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Seasonal Variations of Physico-Chemical Parameters Of River Mahanadi At Cuttack

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Abstract

Physico-chemical parameters of river Mahanadi were studied at different sites around Cuttack city and their seasonal variations were observed. Physical parameters like transparency, colour, odour and taste varied seasonally following Chemical parameters like Dissolved Oxygen, pH, Alkalinity, Total Nitrogen, Inorganic Phosphate, Total Phosphate etc. also vary correspondingly, indicating a change in productivity of the river system.

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Keywords:- Dissolved Oxygen, Inorganic Phosphate, Alkalinity, Transparency. Cuttack.

Introduction :

The major sources that contribute pollutants to the waters are domestic sewage, agricultural runoff waters and industrial effluents. Which has lead to drastic deterioration in its quality within a short span. According to Pathak and Bhatt (1990) fresh water is becoming scarce resource day by day, concern about the water quality is no longer national issue. Almost all human activities have an impact on water resources. Hutchinson (1957) opined that sea is chemically most stable than fresh water as the later is smaller in size. In nature smaller the size of habitat the more abruptly it behaves. Studies on the hydrobiology of many rivers in India have been conducted by many researchers from time to time is (Krishnamurthi and Bharati, 1995;Hyderi and Bidgoli 2012;Umeshwari 2016),

In order to assess the impact of domestic sewage and effluents on the spawning of fishes and provide ecological data, the present investigation is an attempt to study physicochemical parameters of the river MAHANADI in relation to seasonal variations during the year 2020.

State Orissa and its Geography:

State Orissa of Indian subcontinent extends from 17^0 49' N to 22^0 34' N latitude and from 81^0 27' E to 87^0 29' E longitude on the eastern coast of India (Figure 1). It is bounded by state, West Bengal in the northeast, the Bay of

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Bengal in the east, the state Jharkhand in the north, Chhattisgarh in west and Andhra Pradesh in the south. Orissa is a beautiful land enriched with abundant natural resources, beautiful mountains, perennial rivers and waterfalls, rich marine wealth and valuable forest heritage, spreading over an area of 15,57,070 sq. Km.

Geography of Cuttack District:

Cuttack district is located between Dhenkanal on its northern side and Khurda on its southern side and is present between 18, 45^0 E- to $19{,}40^0$ W and $85{,}48^0$ N-$84{,}27^0$ S. The river Mahanadi bifurcates at 20.28^0 N to 85.52^0 E to river Mahanadi and Kathajodi.

Climatology of Cuttack District:

From the climatic condition it is marked that the area is geographically situated in subtropical and sub humid zone. The climate of the area is subtropical monsoon type characterized by oppressive hot summer, biting cold winter an high humid rainy season. The maximum air temperature up to 35. 1^0 C and was observed during May, 2021 while minimum temperature was noticed during December, 2020. This highest average rainfall 315 was recorded during June 2021, while during December 2020; the lowest 4 mm was recorded.

Higher percentage of humidity throughout the year and well distributed rainfall during monsoon, in fact modified the topography the local climate in the some extent.

Summer Season:

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The summer season continues from March to June. During this period maximum air temperature varies from 28^0 to 35.1^0C and the heat is oppressive. The average duration of bright sunshine is 7.85 h per day.

Rainy Season:

This is a hot and humid and wet season. It starts after first fortnight of June and continues up to October. The south-west monsoon sets in towards the end of June. The rainfall is intensified in the months of July and August during which the sky remains cloudy. For several days at a stretch the sky remains cloudy. The average duration of bright sunshine hours is at the minimum i.e. 3.84 h per day. The maximum air temperature varies from 26.5^0C to 30.2^0C. Due to high humidity, the weather remains stuffy and sweaty.

Winter Season:

The winter season is from November to February. In this season during both day and night the temperature begins to drops steadily. December and January become the coldest period of the year. The maximum temperature of this season varies from 19.5^0C to 27.9^0C. The sky remains clear and the duration of the bright sunshine hours is 8.35 h per day.

River Mahanadi:

The river Mahanadi is one of the largest river of India. It is about 860 kms in length, one of the World' largest earthen dam is built over it at Sambalpur. Mahanadi arises from Dhamtari district of Chhattisgarh and falls in the Bay of

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Bengal. The basin of river Mahanadi is shared by Maharashtra, Jharkhand, Orissa and Chhattisgarh. He area occupied by the basin in each state is Chhattisgarh 75,136 sq.km., Orissa 65,588 sq.km. Jharkhand 635 sq.km. Maharashtra 238 sq. Km(Fig.1)

Materials and Methods

Sampling:

In the present investigation, monthly water sampling for seasonal physicochemical analysis was done between 8 a.m.-10 a.m. in the middle of each month during 2020. In addition, the morphometrical and hydro meteorological information relating to the river MAHANADI were collected from the field survey.

Triplicate water samples were collected from each of M_1, M_2 and M_3 sampling stations from the surface layer (below 10 cm. To surface) of the river MAHANADI in plastic water sampler and sterilized BOD bottle (Boralkar, 1981; Voznaya, 1981) of 2 litre capacity (Plate). A number of physicochemical parameters including air, water, temperature, transparency, water depth, rate of water flow, colour, odour and taste of water, pH, dissolved oxygen, sulphate, phosphate and total alkalinity were performed in the field within one hour of sampling to minimize the errors or delaying.

