GENERAL DISCUSSION
In India, rivers though constituting one of the major assets and important fresh water resources are not only grossly polluted due to various man-made activities but also have been paid least attentions by the authorities in concern. The effect of pollutants are harbouring the mass media and gradually hampering the physio-chemical and biotic factors of these riverine systems in their long term effect. The present study has been focussed in the light of pollution impact in river Mahanadi at Sambalpur (Orissa).

The study reveals though limited but is eventually exposed to the threatening dimension of pollution and human tempering with its precious resource and beauty. Opening of thousands of sewages of the highly populated city of Sambalpur (over 1.5 lakh) gross use and abuse of the water body by the uncivilized population (about fifty thousand) with their unscrupulous activities, runoff from catchment areas, effluents from different industries and factories are threatening the hydrographic features, manipulating its characteristic features with gradual pollution load (P|\rightarrow |e.3)

Further it deals with the various aspect starting from the biology and biotic as well as abiotic parameters to pollution assessment for two decades (1960 and 1981). This reveals the upset of hydrographic structures. Thus it is evident that
the river is under stress to a great extent by the human activities along the periphery and surface as well as the sewage tempering in the river. The river is grossly affecting on the life processes of the existing biota at one hand causing mortality, decomposition and rotting of macrophytes and at other hand, on the general life processes of the people, who use the water for bathing, drinking and other domestic activities. Therefore, in the recent past evidences, many outbreaks of dreadful diseases like typhoid, cholera, small pox are reported causing death of several lives and many people are reported to suffer from the allergy and other skin ailments mostly during summer while the river seems to pass through the major pollution stress. To add insult to the injury, the irrigation has also resulted in the salinity of surrounding soils (Gurjer, 1975; Boralkar et al. 1981; Boralkar, Trivedi and Kulkarni, 1981). The drinking water supply by public health engineering to the populated city is only the source from this river, which is becoming polluted in gradual footstep ($\partial\alpha\in\{\beta\}$).

The hydrobiological features may also be assessed in general to show the aspects of prompt dimension of pollution spread in the medium.

The hypoxic state of water, as observed especially during the summer season with higher oxygen deficit value indicate that the river is loaded with alarming amounts of
biogenic and chemical wastes from different concerns.

Some of the physical and chemical alternation of water such as colour, odour, taste rise of temperature, oxygen depletion, free carbon dioxide, alkalinity, chloride and nutrients are the immediate effects of various pollutants.

Water depth though primarily controlled and balanced by the meteoric rains of monsoon (Augustyn, 1979) is also secondarily controlled by the dam authority of Hirakud reservoir for irrigation and power generation. Thus it is only reported to be fluctuated in monsoon with high current and in early winter with feeble current. Summer is the full stagnation period and the water body is affected variously by sewages, animals and men, permitting the adverse physico-chemical characters and high rate of Organic decomposition. Thus it brings about the high mortality rate of aquatic fauna. Rotting of macroflora at high temperature of summer causing excessive scum formation on pelagic layer is the common occurrence. Water flow during monsoon brings the subsoil, silica from the rocky substratum and surface run off (Clarke, 1934; Sundararaja and Krishna-Murti, 1981). It adds up the nutrient factors like inorganic phosphate (Boralkar, 1981; Saad and Samir, 1981), and total nitrogen (Boralkar, 1981) to the level.

On the other hand the water flow in monsoon season
brings down water temperature and also transparency by its pocketing of high residue materials (Clarke, 1938; Kant and Anand, 1979; Boralkar, 1981), which in the other hand changes the colour index (Jhingran, 1978; Voznaya, 1981) from clear to dirty brown and pertains earthen taste due to the soil humins and sand particles in abundant colloidal form. The suspended materials in water highly affect the transparency permitting the low gross and net primary productivity (1.03 gC/m²/day and 0.28 gC/m²/day respectively) during monsoon (Goldman, 1960; Goldman and Wetzel, 1963; Sreenivasan, 1965). The rainy and cloudy weather put a bad impact on the primary productivity. The high rate of water current, drifts away the planktons, macrophytes and macroinvertebrates downstream the river pertaining the water with poor planktonic contents. Especially, the zooplankton fauna suffer due to the water current in monsoon in this riverine ecosystem.

