DISCUSSION

DISCUSSIONS:

It is ancient fact that human inhabitance took place around river source only. There are documentary proofs of historic civilization took place near Narmada river also. However rivers have remained source of water for consumption and utilization, in return human beings have not maintained their purity. Rivers are by and large remained sinks for the all sorts of wastage, may be termed as dumping place (Jemson and Rana, 1996; Rana and Palhariya 1985, Quasim and Siddiqui, 1960). Through several sources, waste materials either solids or aqueous took its way to the major course of river. Municipal wastes, domestic sewage, effluent of various kinds and so called treated effluent goes to the river and alter its ecology (Thamil Chelvan, 1990; Bharti and Krishnamurty, 1992). Narmada, one of the major rivers of the Western India passes through a highly developed Industrial Zone, known as The Golden Corridor, beyond doubt may be termed as polluted river like, Mahisagar (Sharma, 1995; Pandya, 2001; Nanda, 2001). Inflow from several major and minor industries is poured into main stream river Narmada leading to changes in the natural status of its water quality, soil quality, floral and faunal diversity and its economic returns. Organic and inorganic matters flowing into the rivers get deposited on the bottom and influence the quality of the benthic habitat (Death and Winterborn, 1995). A continuous exchange of materials between water and soil of a river could alter the quality of water also (Saxena, 1998). Due to the influence of pollutants, its non-degradable nature and inflow of sewage the water quality of several Indian and International Rivers have exhibited degradation (Table 5.1). Depending of several abiotic parameters and biotic returns these rivers were classified into polluted state as LOW, MODERATE AND HIGHLY polluted. In the last decade the rivers of Gujarat were studied in details and it has been observed that the major rivers like, Sabarmati, Mahi, Narmada, and Tapi etc. are on sensitive level of pollution impact.

Abiotic Status:

Several abiotic parameters which directly or indirectly indicate the water quality status and its stage of degradation were considered over here for the analysis. The status of impact on and due to variations of the water quality by different abiotic features were compared to its normal range for various utility purposes (Tables 5.2 and 5.3).

Surface water temperature which is the physical expression of light, water and atmospheric relationship has been recorded. Diurnal, monthly, and seasonal changes observed at different sites may be due to air-atmospheric interactions and change in water quality. However the temperature ranged from 15° C—32° C in general is comparable to the range usually recorded by several workers in the Indian rivers (Ghosh and Sharma, 1989; Palharia and Malviya, 1986; Rao, 1989; Shukla, 1989), has observed 30° C–33° C surface temperature during summer in the downstream stretch of Narmada river which is identical to our observations.

Due to domestic effluents flowing into the river **pH** alteration has been observed, which usually remains alkaline in the Indian rivers ranging from 7.3 to 9.3 (Balgramy and Duttamunshi, 1985; Bhatt and Pathak, 1990; Venkteswarulu, 1986). Similar observation has been made during our sampling of water for pH analysis. pH of river water remained in the alkaline range (71. – 8.6) for all sites and during post monsoon period only at site I it was bit more alkaline. Even though waste water, un-treated water and effluent inflow at site I major change in the pH has not been observed may be due to tidal influence. **Electric conductivity (EC)** of the water is known to be dependant on the

Table 5.1(A): Level of degradation in some rivers of India.

Level of degradation	River	Author
High	River Ganga, Bihar	Sinha, 1994
High	River Tapı, Gujarat	Raghothaman, 1995
High	River Godavari, Tungbhadra, Andhra Pradesh	Venkateswarulu, 1994
Hıgh	Mahi river, Gujarat	Barodawala, 1992; Sharma, 1995, Nanda 2001
Moderate	River Chambal and Khan, Madhya Pradesh	Rao and Srivastava 1989
Moderate	Vishwamıtri rıver, Gujarat	Patel, 1992
Moderate	Khıspra river Madhya Pradesh	Kulsherestha, 1989
Moderate	River Periyar, Kerala	Sankarn, 1986
Low	Bhagırathı rıver, Uttar Pradesh	Gautam, and Satı, 1994

Table 5.1(B): Impact of aquatic pollutants on flora and fauna (National status)