For further chemical analysis, some samples were carried to the laboratory in black painted bottles after mixing with 2 ml. 1^{-1} of chloroform as preservative. The analysis of

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water was carried by standard methods (Kudesia, 1980; Adoni et al., 1985; Trivedy and Goel, 1986; NEERI, 1988; APHA – AWWA – WPCF, 1989). For the analysis of water, at the outset, some chemical reagents were prepared and water test kits were taken so that some primary investigations were done at the time of procurement of these samples from different locations.

Study Sites:

The present investigation is aimed to study the icthyofaunatic survey of the river Mahanadi in district Cuttack. And the study has been carried out in three study sites (i) Naraj (M_1); (ii) Sikharpur (M_2) and (iii) Aytepur (M_3), along a approximately 21 kms. Distance where the river is subjected to maximum human activities of the district. The dimension of its contamination at Cuttack city are the addition of untreated domestic sewages, industrial effluents from the industrial estate of Choudwar and Jagatpur, runoff water from agricultural lands and focal matters etc. The river water is used extensively for fishery purposes, irrigation and other public uses(Fig.2).

The present study was carried out at three fixed sampling stations (M_1), M_2 and M_3) for one year (January 2020 to December 2020).

Site M_1 (Naraj):

It is about 10 kms. Upstream of river Mahanadi from sampling station M2 (Sikharpur), this study site is 5 kms.

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Away from township and in the upstream direction the public interference is less. The river water always remain enriched with surface runoff from nearby locality, runoff agricultural water and very low rate of sewage contamination from nearby villagers this site is treated as the little contaminated zone of the river (Fig.3).

Site M_2 (Sikharpur):

This sampling station is located at the end of Cuttack city on the banks of river Mahanadi after the Mahanadi Barrage. At this point the maximum fishery activity is observed as the fishery product is in a high demand in the Cuttack city. At this site untreated domestic sewages of Cuttack city is discharged into the river waters in enormous quantities. The water is also enriched with waste from bathing, detergent use by the people for bathing for washing clothes sometimes cattle and buffalos contaminate the water by bathing in it. This site is treated as the contaminated zone as the waste waters of Cuttack city is added into the river.

Site M_3 (Aytepur):

This study site is 11 kms. Downstream from site M_2 . People living on its banks are highly dependent on the riverine fishery resources for earning their livelihood. Here the river water is contaminated with industrial effluents from the industrial estates apart from the domestic wastes of the human habitations on its banks. (Fig.4).

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Various standard methods adopted for analysis of various parameters were as follows:

Water Colour:

The colour was determined by visual comparison of sample with known concentration of coloured solution (by using platinum-cobalt-comparator) after Kudesia (1980).

Odour:

About 100 mi. Of the water sample was taken in a long-necked dark coloured conical flask and tightened with a stopper. Then, the flask was shaken for 5 minutes, opened and smelt (Kuesia, 1980; Voznaya, 1981).

PLATE:

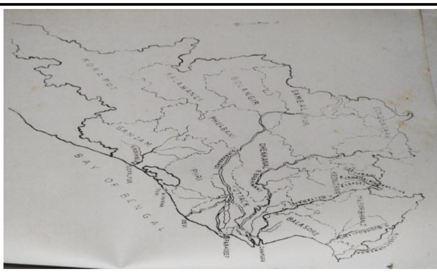	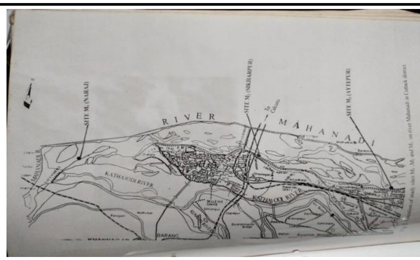
Fig.1 Flow of Mahanadi in Odisha	**Fig.2 Sampling Sites**

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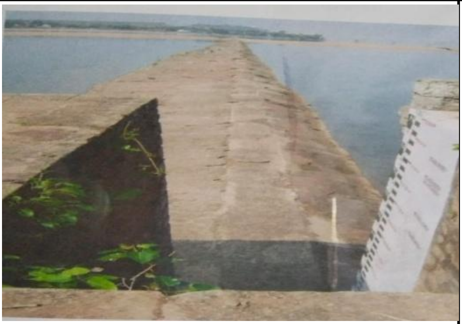

Fig.3 Site M1 at Mundali, Naraj

Fig.4 Site M3 at Aytepur

Taste:

200 ml. of water sample was taken in a beaker, boiled and cooled to room temperature, and then the taste was determined (Voznaya, 1981).

Transparency:

Transparency was inversely proportional to the turbidity of water, which in turn is directly proportional to the amount of suspended organic and inorganic matters. It was measured by Secchidisc method (Welch, 1962). The disc was lowered down in the water with the help of scaled string, until its colour contrast just disappears. The value was then noted in cm from the scaled string.

Air and Water Temperature:

Both air and water temperature were measured with the help of mercury centigrade thermometer graduated up 110^0 C in 0.1 graduation and measured to the nearest 0.5^0 C.

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The water temperature was recorded by dropping the thermometer vertically into the water.

