Myxophyceae**

This group was represented by *Anabaena spheical*, *Oscillatoria limnetica*, *Microcystis robusta*, *M.*

*aeruginosa*, *Spirulina sp.*, *Merismopedia sp.*, *Nostoc sp.* and *Collastrum sp.*

#### **Bacillariophyceae**

This group was represented by *Cymbella*, *Melosira*, *Navicula*, *Nitzschia sp.*, *Diatoma*, *Syndera*, *Fragilaria*, *Pinnularia* and *Cyclotella*.

#### **Euglenophyceae**

This group was represented by *Euglena viridis*.

Davis (1955) pointed out that various physical, chemical and biological circumstances must be simultaneously taken into consideration for understanding the fluctuation of plankton population. Temperature, pH alkalinity and phosphate have been emphasized to be significant factors controlling distribution of Cyanophyceae (Singh, 1965). George (1976) also reported temperature and pH correlation with phytoplankton. In the present investigation pH, DO and transparency showed a positive relationship with Chlorophyceae. Jackson (1971) has reported alkalinity range of 50 to 110 mg/l as optimum for the Myxophyceae whereas Sreenivasan (1965) observed 50 mg/l alkalinity for the growth of Myxophyceae. The present study agrees with them. The rate of production is closely dependent upon temperature conditions of water body (Mc Camby, 1953). According to Roy (1955) low temperature in Hoogly was favorable for the growth of diatoms resulting in highest plankton peak in the year. The present study shows highest phytoplanktons in winter, when water temperature was low. There was decline in number with increase in temperature suggesting that phytoplankton preferred moderate temperature. Rainfall and high turbidity produced by high wind velocity during rainy season had a direct bearing on phytoplankton population reducing them to minimum numbers.

The river harbours many allergenic algae such as *Chorella vulgaris*, *Anabaena*, *Microcystis*, *Nostoc sp.*, and *Oscillatoria sp.* Allergenic problems caused due to such algae are rhinitis, bronchial asthma, hypersensitivity in fish, cattle and animals coupled with symptoms of partial paralysis, loss of balance, hard stool, reduced milk yield, general weakness and photosensitization of skin (Shukla, 1991).

During recent years algae have acquired place of problem organism in eutrophic waters (Trainer, 1978). Toxic characteristic exhibited by certain species *Microcystis aeruginosa*, *Anabaena flos-aquae* and *Aphanizomenon flos-aquae* are the best offenders. Water fowl, fish and livestock are the most frequently affected organisms though human deaths have also been reported. *Ulothrix sp.* and *Diatoms* are some of the more troublesome forms (Evans, 1960 and Edmondson, 1974).

The study made on phytoplankton of water bodies all over the world has shown marked differences in the floristic composition with different levels of pollution which have promoted several workers to use algal composition as the indicator of the level of pollution Hasle, 1947; Rawson, 1956; Hutchinson, 1967 and Palmer, 1969).

Palmer (1969) on the basis of studies carried out at different places in the world has given a list of 60 algal genera and 80 species most tolerant to pollution. The use of diatoms as indicators of pollution has been emphasized by Davis (1964); Patrick (1973); Reynold (1973); Stockner and Benson (1967); Stoermer *et al.*,



(1978); Rai and Kumar (1976) and Verma *et al.*, (1978) have reported *Nitzschia* from highly polluted water in India. Geevarghese and Chandrasekharan (1985) while studying the impact of newsprint factory on Moovattepuzha river found that the diatoms *Nitzschia*, *Melosira*, *Diatoma*, *Pinnularia* and *Navicula* were quite dominating in polluted zone. Some other studies like Raina *et al.*, (1982) on river Jhelum, Gunale (1991) on river Mula. Mutha and Adhola (1988) on river Betwa have also reported certain characteristic diatoms in polluted conditions. These authors have also encountered several members of Chlorophyceae, Cyanophyceae and Euglenophyceae like *Pandorina*, *Scenedesmus*, *Coelastrum*, *Chlorella*, *Chlamydomonas*, *Oocystis*, *Pediastrum*, *Microcystis*, *Oscillatoria*, *Anabaena*, *Ankistrodesmus* and *Euglena* in polluted conditions. Goel and Autade (1995) have reported 61 species of algae during their studies on river Panchganga. Out of these 61 species, 21 are pollution tolerant species. Wani (1998) have reported 91 species of phytoplankton in the lakes of Kashmir. Prasad and Singh (2003) have reported 20 taxa of algae in a tropical water body of Motihari. In the present investigation, 27 species of phytoplanktons were found of which many were pollution tolerant. Algal species can also be used as good indicators of heavy metal pollution in fresh water ecosystems (Forstner and Wittmann, 1979). *Euglena* and *Nitzschia* have been regarded as indicators of Cr and Cu pollution in water (Palmer, 1980). Ramaswamy *et al.*, (1982) reported luxuriant growth of *Synedra* and *Nitzschia* and Euglenophyceae in water having high concentration of Cu. However, in present study no such correlation was observed. Franklin (1972) suggested that blue green algae are general indicators of eutrophication of water. Rama Rao *et al.*, (1978) have also designated green algae to be the indicators of highly polluted waters.