Water temperature varies with the atmospheric temperature. It shows the distinct seasonal fluctuation, relating the increase and decrease of air temperature (Geiger, 1965; John, 1978; Kant and Anand, 1979) and maintains good correlation coefficient with ambient air temperature ($r = 0.893; p > 0.01$). The highest temperature during summer reports the maximum biological decomposition in the benthic zone permitting low dissolved oxygen content. It is further effected by sunlight and bright sunshine hours (Clarke, 1953; Young and Zimmerman,
1956; Geiger, 1965; Macan and Maudsley, 1966; Purbrick, 1972 and Rejmankova, 1973), on the contact ground, on air temperature (Macan and Maudsley, 1966; Moss, 1969; Martin, 1972; Saad and Samir, 1979; Gahtori et al. 1981 and Saha 1981) and pH of water (John, 1978). The poor macrophytic growth during the high summer temperature indicates that these are poor indicators, of high water temperature and ultimately the high temperature causes the rotting, a forms a heavy scum layer on the pelagic layer of river. The thermal regulation during early summer and whole winter is done by the wave action and wind, providing this factor to the plankton and benthic fauna for their metabolic and physiological processes like feeding, reproduction, movement and distribution (Clarke, 1954). The favourable temperature during winter enrich the phytoplankton level and allows the high productivity during this period (William and Murdoch, 1966; Hillbich-Ilkowska and Bouglawza, 1979; Gupta, 1980; Thomas et al. 1980). Besides, during winter, the pH value remains high and the temperature becomes low. These may be another causative factors for the high productivity and also may be due to enriched phytoplankton.

The higher transparency allows the high productivity (Hutchinson, 1957) by allowing the penetration of solar energy under favourable weather condition. The transparency remains comparatively low in summer than winter primarily due to the
bacterial decomposition at the bottom and secondarily due to 
man-made disturbances. The sewage contamination also creates 
the favourable climatic factors for setting differential 
destructive activities which in turn shows the poor transpare-
cy. Comparatively higher transparency values during morning 
hours of summer (0900 h) may be the encountered with less 
interferences of men and animals with the water.

pH value shows positive but poor correlations 
with temperature \( (r = 0.397) \), dissolved oxygen \( (r = 0.459) \) and 
total alkalinity \( (r = 0.613) \). Such poor correlations may 
due to the oxygen depletion and pollution load in summer. 
Besides the seasonal fluctuations, pH shows to increase in 
relation to the increase of dissolved oxygen during winter and 
early summer with little variations. Low pH during monsoon 
may be on account of large volume of surface run off and 
upland currents of water to the main stream (Dwivedi et al. 
1977; Jefferies et al. 1979 and Saha et al. 1981) carrying with 
the large soil materials and nutrients.

The heavy sewage contamination and strong biological 
activities including the biogenic and chemical wastes has 
disturbed the dissolved oxygen compartment of the river showing 
the hypoxic condition (< 7 mg/l) (Boralkar, 1981) but with the 
tolerance limit (> 3 mg/l) (Kudesia, 1980). It reports in the 
medium by photosynthetic activities of macro-autotrophs and
3rd: The relationship between the use of the argument to the command `grep` and the output of the command.