Hydrogen Ion Concentration:

The pH of water was measured by pH universal indicator paper (MERK) on the spot and with a portable digital pH meter of ELICO make in the laboratory (Portable pH model L 1-120).

Dissolved Oxygen:

The dissolved oxygen was measured by Winkler's method.

Total Alkalinity (Carbonates and Bicarbonates):

The total alkalinity was obtained by titrating against sulphuric acid solution using phenolphthalein and methyl orange indicator.

Total Nitrogen:

200 ml. of water sample was taken and digested in a 300 ml. of Kjeldahl flask with 35 ml. of concentrated sulphuric acid (H_2SO_4) and 20 gm. of sodium sulphate (Na_2SO_4) plus catalyst mixture. After proper dilution with 100 ml. of distilled water the completely digested material was transferred to a 800 ml. distillation flask and 100 ml. of 40% sodium hydroxide (NaOH) solution was poured with the help of a separating funnel connected to it without closing the stopcock. 150 ml. of distillate was collected in 500 flask containing 20 ml. of 4% Boric Acid with mixed indicator. Finally, collected blue coloured distillate of 150 ml. was then titrated with N/14

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sulphuric acid till the original red colouration of solution appeared. For comparison, blank titration was carried out with all reagents and with 200 ml. distilled water instead of sample water (Kjeldahl Method, Mishra, 1968).

Calculation :

Amount of total Nitrogen mg. $1^{-1} = T.B \times \frac{1000}{200}$

Where T = ml. of N/14 standard H_2SO_4 used for sample titration,

and

B = ml. of N/14 standard H_2SO_4 used for sample titration.

Inorganic Phosphate:

50 ml. of water sample was taken in a 100 ml. capacity of Nessler's tube and added 2 ml. of acid ammonium molybdate reagent. Mixed thoroughly by gentle stirring and added 2 drops of stannous chloride ($SnCl_2$) solution to it. At the end a blue colouration developed.

50 ml. of pure phosphate free double distilled water was taken in another 100 ml. capacity Nessler's tube and added 2 ml. of acid Ammonium molybdate and two drops of Stannous chloride ($SnCl_2$) shacked gently, waited for three minutes. Then added standard phosphate solution drop wise till blue colouration develops in it. This tube was matched with

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the sample tube. Volume of standard phosphate solution (in ml.) used was noted (Mishra, 1968; Trivedy and Goel, 1986).

Calculation:

Phosphate mg 1^{-1}= ml. of standard phosphate solution x 0.01 x 20

(Here 20 is multiplied for 100 ml. of sample instead of 50 ml.)

Sulphate:

200 ml. of sample was taken in 400 ml. capacity beaker and 20 ml. of Benzidine hydrochloride was added and stirred vigorously. Then the precipitation was allowed to settle. The solution was filtered and the precipitation was transferred to a beaker with distilled water (200 ml.). It was heated to dissolve the precipitation and 3 drops of phenolphthalein was added. It was titrated with 0.05 N NaOH until the first permanent pink colour was obtained (Kudesia, 1980).

Calculation:

Sulphate mg1^{-1} = ml. of .05N NaOH x 9.6

Result:

The physicochemical characteristics of water samples at three different stations in two consecutive years have been presented in table.

1.A, 1.B and 1.C.

Weather Condition:

The weather condition was reported to the bright during winter (November to February). The sky was clear or

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lightly clouded during the winter, bright and sunny at times, moderately clouded during the summer (March to June) and heavily clouded or cloudy and rainy during the monsoon season (July to October) with seasonal variations in the atmosphere temperature. The speeds of wind were less in the post monsoon and the cold season.

Transparency:

It is an important factor which affects the population and distribution of freshwater plankton. The secchi disk transparency ranged between 79 cm to 04 cm. Transparency in the river MAHANADI was low during monsoon due to heavy rainfall runoff water and flood while it increased in early summer and winter. From the data it is observed that the water clarity was low during monsoon months as compared to pre and post monsoon period.

Hydrogen Ion Concentration (pH):

The values of pH fluctuated between 6.2 and 7.9 throughout the study period. The fluctuation of pH in upstream (M_1) water was from 6.3 to 8.2, in (M_2) water from 6.4 to 8.1and in downstream (M_3) water from 6.2 to 7.8.

In upstream water (M_1) the maximum pH was observed in January2020 and minimum was observed in July 2020. In site (M_2) the maximum pH was observed in October 2020 and the minimum was observed in July and August 2020. In downstream water (M_3) the maximum pH was

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recorded in February 2020 and the minimum was noted in July 2020.

Dissolved Oxygen (DO):

Dissolved oxygen concentration varied from 4.9 mg 1^{-1} to 8.0mg 1^{-1}. It ranged from 6.0 to 8.2 in M_1, 5 to 8 in M_2 and 5.0 to 7.6 in M_3 4.9 to 7.4 were noted . The highest value 8.0 mg 1^{-1} was obtained in the month of December 2020 from M_2 and lowest 4.9 mg 1^{-1} in the month of May 2006, from M_3. However, the river water maintained fairly congenial levels of dissolved oxygen throughout the study periods. The dissolved oxygen content was well above critical limit of 3.0 mg 1^{-1} set for aquatic life.