### Zooplankton

Zooplankton forms the vital link between autotrophs and heterotrophs in an aquatic ecosystem. Zooplankton occupy an intermediate position in the food web. Zooplankton, the primary consumers, which play an important role in fish production are being adversely affected. These organisms are highly variable in nature from one water bodies to the other and acts as bioindicators of pollution (Arora, 1966; Sampath *et al.*, 1978; Sharma, 1986 and Saksena, 1987). The Zooplankton forms a link between phytoplankton and macroinvertebrates, which in turn provides food to fishes and aquatic bird. The knowledge of their seasonal qualitative and quantitative fluctuation has been considered always essential for proper understanding of the factors influencing biological productivity and fisheries development. Really, planktonic animals in fresh water are dominated by Rotifers, Cladocera and Copepods. Rotifers are the most sensitive bio-indicators of water quality and their presence may be used as a reference to the physico-chemical characteristics of their habitat. Several zooplankton species have been classified as indicator of polluted conditions. The zooplankton community mainly comprises of Rotifers (46.83%), Cladocera (36.46) and Copepods (16.71%) (Table 3 and Fig. 3). The three groups of zooplankton were:

#### A. Rotifera

*Brachionus rubens*, *B. falcatus*, *B. calyciflorus*, *B. plicatilis*, *B. angularis*, *B. forticula*, *B. caudatum*, *Keratella tropica*, *K. vulga*, *K. eanadensei*, *Monostyla lunaris*, *M. bulla*, *Horaella sp.*, *Lepadella sp.*,

*Cephalodella forticula*, *Rotaria sp.*, *Polyarthra sp.*, *Ophryoxus sp.* and *Chydorus gibbus*.

#### **B. Cladocera**

*Moina micrura*, *M. brachiata*, *Macrothrix sp.*, *Daphnia sp.*, and *Ceriodaphnia sp.*

#### **C. Copepods**

*Nauplius sp.*, *Mesocyclops sp.* and *Heliodaptomus vidunus*.

Species richness is a good indication of the dynamic balance of the communities. The rotifers constitute from 33.33% to 53.84 % in total zooplanktonic communities in various waters (Kaushik, 1992). In the present investigation, the percentage of rotifers in total zooplankton is 46.83 %. The difference in rotifer community structure in the river can be attributed to intense variability in physico-chemical and geographical condition. Other factors responsible can be nutrients, organic matter and phytoplanktonic growth. Lakshminarayana (1965), Chourasia and Adoni (1985) have found a direct relationship between pH and zooplankton production. It is quite evident from the present study that the pH range of 7.3 to 8.2 favoured the growth of zooplankton. Nasar (1977) noted that pH between 7.6 to 7.7 is quite suitable for development of zooplankton. Low value of nutrients act as limiting factor for zooplankton development despite good illumination (Sreenivasan, 1970).

The structure of zooplankton community is characteristic and is the product of the environmental conditions prevailing there. Presence of maximum zooplankton population in summer might be due to the presence of higher population of bacteria. According to Singh (1991), Pandey *et al.*, (1995) optimal thermal and nutritional condition and higher concentration of oxygen might be responsible for the higher rotifer population during summer. The lower density of zooplankton during rainy season might be due to flood and fast current of river water (Pandey *et al.*, 1995, 2004). The abundance of zooplankton in the ecosystem in comparison to other group is an indication of eutrophication (George, 1966).

Dominance of rotifers in the seasonal data of zooplankton as observed in the present study is in accordance with the findings of Michael (1968); Saha *et al.*, (1971); Bahura *et al.*, (1993), Pandey *et al.*, (1992b, 1994, 1995, 2004) and Hosmani (2002).

The species composition of zooplankton indicated that rotifers occur more predominantly than cladocerans and copepods. Dominance of rotifers in other groups has also been reported in other water bodies of the world (Pennak, 1994; Alikuhni, 1957; Michael 1968 and Singh and Sahai, 1978). However, Patra and Dutta (2004) have reported copepodans as the largest group. The sequence of dominance of various groups was Rotifera > Cladocera > Copepods. Rotifers form an important component of zooplankton community involved in the trophodynamics of an aquatic ecosystem.