4th: The relationship between the use of the argument to the command `grep` and the output of the command.
Fig. 17.
benthic components as well as from free atmospheric diffusion (Odum, 1971). The low concentration of oxygen during summer is due to the high temperature and thus remains below the saturation point with oxygen deficit (Voznaya, 1981) resolving the high rate of decomposition in the medium. During winter, dissolved oxygen content is reported to be high, may be due to high transparency, rich plankton growth, and comparative low water temperature (Jana, 1974; Nassar and Munshi, 1974; Bohra, 1976; Nassar, 1977 and Wong et al. 1979). The adverse conditions are associated during summer while the dissolved oxygen content is depleted (Burge and Juday, 1914) by sewage contamination, high temperature, stagnant water condition and above all the excessive scum formation further blocks the respiratory and photosynthetic activities in the water millue. Oxygen in the medium circulates to the deep benthic community by effective wave and wind action as well as eddy conduction (Redfield, 1941). The diffusion rate against the water current decreases the DO₂ value during monsoon and the presence of residual deposition in water (Boralkar, 1981). The low concentration is probably a handicap of sewage rush and high decomposition at the bottom with mass abuse.

Free carbondioxide concentration (4 mg/l to 20 mg/l) reports to be within the safe range against the acute pollution (41.5 mg/l) as opined by Kudesia (1980). However, it provides
an unhealthy situation in the medium for its concentration above 5 mg/l (Dennell, 1976). The high rate of organic putrification at the bottom layer in summer and simultaneously it is produced (Ultsch, 1971) due to fermentation and the oxidation process. The elemental diffusion rate (Ruttner, 1953; Hutchinson, 1957; Mann, 1958; Warren, 1971; Nasar, 1975) is high during monsoon with the inflow of ground water and main stream (Jhingran, 1978) and in late summer may be due to the high rate of respiration, bacterial decomposition and sewage contamination. Its higher concentration is reported with low dissolved oxygen during monsoon, late summer and supported by Whipple and Parker (1902), Brige and Juday (1911), Pearson (1930), Ganapati (1943), Gonzalves and Joshi (1946), Rao (1955), Saha, Sen and Sengupta (1959) and Munawar (1970).

Faecal matter and human influences also add to the concentration to high of free CO$_2$ in summer. In winter, low free CO$_2$ level in the aquatic milieu may be due to the fact that favourable environmental conditions prevail in the season that enhances the peak growth of phytoplankton and during respiration aquatic flora and fauna expediated CO$_2$ and free CO$_2$ in water are readily utilized by autotrops (Verma, 1967; Saha, 1981). During late monsoon the low free carbon dioxide level may be related with the rapid water agitation by vertical wind movement and low rainfall (Ruttner, 1953; Hutchinson, 1957, Mann,
The high alkalinity level during winter and early summer may be due to the plankton growth and sewage organic and inorganic inflow to the river. It is carried away by the water current, rain. The higher values of alkalinity relate with high pH, more dissolved oxygen content and low free-carbon dioxide in these periods.

Chloride content reports high value at high water and air temperature of summer and agrees with the findings of Gonzalvels and Joshi (1946), Singh (1960), Zafar (1964), Pahwa and Mehrotra (1966), Ray et al. (1966), Munawar (1970 a). This may be due to the stagnant condition of water, sewage influx, high abuse by men and animals as well as rapid evaporation of the medium (Nayak and Patra, 1982). The inflow of rain water and heavy water discharge decreases the its concentration during monsoon (upto 2 mg/l) and supports the findings of John (1978), Saad and Antoine, (1979), Saad and Samir (1979). The rise of chloride content during winter may be due to pertaining salinity by the bank-side irrigated lands (Gurjer, 1975; Boralker, 1981; Boralkar et al. 1981). However its range remains within the tolerance limit against the findings of Kudesia (1980) without causing much pollution regime (Choudhry et al. 1979; Saad and Samir, 1979) and also becomes suitable for irrigation.
(Keulder, 1979). The sewage contamination and extensive human interferences probably make those salinity to the medium rather than the monsoon. It relates positively with pH, dissolved oxygen.