Total Alkalinity:

Phenolphthalein alkalinity was not found during the study period at all the three stations, whereas bicarbonate alkalinity was the dominant anion and ranged between 30.00 mg 1^{-1} and 109.00 mg 1^{-1}. High values of total alkalinity were reported during early winter and early summer. The value was comparatively low during the rainy season. However, the variation in total alkalinity was marked significant in seasonal regime. In both the years, bicarbonate alkalinity attained the maximum in the month of April at M_3.

Inorganic Phosphate:

The inorganic phosphate concentration of water was low and its concentration fluctuated between 0.01 mg 1^{-1} to 0.079 mg 1^{-1}. In M1, the phosphate value varied from 0.01 mg

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1^{-1} to 0.054 mg 1^{-1}, 0.20 mg 1^{-1} to 0.072 mg 1^{-1} in M_2 and 0.017 mg 1^{-1} to 0.079 mg 1^{-1}The highest concentration in the medium correlated with high rainfall and high water flow.

Sulphate:

Sulphate, a common anion plays an important role in the fresh water syste4m where certain organic chelate or complex metal ions present ionic reaction with other substance. The sulphate concentration of the river varies from 4.8 mg 1^{-1} to 11.9 mg 1^{-1}. The value remained high during monsoon period and low during winter. Moderate values were observed during summer. The values declined from September to March.

Total Nitrogen

The total nitrogen concentration varies between 0.124 mg 1^{-1} to 0.587 mg 1^{-1} . The concentration of phosphate in water got a rising trend from late winter to late monsoon, during the winter and early summer the phosphate content in water was less i.e. < 50% of the monsoon value.

Phosphate content at study stations in the 2020 varied between 0.124 mg 1^{-1} to 0.514 mg 1^{-1} in study station M_1, similarly the values varied from 0.136 mg 1^{-1} to 558 mg 1^{-1} in study station M_2 and the values varied from 0.158 mg 1^{-1} to 0.587 mg 1^{-1} in study station M_3.

Results And Discussion

Data collected at three different sites are shown in tables. Site M1 at Munduli Naraj shows that the physical

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parameters are shown in table 1, transparency, pH and DO are shown in table 1A (Fig. 5), and other chemical parameters in table 1B. Similarly data from site M2 at Sikharpur are shown in tables 2, 2A and 2B (Fig.6) and Site M3 at Attapur are in tables 3, 3A and 3B.

Water Quality:

The change in quality of water in different months of a year is due to the colloidal components of iron, humus, suspended matter and the colour of the water. It is further due the intense growth of planktons in the water medium (Jhingran, 1971; Voznaya, 1981).

Winter Season

During the winter period the water becomes transparent and clear as there is no rainfall which leads to the settling down of residual matters, mineral and nutrients and are used up for organic production. During the winter, highest biological production is observed as there is presence of bright day light and comparatively low air and water temperature.

Summer Season:

During the early summer period the water colour becomes green and in the late summer it becomes opaque and dirty. The green colour appears due to the plankton blooming and the opaquicaty during the late period is due to the bacterial decomposition and formation of a thick scum layer on the water surface. During summer, the weather

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remain bright and sunny accompanied with high air and water temperatures which result in rapid evaporation from the surface and high decomposition of organic matter. The water temperature shows a good correlation (r= 0.9481 with atmospheric temperature. The high water temperature slows down the diffusion of atmospheric oxygen into water which results in lower DO levels during the summer period.

Rainy Season:

During the rainy season the water colour changes to brown as a results of addition of large amounts of sub soils, sand, clay, rock, mineral and other inorganic material which comes along the runoff water from the landmass during heavy rains. During this period weather remains cloudy due to the effect of monsoon; the cloudy weather retards the rate of photosynthesis and lowers the amount of dissolved oxygen in water.

Transparency:

Transparency is defined as the measure of clarity of the water which affects the penetration of light. Transparency has a direct impact on the penetration of the amount of heights that enters in the water. It directly proportional to the suspended organic and inorganic matters which as silt, soil particles, plant fragments or phytoplankton and other microscopic organisms (Micheal, 1984; Adoni et al., 1985; Pandey and jha, 1992; Swarup et al., 1992). Reduction in

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transparency reduces the amount of light that penetrated into the medium which has a direct effect on the rate of photosynthesis in the deeper layers and ultimately it influences the primary productivity of aquatic ecosystem. In this way, transparency indirectly controls the biological setup of the water (Swarup et al., 1992). According to Nemerow (1991) transparency has a direct effect on the fishes but the major impact is an indirect on it either reduces the amount of fish food or harms fish spawning grounds. Blaber (1997) had different views and he stated that turbidity has a positive effect as it protects the juveniles and small fishes from the mouths of predators and Piscivorous birds. The fishes are divided into three types according to their tolerance to turbidity. First category is the tolerant ones second category those who are indifferent and third category is of the intolerant ones (Blaber and Blaber, 1980). Seechhi disc visibility of 40 to 60 cm has been considered as optimum visibility in context of fresh water prawn farming (Adhikari, 2000).

High transparency value observed in the presence study during the winter can be explained due low water current, stagnation of the medium and low concentration of total residue in water (Clarke, 1938; Kant and Anand, 1979). Further the water transparency also remains high during the winter and early summer because of low total solids. High transparency during the winter as the residual matter settle down. Minerals and nutrients both organic and inorganic are

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utilized by the phytoplanktonic community for organic body productions. Due to the lessening of water flow there is a decrease turbidity which has a positive effect on the penetration of light into the medium.