The Cladocerans were succeeded by the Copepods, which in turn indicates that Copepods build up their population taking more time than Rotifers and Cladocerans. However, once they become dominant, they continue to dominate the habitat till hydrological conditions favour their existence. The phytoplankton bloom physical and chemical characteristic of water are stated to be greatly responsible for the Copepods population (Patalas, 1975). Copepods were abundant during rainy season followed by winter peak. Winter

and rainy peaks have been reported by Maruthanayagam *et al.*, (2003) and Pandey *et al.*, (2004). Comita and Anderson (1959) found that copepods multiply when that phytoplankton population was abundant. Such an observation was not found in the present investigation. This supports finding of Hosmani (2002). The cladocerans population was scanty in comparison to the rotifers. The main cladoceran peak was observed during summer and rainy seasons. According to Wright (1965) the density of cladocerans is primarily determined by the food supply but in the present investigation decline in the number of cladocerans in the presence of sufficient food may be due to fish predation and the active competition between cladocerans and other groups.

The zooplanktonic species have been recognized as pollution indicators by their usual absence or presence in water body. Sampath *et al.*, (1978), Verma *et al.*, (1984), Sharma (1986), Mishra and Saksena (1990) have commented on the basis of study of zooplankton communities that *Arcella discoides*, *Diffugia cornata*, *D. muriformes*, *Brachionus angularis*, *B. rubens*, *B. caudatus*, *B. falcatus*, *B. calyciflorus*, *B. diversicornis*, *Keratella lenzi*, *K. tropica*, *Moina* sp., *Daphnia carinata*, *D. lumkoltz*, *Cypris* sp., *Cyprinotus* and *Mesocyclops* are present in mesotrophic waters. *Arcella* sp., *Diffugia* sp., *Centropxyxis* sp., *Brachionus angularis*, *B. calyciflorus*, *B. rubens*, *B. caudatus*, *B. quadridentatus*, *B. budapestinensis*, *B. petrodinoides*, *B. sessilis*, *Keratella tropica*, *K. cohlearis*, *Anuracopyxis fissa*, *Platytias quadricornis*, *Lecane crenata*, *L. cornuta*, *L. lunaris*, *L. decipiens*, *L. pyriformis*, *L. closterocerca*, *Colurella bicuspidate*, *Filinia longiseta*, *F. terminalis*, *Asplanchna* sp., *Rotaria neptunia*, *Cephalodella* sp., *Conchilus* sp., *Polyarthra* sp., *Daphnia parvula*, *Ceriodaphnia lacustaris*, *Chydrous sphaericus*, *Daphanosoma leuchtenbergianum*, *Moina* sp., *Mesocyclops edax* and *Diaptomus busiciloides* are representative of eutrophic waters (David and Roy, 1966; Arora, 1966; Sharma, 1986; Bhatti and Rana, 1987; Cap, 1980; Janicki *et al.*, 1979 and Saksena, 1987). In the present study, *B. calyciflorus*, sp., *B. falcatus*, *B. forticula*, *B. angularis*, *Cephalodella* sp., *Polyarthra* sp., *Moina*, *Mesocyclops* sp., *Cypris* sp., *Ceriodaphnia* sp. were present in the river and they are suggestive of pollution.

All forms of organic matters are basically undesirable in the water though to a certain level of is tolerable. This may lead to serious trouble like eutrophication and depletion of the oxygen content of the system and thus impairing its health. Indian standards set 3 mg/l of DO as the limit. The DO level throughout the year was more than 3 mg/l. This perhaps indicates that the self purification capacity of the river can assimilate the existing load.

The results of physico-chemical study of water quality of the river depict a very critical level of pollution. An over all nutrients status, a low level of dissolved oxygen, high BOD, COD, solids and low oxygen are some of the positive factors favouring the growth of phytoplankton (Palmer, 1969). The growth of algae causes eutrophication, which may enhance the fish production (Lund, 1972).

It is clear from the present findings that the aquatic environment of the river has undergone degradation. The main sources of river pollution in the present study were recognized as:

- a) Discharge of domestic sewage from near by villages as well as industrial wastes
- b) Agricultural runoff

- c) Burning of corpses on the bank of river
- d) Bathing habits of human as well as cattles.
- e) Washing of clothes and utensils and
- f) Soil erosion
- g) Jute retting

Proper remedial measures should be taken immediately in order to restore it from further deterioration. There must be alternate waste disposal system away from the river and the disposal of solid and liquid wastes must stopped forthwith. Planting some macrophytes like *Polygonum amphibium*, *Bacopa momiesi*, *Alternanthera sessilis* and *Leonots nepataefolia* on both sides of the river has been reported to reduce toxicants from the polluted river water (Gupta, 2000).