The total nitrogen concentration exceeds the range of pollution (< 0.48 mg/l) during June and July (late summer and early monsoon) and may be the initial phase of pollution. In other months, its value does not show the significantly high level. During monsoon, it is added to the system from the catchment axes (cornfields), where nitrogenous fertilizers are added abundantly and leaked to the rivers through canals and from surface runoff including water current. The discharge of sewage water increases the salinity as the evidences are there (Goel, et al, 1981). Scum deposits in surface layer also adds to its concentration (Sundarraj and Krishna Murty, 1981) and also the samething happens with mineral nitrogen in the medium (Pasternak and Kasza, 1978) which is added during summer. Uptaking the nitrogen in the form of nutrient level rushes to the phytoplankton and macrophytes (Eppley et al.1979; and Saad and Samir, 1979) as they are dependent on it (Wong et al. 1979). It is an index of the carbon budget (Munawar, 1970a, Pillai and Sreenivasan, 1975) and on concentration it largely depends and the decomposition of organic matter. It presents in the medium by diffusion from atmosphere and fixed
up by the cyanophyta (Rice, 1968 and Howard et al., 1970) and assimilated by chlorophyta (Algeus, 1951) during the enriched phytoplankton period in winter and early summer.

Inorganic phosphate in the other hand is also another important nutrient factor like nitrogen reporting high in May and June as probably assigned by the sewage flux (Goel et al. 1981) and present below the pollution level (0.009 to 0.183 mg/l) against the value of 0.2 mg/l (Willen, 1976; Lee, 1977; Jhingran, 1978) but above the critical point (0.01 mg/l) as reported by Vollenweider and Neuwreck (1961), Vollenweider (1969) and Lee (1977). In monsoon the highest concentration is due to the addition from catchment areas by surface run off leaking along with water current and sewage discharge (Boralkar, 1981; Saad and Samir, 1981).

Nitrogen in form of compound passes from autotrophs to heterotrophs in the food chain in form of the protoplasmic components of the cell. They are derived to the medium by autochthonous or allochthonous sources and acts as the limiting factor for the living biotic indication of pollution stress. The biological involvement in the medium is rather complicated and more complex phenomenon where it passes in a cycling form showing the nitrogen budget (Misra, 1968) adding by death and decomposition, sewage inflow, rain sources and soil and lost
by the uptake and vice versa. It reports in form of air ——> water ——> soil ——> autotroph ——> heterotroph ——> soil and water, due to the method of destruction and construction.

It deals directly with the physiology and morphology of phyto-plankton (Gibson and Stevens, 1979, Saad and Samir, 1979) during winter season. The soil phosphate also exchanged with the medium (Boyd, 1971) as well as by the death and decay of biota (Thomas, 1970; Howard-Williams, 1972). Phosphate releases more quickly in the food chain and remain locked up in the phytoplankton during winter showing as the residence time. Phytoplankton community intake, high rate of nutrients during winter witnessing low temperature of the medium and bright illumination (Clarke, 1954; Olems et al 1979). Distribution in the medium is done by horizontal and vertical current of wind overturns. The sinking plankters (Rotifers, Cladocera, Copepoda) are very often facing the autolysis and release phosphatase from their nuclear protein of cells.