Rivers	Specific effect
River Ganga, Patna, Bihar	High nutrients leading to decrease in population of macro organisms and making water unfit for human consumption
Tapi estuary, Surat, Gujarat	High temperature, salinity, pH, silicate and calcium and low dissolve oxygen and low nutrient concentration leading to high diatom population.
River Kshipra, M.P	High COD leading to depletion of benthos
River Khan, M.P.	Fluctuations in physicochemical parameters leading to unstable community structure of macro benthos
River Godavari and Tungbhadra Andhra Pradesh	High concentrations of heavy metals elevated density of certain species of *Nitzschia*, *Euglena* and *Oscillatoria.*
Rivrer Tungbhadra	Increase in bicarbonate, chlorine, phosphates, total solids, total dissolved solids and hardness leading to decrease in general species diversity.
River Pauna, Maharastra	Increase in nutrients leading to a drastic drop in number and species richness of both phyto and zooplankton especially ciliates and arthropod
River Coovum and Adyar - Madras city	Fluctuation in plankton population associated with fluctuations in physico-chemical parameters

Table 5.1(C): Impact of aquatic pollutants on flora and fauna (International status)

Rivers	Specific effect
Streams in Northeastern USA	Very low pH leading to acidification and long term decrease in the fish communities
King river, Tasmania, Australia	High temperature, low dissolve oxygen and high nitrogen content leading to fluctuation in the population of zooplankton
Kumamoto zoo Basin	High concentration of ammonia, phosphate and chlorine leading to decrease in number of oligochaeta
Rivers of East of France	High concentration of nutrients, high nannoplankton biomass and increased fertility in *Brachionus angularis*
Chesapeake Bay and Elizabeth River, USA	Increase in eutrophhication and decrease in tintinids, copepod naupli and mesozooplankton population.
River Medlock and tributris Manchester, England Delaware and Neches esturies and the Flint river	Increase in density of pollution tolerant oligochaets and polychaets, viz. *Streblospio beneteeti*, *Neris succnea* and *Polydora* sp. and crustaceans viz. *Penaeus aztecus, P.setiferous, Leptochelia dubia, Chironomus* sp. and *Tanytarsus* among dipterans. A general decrease in number of other insect group.
Haneefah Stream, Riyadh, Soudi Arabia	Following the elevated level of chlorine, carbonate, bicarbonate and sulphur, zooplanktons belonging to phylum protozoa, rotifer and class crustacean of arthropods became prominent, i.e increase in frequency of occurrence.
Swannee river and estuary, USA (an unpolluted river)	High species richness of benthic macrofauna, 70% arthropoda, 12% mollusca, 15% annelida, 3% hemichordata and chordata.
Guorau river estuary, Southeast of Brazil	Elevated aluminium sulphate has no long-term effect on zooplankton species diversity

Table 5.2: Permissible levels of aquatic pollutants

PARAMETER	MAXIMUM PERMISSIBLE CONCENTRATION
1. Temperature	45°C
2. pH	5.5 to 9.0
3. Total suspended solids	100
4. Total dissolved solids	5000
5. Biological oxygen demand	100
6. Oil and Grease	10
7. Phenolic compounds	1
8. Cyanide	0.2
9. Sulphide	1.0
10. Fluoride	10
11. Arsenic	0.2
12. Barium	1 .0
13. Cadmium	2.0
14. Copper	3.0
15. Chromium	0.1
16. Nickle	3.0
17. Lead	0.1
18. Mercury	0.01
19. Zinc	10
20. Sulphate	1000
21. Chloride	1000

All values except temperature and pH are in mg/l

Table 5.3: Standards for drinking water

CHARACTERISTICS	ACCEPTABLE	REJECTIONABLE
Turbidity (units F.T.U scale)	2.5	10
pH	7 to 8.5	6.5 to 9.2
Total dissolved solids	500	1500
Total hardness	200	600
Chlorides	200	1000
Sulphate	200	400
Nitrates	40	45
Calcium	75	200
Magnesium	30	130
Iron	01	1.0
Copper	0.05	0.15
Zinc	5.0	15

All values except turbidity and pH are in mg/l

salts in the water, enhance due to sewage and industrial effluents mixing regularly with the riverine water. In our observations for water samples from various sites the EC ranged higher always, and it ranged between 300-2500 units. Moreover, at site I during post monsoon EC found increased due to inflow or effluent. It ranges from 150 to 700 units Ganga and Yamuna rivers which are quite similar to the readings from Narmada river flowing in of Madhya Pradesh (Ghosh and Sharma 1989; Balgramy and Duttamunshi, 1985; Tiwari et. al., 1985). Higher values of EC in the downstream is evident due to several reasons, however, major reasons may be tidal flow and inflow of polluted water.