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**Table – 1 : Physico-chemical characteristics of the river water . (All values are expressed in mg/L except pH and transparency (cm))**

Months	Temp °C		pH	Trans.	COD	DO	BOD	Free CO <sub>2</sub>	CO <sub>3</sub>	HCO <sub>3</sub>	PO <sub>4</sub>	NO <sub>3</sub>	Cl	Sulphate
	Air	Water												
Jan	20.1	18.9	8.6	72.8	66.8	9.9	19.9	0.9	0	90.8	0.09	0.38	25.6	55.6
Feb	22.4	19.5	8.4	70.3	64.7	9.5	20.4	0.8	0	90.5	0.08	0.41	23.2	66.4
Mar	30.5	27.9	8.2	58.6	59.5	9.3	20.6	1.1	0	88.4	0.09	0.43	28.5	73.1
April	34.8	32.5	7.9	50.9	71.6	8.5	21.9	1.9	0	92.1	0.12	0.49	29.4	77.6
May	37.4	35.1	7.5	48.7	74.2	8.3	24.2	1.14	0	99.9	0.14	0.54	32.4	72.9
June	38.2	36.8	7.3	45.1	78.2	8.1	25.4	1.19	0	80.4	0.16	0.56	33.5	71.4
July	38.9	36.9	7.4	38.9	90.4	7.8	25.1	1.04	0	64.6	0.16	0.58	33.9	80.5
Aug	37.4	35.8	7.3	34.1	92.8	7.6	29.8	1.08	0	55.8	0.18	0.61	32.6	74.2
Sept	35.9	28.2	7.6	31.5	76.5	6.8	22.9	1.09	0	50.1	0.18	0.64	29.7	81.9
Oct	33.5	25.4	7.9	35.5	69.8	6.4	21.8	1.04	0	55.2	0.15	0.47	28.2	63.5
Nov	29.1	22.2	8.0	46.5	66.5	7.9	21.4	1.1	0	59.6	0.12	0.42	26.1	58.3
Dec	24.5	20.1	8.4	60.1	65.3	8.1	19.6	1.0	0	70.4	0.11	0.40	25.2	60.4

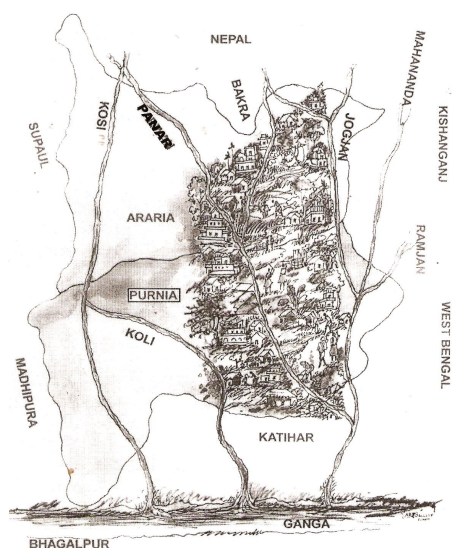
**Table-2: Monthwise distribution of phytoplankton groups in river water .**

Months	Chlorophyceae	Myxophyceae	Bacillariophyceae	Euglenophyceae
Jan	1680	1450	720	178
Feb	1388	1595	758	202
Mar	1350	1680	790	295
April	1485	1588	670	188
May	1498	1450	498	205
June	1370	1378	390	198
July	1295	1198	340	178
Aug	1145	1078	320	155
Sept	950	945	305	195
Oct	1058	1250	405	325
Nov	1425	1356	520	395
Dec	1795	1580	680	575
%	16439(38.71)	16542(38.96)	6396(15.06)	3089(7.27)

Table – 3: Month wise distribution of zooplankton & group in river water

Months	Rotifera	Cladocera	Copepods
Jan	285	160	130
Feb	250	145	95
Mar	475	165	150
April	498	580	175
May	380	650	195
June	350	375	110
July	290	180	95
Aug	210	150	70
Sep	230	140	60
Oct	298	125	88
Nov	280	170	78
Dec	295	150	125
%	3841 (46.83)	2990 (36.46)	1371(16.71)

Fig. 1: River Panar showing sampling sites.



# Seasonal variation in physico-chemical and biological properties