The diatom population in the medium is probably controlled by the nutrient factor as the highest concentration of nitrogen and phosphate does not provide a big stand of these groups and on the other hand they are reported to be at optimum range for a better population growth in summer and winter period.
Silicate correlates with the atmospheric and water temperature showing the higher value in summer and monsoon. Due to the high population growth of diatoms during winter the silicate content in water is decreased, as observed by Ruttner (1953), Lee (1962), Kutuzova (1969), Munawar (1970a), Bailey-Watts and Lund (1973), Bailey watts (1976a,b), Willen (1976), Lemoalle (1979), Kant (1981). Inverse relationship \( r = -0.816; p > 0.02 \) between silica and diatom indicates that they prefer lower silicate medium for their metabolic process but it is solely responsible to form a diversified diatom community (Pearsall, 1923; Atkins, 1926; Komarvosky, 1953; Kilham, 1971, Munawar, 1974 a,b). Silicate content adds to the water from surface rock substratum containing quartz in monsoon and by dragging of the sewage materials and by the decomposition of hard shell materials of diatoms and testacean rhizopods. It acts as the body building material i.e. shells of testacean rhizopods and diatoms. So they concern with the silicate metabolism (Lee, 1962; Admundson, 1970; Munawar, 1970 a, Likens and Boramann, 1975). The high rate of silicate metabolism of diatom population may be expected in the early summer and winter as they are found to be in highest number and the silicate concentration in the medium remains low. Silica is an essential component for increasing of diatom community (Atkins, 1926; Komarvosky, 1953; Kilham, 1971; Munawar, 1974 a, b; Bailey-Watts, 1976; Knoeckel and Kalff, 1978).
The physical and chemical fluctuation of hydrographic parameters disturb the aquatic life. The rise of water flow decreases the plankton population and in other hand they become rich in the medium during slow water current and favourable physico-chemical factors. In general, both the plankton population show their total response to the seasonal parameters like temperature dissolved oxygen, carbon dioxide, pH and nutrient concentration of the medium and on the other hand their life processes are effected by the inflow of different ingrediants and sewage contamination, fertilizers from the upland soil, effluents from industrial and urban area.

During the regime of phytoplankton and zooplankton, the better aquatic parameters are recorded. They show the maxim in early summer and late winter and probably the concerning medium acts on their standing stock and population richness. The blooming of phytoplankton and swarming of zooplankton are generally time specific in the annual cycle.

The most tolerant group of cyanophyta shows its population peak towards the early summer may be due to its high tolerating capacity to the adverse ecological conditions in the medium. The population peaks of phytoplankton group i.e. chlorophyte and Bacillariophyta during summer and winter was discussed by large number of investigators i.e. Zafar (1964),
Phytoplankton group generally responds to the medium for the photosynthetic activities. Therefore, the bright weather condition and good temperature regime during winter and early summer may be responsible for their abundance as the rate of productivity may lead the population to grow and reproduce in the medium.

Microscopic and benthic population in the medium shows their tolerance limits for the specific range of temperature and above this optimum value, they may be decomposed by bacterial population. Diatom population shows its wide accepted tolerance limit of ± 15°C with the perennial distribution may be indicated as they are highly tolerable to the aquatic hazards and pollution. *Nitzschia closterium* Ehr., *Gomphonema* sp., *Navicula* sp., *Pinnularia varidis* Ehr. were reported during hot summer months.

Concentration of high and low dissolved oxygen and free carbondioxide may be expected as the limiting factor for the population growth of green algae. Findings of algae mats of *Oscillatoria limosa* Ag., *Spirogyra* sp., *oedogonium* sp., *Ulothrix* sp. may be due to the favourable water conditions during summer by filamentous algae.
The importance of water temperature in the periodicity of cyanophyta has been reported by Pearsall (1923), Fritsch (1931), Gonzalves and Joshi (1940) and Prescott (1951). They opine that high temperature in summer facilitates the growth of cyanophyta population as found in the present study. They are reported at the peak summer.

High productivity value in winter and early summer may be due to the good weather condition and bright illumination, where the rich phytoplankton medium draws the solar energy directly through the transparent water medium. Beside, the winter period is recorded on the peak of phytoplankton stock. Thus the high phytoplankton level in relation to the bright weather condition, bright sunlight and comparatively higher transparent medium provides high productivity.

Among the phytoplankton, species of chlorophyta reports to be most sensitive to pollution. Cyanophyta reports as the pollution tolerant species and Bacillariophyta shows the perennial form of distribution.