During monsoon period low values of transparency are observed due to heavy rains, high turbid waters and turbulent flow of the river (Saxena and Chauhan, 1993). During monsoon the water clarity gets reduce due to influx of silt and suspended organic matter into the medium (Sharma and Gupta, 1994).

Higher transparency values were observed during the winter and early summer due to no rains run off and flood waters accompanied with high settling down of suspended particle.

Hydrogen Ion Concentration (pH):

pH: The pH van be simply defined as the Hydrogen ion concentration and it is a measure of the amount of acidic and basic nature of the medium, the pH of water depends on the presence of relative quantities of calcium, carbonates, bicarbonates and carbon dioxide in water (Prasad and Singh, 1980). It is expressed as the negative logarithm of the $[H^+]$, where $[H^+]$ is considered as the amount of hydrogen ions in moles per litre of the solution.

Jhingran (1971), viewed water as an important environmental factor linked with different hydro biological processes, its slight alteration brings significant changes in

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the medium. Increased pH values are observed during the day due to increase in photosynthetic activity (consumption of CO_2), while decreases at night because of the respiratory activity (release of CO_2). Swarup et al. (1992) opined that exposure to external factors such as air, temperature and disposal of industrial wastes also results in change of the pH. pH indicates the amount of pollution in the water as it is a measure of acid and base present in the system. If there is variation in the optimum pH values within a few hours, along with the slight increase in temperature or lowering of the dissolved oxygen (DO) can prove to be fatal to various warm water fishes (Ellis, 1948). Low pH causes female fish to defer laying of their eggs and if eggs are laid, the fish are very sensitive in the egg, larval and fish fry stages (Nemerow, 1991), Swingle (1967) opines that pH values ranging between 6.5 amd 9.0 are suitable for fish culture.

In the present study lowest value of pH was recorded shortly after long spells of heavy monsoon showers which resulted in influx of free CO2. The surface pH was observed below 7 from July to September accompanied with irregular fluctuations. The pH values gradually showed an increasing trend from late October to early summers i.e. (February and March) then the values decreased in the summer at higher temperature as well as in the monsoon period after heavy showers and influx of floods water. The increase and decrease of pH values during dry and wet seasons have also

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been reported from a number of lakes in Australia (Farrell et. Al., 1979). The high pH values which was observed during early summer and winter in the present work is possibly due to the phenomenon of photosynthesis (Mahajan and Kanhere, 1995).

Dissolved Oxygen (DO):

It is an indicator of the amount of oxygen dissolved within the water. It is also a result of all the physical and biological processes taking place inside water.

Dissolved oxygen is regarded as a significant indicator of the water quality, because when it is not present in sufficient amount existence of life is threatened. The amount of DO in water is controlled by two prime phenomenon's first one is diffusion and photosynthesis. Diffusion is regulated by physical factors while photosynthesis is controlled by presence of autotrophic factors while photosynthesis is controlled by presence of autotrophic light condition and CO2 (Odum, 1971; Nasar and Datta Munshi, 1974;). According to Jhingran (1991) DO always tends to maintain a value towards the saturation point. Polluted waters usually have lower concentration of DO; on the contrary unpolluted waters normally have high amounts of DO (Munawar, 1970; Hegde, 1985).

Lower DO values are recorded in rainy season due to increase in growth of bacteria that utilize oxygen for their

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metabolic activities. (Ahmad and Krishnamurthy, 1990; Pandey et al., 1992).

Low DO values were observed in the present work during rainy and still lower values were observed during late summer. Higher values were observed during winter and early summer Rai and Dutta Munshi (1979) have also reported similar observations of DO concentration lesser than 7 mg 1^{-1} in aquatic medium which is found along with luxuriant macrophytic community, but the lower values during the late summer and monsoon period in river Mahanadi is not caused due to the above cited factors as macrophytic growth is only restricted during early summer and late winter. In comparison with study station one (M_1) the other two stations M_2 and M_3 are loaded with considerable amount of biogenic and chemical wastes by sewage contamination and more biological activities and thus probably created the condition for lower DO value (Boralkar, 1981) throughout the year. Thus the upstream M1 oxygen content was noted to be higher 6 to 8 mg 1^{-1} than the (M_2) 5 to 8 mg 1^{-1} and M_3 5 to 7.0 mg 1^{-1}.

So it can be concluded that pollution depleted the level of dissolve oxygen from water (Chandrasekhar et al., 1991) low values of DO are observed in late summer and rainy season and higher value in winter early summer according to Mishra et al. (1975, 1976) and Mathew (1985) higher values of DO during winter is due to the lesser water temperature which facilitates the oxygen dissolving capacity

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of the water. The low values of DO during rainy season might be due to high growth of bacteria which utilize oxygen for their metabolic activities (Pandey et al. 1992).