Dissolved gases like oxygen (DO) and carbon dioxide (CO_2) are very essential parameters of water quality assessment. Here **dissolved oxygen (DO)** values ranged from 3 to 9 mg/l at different sites and during different seasons. In rivers like Ganga, Yamuna, Tapi, and Krishna, etc dissolved oxygen ranges from1.2 to10 mg/l, which quite similar to our observations for water of river Narmada (Shukla, 1989; Chattopadhyay, 1984; Saxena, 1986; Trivedi, 1990). Site I, which at the lower reaches of river Narmada, DO values remained fluctuating, this may be attributed to influx of chemical loaded water from several sources No significant observation has been made for **free CO_2** from the water of river Narmada. However, It has been recorded to range between 1.2 to 12.5 mg/l in rivers like, Ganga, Kumaon and Jhelum by Tiwari, 1990; Sharma, 1990; Shyam sundar, 1998.

Dissolved and un-dissolved salts imparts turbidity as well as variation in the values of total hardness, total solids etc. Dissolved **carbonates** ranged from 1-26 mg/l at different sites and during different seasons. Further it was observed that during post monsoon period at site I and site II the dissolved content of carbonate was recorded more, this may be due to siltation and dense vegetation in the same area of our study site in river Narmada. Carbonate alkalinity in the rivers of North India, usually trend of 2 to 12 mg/l which very much similar to the values recorded from the sample waters of river Narmada (Balgramy and Dattamunshi, 1985; Tiwari, 1990 and Sharma, 1990). Whereas the same in the rivers of south India like, Kanga and Tungbadhra ranges from 1 to 13 mg/l, due to influence of sewage and industrial wastes (Venkteshwrulu, 1986). The range observed from our sampling sites follows the trends recorded from rivers of North to South India, as well as the higher values observed is due to sewage and waste disposal. **Bicarbonate** alkalinity is comparatively higher than that of carbonate alkalinity, fluctuates between 130 to 500mg/l, in the rivers flowing from Himalayas, (Saxena, 1966; Ghosh and Sharma, 1989; Lakshminarayan, 1974). Similar high values were recorded in our sampling also. In the zone of the reflux of the industrial wastes either loaded or unloaded the bicarbonate alkalinity represents higher values ranging from 200 to 950 mg/l (Venkteshwrulu, 1986). However, due to strange reasons such observation of higher values at the site of dumping has not been observed for river Narmada, one of the reasons may be the tidal flow which regulates the inflow and dispersal of polluted water in the study sites.

A seasonal fluctuation in the values of the **total hardness** has been reported by (Saxena, 1966; Chattopadhyay, 1984. and Lakshminarayan, 1965), Narmada shows much lower hardness than that of Ganga, (Lakshminarayan, 1965), and similar observation has been made during our sampling also. Specifically depending upon the intermingling of the wastes like gelatin paper-pulp, domestic sewage and bottom rocks leads to the calcium hardness 20 to 190mg/l was observed (Lakshinarayan, 1965). Due to the partial influence of the sewage and basin rocks magnesium hardness of the water of river Narmada mostly exceeds than that of Ganga In the water of river Narmada the magnesium hardness has been observed more as compared to calcium hardness in the study area, this may be correlated to two major factors like tidal fluctuations in the study area and inflow of water influenced by anthropogenic activities. Total dissolved and suspended solid which also contribute to hardness of water, has shown quite large variation in their values. As suspended solids were not more in amount the resultant turbidity has not been observed at different places.

Chloride has been considered as the most important indicator of water pollution. Its concentration ranges from 8.0 to 55 mg/l in the river Ganga near Varanasi (Balgramy and Duttamunshi, 1985, Shukla, 1989). In the Zone around Allahabad in the river Ganga and Yamuna chloride content nearly observed were as 70 mg/l, (Ray et. al., 1966; Shukla, 1989, Sharma, 1995). Comparatively Naramada is also considered to be as polluted as Mahi and other major rivers. Chloride content of the lower reaches of both the rivers has always been very high due to tidal influence and dumping of waste water. **Sulphate** content in the water varies from 1 to 10 mg/l, considered to be moderate range by Ghosh and Sharma, 1989. However, from the samples collected from river Narmada the sulphate content always remained very high, this may be attributed to mainly pollution through effluents of various types flowing in from several sources. The higher values of sulphate up to 40 mg/l has been reported from the water having pollution load has been comparable to the observations recorded for water samples from various sites, especially from site I of the study area (Chattopadhyay, 1984). **Phosphate** invades into the water principally through the sewage and gets dissolved, leading to nutrient enrichment of the water. The normal amount of phosphate water usually ranges from 0.4 to 4.0 mg/l, has been reported from rivers, Ganga, Yamuna, Tungbadhra and Hoogly (Shukla, 1989; Duttamunshi, 1985; Ray and David, 1966). The phosphate content in the sample water has been recorded with in the specified range and similar to the observations made for different rivers. No significant observation has been made regarding phosphate content from various sites and for different seasons. **Nitrate** content usually in different forms were recorded in traces from the unpolluted water of river Ganga (Raina, 1984, Shyamsunder, 1988). Except at few places and during some season fluctuations in the nitrate content has not been observed from the sampling sites. These traces of nitrate in water are due to the action of the Nitrifying Bacteria (Ganpati et al., 1951), and the same from the unpolluted zone of river Narmada (Prasad and Saxena, 1980).