Presence of more number of species gives the higher species diversity index. Phytoplankton species though shows the seasonal variations in number and percentage, the equitability
is more or less found in winter, while the common species increases in the number and probably for competition in the medium. Rotifer levels are found to be increased while the phytoplankton level is well developed. This may be due to the grazing activity on phytoplankton as the evidences are there (Edmondson, 1957; Winner, 1975). Besides, their higher number during summer may be due to the presence of high detritus in the medium. The cyclomorphosis and vertical diurnal migration exhibits their morphological variation in form due to high temperature and grazing respectively corresponding to the biological time scale. Cladocera and copepoda show the same pattern of rhythmic vertical movement showing the abundance in night hours for their negative phototactic habit of the medium. Both these groups followed the seasonal pattern of fluctuations relating to the thermal stratification and envelope nutrient and respiratory of the medium. Availability of chloride and nutrients are supposed to be favourable factors for their growth. Macrophytic population is less and far more restricted to the late winter to early summer only. Macro-invertebrates bring down its population during monsoon. This may be due to the high current of water, making the population disturbed. Soils, mainly deposited on the rocky substratum by surface run off from the catchment areas and its assigned sides in monsoon. Heat returning capacity, reflexivity and penetration of incident light radiation in its prennial body forms a
physical macroclimate. It is on further assignment of the heat flux and the respiratory gases for the growth and development of its structure.

Summarising the above factors it can be concluded that the alternate increase and decrease in the level brings the seasonal fluctuations in physico-chemical factors and population and productivity. High water current in monsoon arrests the transparency with minimising the light penetration value, is a threatening the autotroph level, allowing very little production in autotroph level. pH, DO₂ of water are decreased pertaining a low chloride concentration and high nutrient, silica due to the heavy rain and high water flow. The hypoxic condition continues up to the winter when the water current becomes feeble, transparency goes up in the river allowing the better penetration of solar energy. This increases the productivity, life forms and pertains a good physico-chemical compartment as well as nutrient medium. The active uptake and recycling of gases and nutrients from the rich medium is a common practice of inhibiting life forms in water. Fall of temperature permits them to flourish and showing the peak period for the different planktonic groups. Algal bloom and algal mat by the filamentous algae are reported in this good physico-chemical regime. Vertical migration of zooplankton in the circadian cycle reports their grazing activity on the
autotroph increasing during the night hours with a continuous trend. On the other hand, the phytoplankton level shows the vertical upward movement during day hours due to their phototactic nature for production. High free CO$_2$ value in night hours may agree due to the absence of phytoplankton. Thus, it is a most favourable period for the riverine environment and continues upto early summer.

Summer is the stagnat period for the river suffering high by the large stress and under the thresh hold of mass biological activities. The sewage contamination is highly felt during this period as the water is highlighted by water and the extent of polluting agents. Temperature regime is highest and brings down the dissolved oxygen concentration in the medium. Simultaneously, the biotic compartment of the medium suffers due to alternation of the physico-chemical regime. Oxygen value is depleted and biological decomposition of fauna and flora starts which ultimately decrease the transparency and the macrophytic deposit on the surface layer in form of scum. The cyclomorphosis in case of Cladocera, Copepoda and Rotifers are reported with the variation of their morphology and may be due to escape from the highest polluting environment. Bathing, abusing, sewage contamination are the major factors for increasing the pollution stress to the water medium and bank sides is done by the animals and men. Fishing is increased and the medium is stirred continuously
Plate-3. Shows different use and abuse of the river water at Sambalpur by men and animals.

(i) Opening of the city drains into the river water.

(ii) Drinking water supply through water pipes to populated city of Sambalpur.

(iii) Abuse of the river water by men.

(iv) Abuse of the river water by animals.
due to its stagnation. Ultimately death and decomposition go up by the bacterial activities in water. This adds up on the human hygiene and manifests the physical and physiological ailments and thus creates the allergy, burning and itching pains to them. The intaking of water pertains a high rate of diarrhoea and dysentery etc. as drinking is not uncommon practice. Its high rate of pollution probably effecting variously reflecting on different aspects on human life due to their use and abuse in mass and media. Therefore, the rate of pollution is very prominent which may be eliminated by the sharp action of the Government authority by taking different steps by biological means of eradication of pollutants and the proper preservation of these valuable assets.