Total Alkalinity (TA):

Alkalinity can be simply defined as the acid neutralizing capacity of the water. According to (APHA, 1992), it is the sum total of the titratable bases present in the water. The alkalinity is the description of the degree to which the water accepts protons and is defined as the sum of the concentrations of bicarbonate, carbonate, borate and hydroxyl ions minus the concentrations of the hydrogen ion (Day et at., 1989). The basic nature which is exhibited by the oceanic and estuarine waters is due to the presence of HCO_3, CO_3^{2-} and BO_3^{2-} ions in combination with cations like Na^+, K^+, Ca^{++}, Mg^{++}, NH_4^+ and Fe^{++}.

The OH- and H+ can be ignored at a range of 5.5 to 8.5. The definition of 'carbonate alkalinity' is the summed concentrations of the remaining ions (Day et al., 1989).

Within the pH value range of 4.5 to 8.3, free CO2 and bicarbonates may be present but practically no carbonate is existent, whereas within 8.4 – 10.5 pH values, a mixture of bicarbonate and carbonate alkalinity is encountered and in still higher pH values bicarbonate are reduced (Jhingran, 1971). The alkaline waters in general are highly productive in nature as suggested by Michael (1984). Also he suggests that

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alkaline waters are generally known to show high biological productivity.

Increased values of TA values are observed in the summer months and lower values during the wet season are supported by similar observations of Sreenivasan (1965). David et al. (1969) recorded maximum alkalinity in March and minimum in September, whereas Sreenivasan (1976) and Goldman and Wetzel (1963) observed maximum alkalinity during summer that declined subsequently in the monsoon. The alkalinity value in highly productive waters ought to be over 100 ppm. Since water with a TA below 120 ppm cannot be considered as 'alkalitrophic' (Gupta and Sharma, 1994), River Mahanadi water can be termed as 'non-alkalitrophic'.

Nitrate-Nitrogen (NO_3-N):

Nitrogenous compounds are found both inorganic forms (nitrates, nitrites and ammonia) and organic forms amino acids, proteins, nucleic acids, urea etc.) in aquatic systems. Nitrogen is a constitute (79%) of air, but only few prokaryotic organisms possess the capability to utilize the atmospheric nitrogen and convert it into organic form and make it available for other organisms by the process of nitrogen fixation (Rice, 1938; Algeus, 1951, Howard et al., 19700. Plants use nitrogen in the form of nitrates, nitrites and ammonia which is derived from organic decomposition and it is found in minute quantities.

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Due to non-availability of these compounds, plant growth is limited and thus it indirectly affects the animal populations in aquatic habitats (Wurtsbaugh et al., 1985).

Deforestation and land clearance have increased the nitrogen flux in stream flow (Begon et al., 1990), that is consequently transported into the other sources which add nitrogen into the waters are wastewater, nitrogenous fertilizers (Brawley et al., 2000). Overabundance of Nitrogen and Phosphorous causes algal blooms to grow which depletes oxygen in aquatic medium. Under these conditions the aquatic organisms such as fish and other animals may simply be choked to death (Diwan and Arora, 1996; McGinn, 1998).

T In the present study, the total nitrogen content is found to be low because of high uptake by phytoplankton and mesophytes Pandey et al. (1992) have also reported similar results.

Phosphate (PO_4-P):

Phosphorous is present in the form of phosphate in biological systems and serves as major nutrient component of animals and plants. It is the important component of nucleic acid, phospholipids and numerous other phosphorylated compound. The phosphorous present in the natural waters comes from leaching of rock in the catchment areas. The phosphorous in its inorganic phosphate form is utilized by the plants for the nutrition and convert it into organic phosphate which enters into the consumers through the food chain.

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Phosphorous deficiency often causes poor productivity of waters (jhingran, 1991). But Ganapati (1960) viewed that phosphates are always present in adequate quantities in tropical waters and does not function as a limiting factor. However the presence of excess amount of phosphate in the medium results in eutrophication, which has far reaching repercussion. Ramade (1981) suggested that human activities are major source of phosphates in the river. Jhingran (1991) viewed that presence of phosphate in excess amount in open waters is a sign of heavy organic pollution, amount as low as point 0.01 mg 1^{-1} can cause serious eutrophication. The phosphate concentration of river Mahanadi remained high during summer probably du stagnation of water.

Use of detergents is also caused for the increase in phosphate concentration (0.081 mg 1^{-1}) during summer and rainy season. This is probably due to decomposition. Lower values which are found during the winter months (0.010 mg 1^{-1}) are due to its utilization for growth and abundance by phytoplankton.

Sulphate:

Sulphate is an ecologically important element and it is needed by the plants for the growth and is shortage in the environment may lead to reduce development of the planktons (Odum, 1971). Sulphate available in the riverine ecosystem is reduced by the autotrophs and is integrated in them. Elemental sulphate is an important constituent of

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certain amino acids in the cells. Sulphate is present in adequate amount in the soil and sediments while the amount of sulphate present in the atmosphere is dismal. But sulphate is not a limiting factor for the growth or distribution of plants and animals.

Very high concentrations of sulphate has been recorded by many workers Govindan and Sundarsan (1979) have observed sulphate concentration ranging from 30.00 to 127.00 mg 1^{-1} from Adyar River. Similarly Dakshini and Soni (1979) recorded sulphate concentration ranging from 13 to 55.37 mg 1^{-1} and 23.92 mg 1^{-1} from Nazagarh and Rajghat of Delhi.