The **chemical oxygen demand (COD)** of riverine water has usually been recorded excess over the permissible limits from the rivers like, Khan, Zhelum and Ganga etc. by Raina 1984; Shukla 1989. Due the sewage discharge and pollutants affect the chemical oxygen demand of the river Narmada water is recorded always high (Barodawala, Patel and Patel, 1992, Ragothaman, 1981,1986). Chemical oxygen demand of water found increased during pre monsoon and may be due to supplement of fresh water during monsoon and post monsoon this demand decreased. **Metals** get introduced in river system as a result of weathering of rocks, siltation and through man made sources like effluent discharge. Cobalt, copper, iron and zinc has been analyzed here, usually such metals were found only in traces form various samples. No significant variation has been observed in their seasonal content. However, Zinc and Iron where slightly more during pre monsoon for all the sites. Zinc as such is a beneficial metal and its more quantity has been observed during monsoon in the river Bhagirathi also (Gautam and Satti, 1989).

All though several anthropogenic influences in the form of municipal waste, domestic sewage, treated and untreated effluent from minor industries as well as large amount of various discharges from major industries, water quality of Narmada river may not be considered degraded at all. Except local damages to riverine patches, largely the ecosystem remains stable due to perennial fresh water flow from upstream and tidal influence from downstream of Narmada River.

Biotic Status:

Biotic status of any ecosystem is dependent on the abiotic status of that ecosystem. Here we have observed variations in the abiotic parameters of water quality for different sites and seasons, and the same may have influenced the biotic status of the study area. Biotic components are principally flora and fauna of the ecosystem which has been elaborately studied for diversity patterns. Planktonic forms were more studied compared to nektons and benthos for the Indian rivers (Rathod et. al., 2005). Among phytoplankton Cyanophyceae and Chlorophyceae were reported more at site II during all the seasons, this may be due to inflow and dispersal of domestic sewage leading to nutrient enrichment (Venkatshwarlu, 1986 and Trivedi, 1990). Replacement of one type of Planktonic form by other in its dominance, like Cyanophyceae replaced by Chlorophyceae has been observed at site II is quite similar observation to the one made by Trivedi et. al, for Panchganga river. Increased pollution level in terms of dissolved and dispersed effluent in large quantity has been observed few times at siteI. Such condition has been biologically quantified by the amount of Bacillariophyceae and its replacement by Cyanophyceae in following season. Seasonal variation in the amount of Euglenophyceae may be related to the influence of abiotic factors (Ramarao et. al., 1978, Manoj, 1993). From unpolluted sites of several rivers of India, it has been observed that Bacillariophyceae was dominating (Bulgranimi and Duttamunshi, 1985, Bulusu, 1967) followed by the dominance of Chlorophyceae, similar observation has been recorded for our sampling sites also. On the basis of observations made for phytoplankton a sequential relationship may be established as Bacillariophyceae ⟶ Chlorophyceae ⟶ Cyanophyceae ⟶ Eulgenophyceae for the unpolluted sites of river Narmada. Variety of algae has been reported as indicators of inflow of effluents and pollution status of the river water (Sankaran, 1993, Ragothaman et. al., 1995). Variation in the percentage content in the algae at site I of the study area represents the similar condition. Variation in the density and diversity of the aquatic flora has been observed from different sites of the study area, also seasonal variation was marked. At site I comparatively aquatic flora was less due to probably the influence of salinity stratification in the water. Here the water mass movement is more and also water quality is influenced by inflow of effluent from the industrial zone. Due to the effect of chemicals flowing in with effluent, the pigment loss was observed in the aquatic flora of site I. Such damage and degradation to aquatic flora has been reported by several authors (Chauhan, 2004). As the domestic sewage enters the river main stream via an ephemeral pond and some minor channels the entire zone of site II remains vegetation dense. It has been observed that even though there is dense vegetation at site II, the floral diversity is such that the floating vegetation remains under control as well as the submerged vegetation like Hydrilla and Velisneria do not spread. This is because of natural biological control and hydrological features (Blackburn et. al, 1971). The lesser density of all the varieties of aquatic plants at site I may be attributed to salinity of water and inflow of effluent, similar observation has been made by Blum, 1957.Usually post monsoon flowering has been recorded for the variety of water hyacinth and Nymphea in tropical rivers (Dana, 1974), such condition is prevalent in Narmada river also and at sampling site II.