Increased sulphate concentration observed during monsoon may be due to the surface runoff which brings in more suspended solids along with organic and soluble salts (Sinha, 1986). The reasons that contribute sulphates concentration in the reverence ecosystem are erosion, leaching, rain, adsorption and so on and biological process.
Sulphate has an important role in the growth of phytoplankton. The lower value of sulphate observed during might be a result of a higher intake of sulphate by phytoplankton population (Sinha, 1986)

Table.1: Seasonal Variations in Physical Parameters of River Mahanadi at Mundali, Naraj (Site-M_1) in 2020.

Months	Weather Condition	Water Colour	Odour	Taste

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January	Bright	Clear	Faint	Sweet
February	Bright	Clear	Faint	Sweet
March	Bright & Sunny	Clear	Faint	Sweet
April	Bright & Sunny	Dirty	Fishy	Fishy
May	Bright & Sunny	Dirty	Fishy	Fishy
June	Cloudy & Rainy	Muddy	Earthy	Earthy
July	Cloudy & Rainy	Muddy	Earthy	Earthy
August	Cloudy & Rainy	Muddy	Earthy	Earthy
September	Cloudy & Rainy	Muddy	Earthy	Earthy
October	Cloudy	Opaque	Earthy	Earthy
November	Bright	Light Green	Faint	Sweet
December	Bright	Green	Faint	Sweet

Table 1.A.: Seasonal variations of Transparency, pH and DO at Site M1.

Month	Transparency (cm)	pH	DO (mg 1^{-1})
January	72	8.2	7.8
February	75	8.1	7.6
March	63	8.0	6.5
April	60	7.7	6.2
May	20	7.3	5.6
June	04	6.9	5.8
July	04	6.3	6.1
August	04	6.8	6.0
September	08	6.9	6.8

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October	19	7.8	7.4
November	58	8.0	7.8
December	59	8.1	8.0
Mean	37.16	7.50	6.8
± SD	29.41	0.64	0.87

Table 1 B.: Seasonal Variations of Alkalinity, Total Nitrogen, IP and Tp at Site M1 in 2020

Months	Total Alkalinity (mg 1^{-1})	Total Nitrogen (mg 1^{-1})	Inorganic Phosphate (mg 1^{-1})	Phosphate (mg 1^{-1})
January	65.0	0.295	0.010	4.8
February	76.0	0.221	0.012	5.1
March	88.0	0.205	0.018	6.8
April	94.0	0.238	0.022	6.9
May	52.o	0.316	0.028	7.2
June	40.0	0.384	0.039	8.3
July	37.0	0.541	0.061	9.8
August	30.0	0.538	0.054	8.3
September	38.0	0.540	0.046	7.8
October	50.0	0.290	0.020	6.3
November	68.0	0.174	0.015	6.1
December	77.0	0.124	0.012	6.3
Mean	59.58	0.32	0.028	6.97
± SD	21.42	0.14	0.017	1.42

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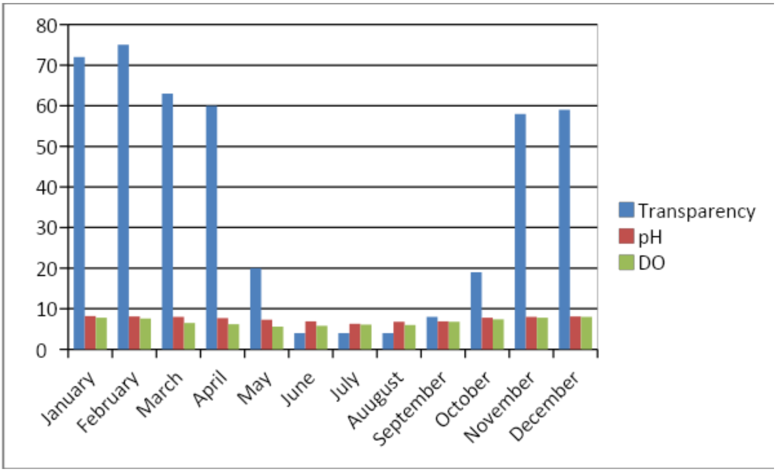

Fig.5 Month wise variations of transparency, pH and Dissolved Oxygen (DO) at M1.

Table2. Seasonal Variations in Physicochemical Parameters of River Mahanadi at Sikharpur (Site- M_2) During 2020.

Months	Weather Condition	Water Colour	Odour	Taste
January	Bright	Clear	Faint	Sweet
February	Bright	Clear	Faint	Sweet
March	Bright & Sunny	Clear	Faint	Sweet
April	Bright & Sunny	Dirty	Fishy	Fishy
May	Bright & Sunny	Dirty	Fishy	Fishy
June	Cloudy & Rainy	Muddy	Earthy	Earthy
July	Cloudy & Rainy	Muddy	Earthy	Earthy

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August	Cloudy & Rainy	Muddy	Earthy	Earthy
September	Cloudy & Rainy	Muddy	Earthy	Earthy
October	Cloudy	Opaque	Earthy	Earthy
November	Bright	Light Green	Faint	Sweet
December	Bright	Green	Faint	Sweet

Table 2 A.: Seasonal variations of Transparency, pH and DO at Site M2.