Zooplankton communities were abundant in the study area. These zooplankton are the food for several fish and crustaceans, as well as for the benthic macro faunal communities. The density and diversity of zooplankton certainly get influenced by the physico-chemical properties of water (Sarkar et. al., 1986: Osore et. al., 1997), also for tropical rivers it has been marked that the density of zooplankton remains more in the lower reaches of the rivers and very less density as well as diversity of zooplankton community has been reported from head water and first and second order streams. Further, it is a fact that the diversity of zooplankton is always less in the flowing fresh water compared to estuarine water or tidal influenced zone, the similar observation has been recorded for rivers like Narmada, Tapi, Mahi and Sabarmati (Sharma, 1995, 1999; Nanda, 2003). High percentage of Protozoan observed at various sites may be compared to fresh water inflow, and less concentration of effluent in the river water. Similar observation has been made by Nanda, 2001 in Mahisager River. Diversity of Arthropods was recorded more from site I presumably due to marine water influence. The presence of variety of Branchionus sp. and copepods are the indicator of influence of pollutants as well as domestic sewage discharges (Kulshreshtha et.al, 1989, 1991; Sexena and Kulkarni, 1986, Nanda, 2001, Naik et. al, 1989), the same pattern of presence of such Rotifers and Arthropods has been observed from site I and site II of the study area. Spatial and temporal variability in the different forms of zooplankton and especially arthropods has been observed in the study site may be due to the impact of tidal water, effluent and domestic discharges and fresh water inflow velocity (Verma et. al, 1984, Nanda, 2003). Other than zooplankton communities faunal diversity recorded from the large spectrum of invertebrate phyla and Piscean group from River Narmada. The insect fauna has been recorded as several larval or nymph form of Mayfly, Dragon fly, mosquitoes etc. From the entire sampling site such insect fauna has been reported with variation in their abundance mainly dependent on seasonal conditions (Nanda et. al., 2005). The site II of the study area is highly influenced by inflow of domestic sewage, from this location we have recorded high density of nematodes and annelids which may be significantly attributed to the high organic content of the water as well as bottom soil (Saxena and Kulkarni, 1986). The study area accommodates diverse condition of fresh water and salinity intrusion zone, the diversity of fauna varies due to this condition.

From site I large variety of fishes and crabs has been recorded as it is tidal influenced zone. All euryhaline organisms are able to withstand environmental condition changes hence their diversity is high. To some extent the abundance of fish reports decline in last five years may be due to inflow of large amount of effluent from the industries. The site I and site II were important zones for the fishing of Palva during monsoon, but in recent years the area has extended to site III also as the fresh water inflow has been reduced during post monsoon. Further it is envisaged that annual fresh water regime will change following the construction of Sardar Sarovar Dam (Thamil Chelvan, 1990; Bolton 1992; Sabnis and Amin, 1992; Wallingford, 1995) will have some impact on fishery component The impact of dam construction has been analyzed in detail for the fishery component by GOPA consultancy, 1991 and reported changes in the diversity pattern and distribution pattern of fish fauna and other crustacean fauna. In our investigation the distribution extent for Palva and Macrobrachium shows pattern change compared to the observations made earlier, hence significantly supports the need for conservation action (CICFRI, 1993; Bonny et. al., 1994, COF, 2003).

The River Narmada has been reported reach in biodiversity mainly due to its water quality. It is one of the major rivers for fisheries purpose also. Along with several minor fishery, it is known for Hilsa and Scampi fisheries. Even though the treated as well as untreated effluent is flowing in the main channel of the downstream of river,· no significant adverse effect has been reported yet. During our investigation very less impact has been observed on fisheries component. Except some pattern change in the distribution extent of Hilsa and Scampi, their contribution in the fisheries of Gujarat State has not decline (COF, 2004). Only concern about water quality and fisheries is that of fresh water inflow to sustain these parameters. To sustain the importance of this river few steps should be taken like, maintain post-monsoon fresh water flow dynamics, control ingress of saline water as tidal water to reduce of increase in saline intrusion zone, manage the dumping of treated effluent to other site and allow only treated effluent on the outer most reach of river mouth to reduce its impact etc.