Months	Transparency (cm)	pH	Dissolved Oxygen (mg 1^{-1})
January	68	8.0	7.6
February	73	7.9	7.4
March	61	7.9	6.1
April	59	7.6	5.9
May	19	7.1	5.0
June	04	6.4	5.7
July	04	6.4	5.9
August	04	6.9	5.7
September	06	7.7	6.6
October	23	8.1	7.4
November	56	7.9	7.6

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December	54	7.47	7.8
Mean	35.91	0.61	6.55
± SD	28.12	1.42	0.95

Table 2 B Seasonal Variations of Alkalinity, Total Nitrogen, IP and Tp at Site M2 in 2020.

Month	Total Alkalinity (mg 1^{-1})	Total Nitrogen (mg 1^{-1})	Inorganic Phosphate (mg 1^{-1})	Total Phosphate (mg 1^{-1})
January	60.0	0.315	0.021	5.1
February	82.0	0.227	0.020	5.9
March	80.0	0.236	0.028	6.3
April	91.0	0.256	0.030	7.2
May	57.0	0.336	0.039	6.8
June	38.0	0.397	0.052	8.9
July	32.0	0.545	0.072	10.8
August	33.0	0.546	0.068	9.7
September	41.0	0.558	0.056	8.0
October	59.0	0.318	0.028	7.1
November	71.0	0.184	0.023	6.8
December	83.0	0.136	0.021	6.0
Mean	60.58	0.35	0.38	7.38

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± SD	21.07	0.15	0.018	1.67

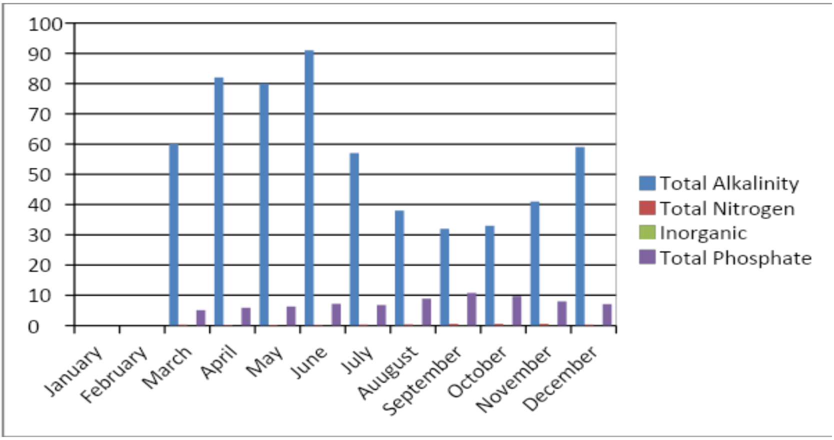

Fig.6: Seasonal variations of TA,TN, IP and TP in 2020 at site M2.

Table 3. : Seasonal Variations in Physicochemical Parameters of River Mahanadi at Ayetpur (Site- M_3) during 2020.

Months	Weather Condition	Water Colour	Odour	Taste
January	Bright	Clear	Faint	Sweet
February	Bright	Clear	Faint	Sweet
March	Bright & Sunny	Clear	Faint	Sweet
April	Bright & Sunny	Dirty	Fishy	Fishy
May	Bright & Sunny	Dirty	Fishy	Fishy

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June	Cloudy & Rainy	Muddy	Earthy	Earthy
July	Cloudy & Rainy	Muddy	Earthy	Earthy
August	Cloudy & Rainy	Muddy	Earthy	Earthy
September	Cloudy & Rainy	Muddy	Earthy	Earthy
October	Cloudy	Opaque	Earthy	Earthy
November	Bright	Light Green	Faint	Sweet
December	Bright	Green	Faint	Sweet

Table 3 A.: Seasonal variations of Transparency, pH and DO at Site M2 in 2020

Months	Transparency (cm)	pH	DissolvedOxygen (mg 1^{-1})
January	65	7.8	7.4
February	70	7.9	7.3
March	59	7.6	6.1
April	57	7.5	5.9
May	17	7.4	4.9
June	04	7.0	5.4
July	04	6.2	5.3
August	04	6.7	5.1
September	06	6.6	6.3
October	22	7.4	7.0
November	56	7.6	7.2
December	57	7.7	7.1

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Mean	35.08	7.28	6.21
± SD	27.51	0.53	0.94

Table 3 B.: Seasonal Variations of Alkalinity, Total Nitrogen, IP and Tp at Site M3 in2020.

Year & Month	Total Alkalinity (mg 1^{-1})	Total Nitrogen (mg 1^{-1})	Inorganic Phosphate (mg 1^{-1})	Phosphate (mg 1^{-1})
January	71.0	0.325	0.029	5.5
February	87.0	0.237	0.017	6.4
March	89.0	0.246	0.026	7.0
April	109.0	0.276	0.037	7.9
May	64.0	0.366	0.049	7.3
June	51.0	0.418	0.059	9.5
July	37.0	0.561	0.079	11.9
August	38.0	0.587	0.073	10.4
September	46.0	0.598	0.061	9.6
October	67.0	0.341	0.036	8.4
November	82.0	0.196	0.025	7.9
December	95.0	0.158	0.018	7.4
Mean	69.66	0.34	0.042	8.26
± SD	23.42	0.17	0.021	1.80

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