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# Surface Water Quality Analysis Along Mahanadi River,Odisha: [A Case Study]

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***Abstract:*** *In the present research program the status of pollution of water of a major river namely Mahanadi of Odisha (downstream of Hirakud dam) has been analyzed. The study was conducted to assess and ascertain thephysico-chemical properties of Mahanadi river water from sixteen different water quality monitoring stations of State Pollution Control Board. The analysis was carried out by taking certain important water quality determining parameters like pH, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Chloride, Total Dissolved Oxygen (TDS), Nitrate, Sulphates, Total Hardness (TH), Electrical Conductivity (EC) and Fluoride. Analyzed parameters like pH, DO, TH, Chloride, Sulphate and TDS were found within permissible limit prescribed by IS 10500 except Nitrate and Fluoride content which exceeds at some sites.*

*It is realized from the study thatthe main pollutant of water in Mahanadi is the sewerage systems influenced by urban and industrial growths in Sambalpur,Bbsr (D/s) and Cuttack town.The study puts an alarm for utilizing Mahanadi water in Cuttack D/s, Paradeep, Bbsr D/s and Choudwar at these zones for intense agricultural activities and industrial purposes. Also it focuses in order to provide better survival of flora and fauna of the system the pollution should be checked at the source i.e. at Cuttack d/s and Chowdwar.*

***Keywords:*** *Mahanadi River, Physico-chemical parameters, Industrial/urban sewage, Industrial.*

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## I. Introduction

Water, a prime natural resource, is a basic need for sustenance of human civilization. Sustainable management of water resources is an essential requirement for the growth of the state's economy and wellbeing of the population. As per National water policy, 2002, water resources development and management will have to be planned for a hydrological unit such as drainage basin as a whole or for a sub-basin for sustainable use incorporating quantity and quality aspects as well as environmental considerations.

The water environment quality is a very important and is a subject of major concern for economic development of any country. The water resource problems related to degradation have increasingly been serious because of rapid industrialization and urban sprawl. Anthropogenic influences such as urbanization, industrial and agricultural activities, increasing consumption of water recourses along with natural process i.e. change in precipitation inputs, erosion, effectively deteriorate surface water quality and impair their uses for drinking, industrial, agriculture, recreating and other purposes.

The Mahanadi watershed is the most developed and urbanized region in the state of Odisha. The increasing deterioration of water quality of the watershed is mainly attributed to the uncontrolled and improper disposal of solid and toxic waste from industrial effluents, agricultural runoff and other human activities. This alarming water pollution not only causing degradation of water quality but also threatens human health and balance of aquatic ecosystem, and economic development of the state.

In the present study, data matrix obtained during 14 years monitoring program (2000 to 2014) is subjected to different multivariate statistical approach to extract information about the similarities or dissimilarities between sampling sites, and the influences of possible sources on water quality parameters of the Mahanadi watershed.

The ***specific objectives of the research*** are to

- Classify the watershed into several zones with different water quality.
- Extract and establish the parameters that are most important in assessing variation in water quality of different zones,
- Find out a good approach to assess the water quality of each cluster reasonably that can be helpful to the managers to take the effective measures to manage the water resource respectively.

## II. Review of Literature

Water is one of the vital needs of all living beings. Humans need water in many daily activities like drinking, washing, bathing, cooking etc. If the quality of water is not good then it becomes unfit for drinking and other activities. The quality of water usually described according to its physical, chemical and biological characteristics. Hence it becomes necessary to find the suitability of water for drinking, irrigation and Industry purpose.

**Dugan [1972]** suggested that all biological reactions occur in water and it is the integrated system of biological metabolic reactions in an aqueous solution that is essential for the maintenance of life. **Pani [1986]** in his study realized that due to increasing industrialization on one hand and exploding population on the other, the demands of water supply have been increasing tremendously. Moreover considerable part of this limited quality of water is polluted by sewage, industrial waste and a wide range of synthetic chemicals. Heavy metal are considered as major environmental pollutants and regarded to be Cytotoxic, Mutagenic, and Carcinogenic. The Heavy Metal pollution of natural environment has been consistently increasing through effluents, sedimentation of rocks and mining activities **(Manjit [1988])**. **Priti Singh et.al [2005]** assess and map the spatial distribution of surface water quality of the Mahanadi, Odisha by using GIS.APHA's standard laboratory procedure has been adopted to assess the quality of ground water. The spatial distribution map of pH, Chlorides, Magnesium and sulphate shows that, these parameters are within range as per standard. **Samantray et al.** were studied the water quality of Mahanadi and its distributaries rivers, streams, Atharabanki river and Taldanda Canal adjoining Paradeep in three different seasons namely summer, pre-monsoon and winter..Their findings highlighted the deterioration of water quality in the rivers due to industrialization and human activities **(Samantray et al., 2006).Kamal [2007]** carried out on physicochemical parameter of river water affects the biological characteristics and indicates the status of water quality. Different types of Physicochemical parameters of water are pH, DO, BOD, COD, Chloride, TDS, Nitrate, Sulphates, TH, EC and Fluoride. These parameters are solely responsible for water quality. **Adetunde et.al [2007]** have studied the area and investigated physicochemical and bacteriological qualities of surface water in the north areas and south local government areas of State, Odisha. Water samples were collected from different areas of North and South local areas. **Swarna Latha [2008].** The desirable limit of TDS is 500 mg/l. If TDS value is more than 500 mg/l, it may cause gastro intestinal irritation. High TDS presence in the water decreases the quality and affects the taste of water as found from **Guru Prasad, 2005. Sayyed et.al [2009]** assessed the surface water from the south-eastern part of Odisha city for the seasonal variation in their quality parameters. Using Piper diagram the hydrogeochemical facies were identified and the surface waters were classified with regards to the changes in their major chemical compositions. **Shimaa M. Ghoraba et.al [2008]** collected many ground water samples from different districts of Mahanadi,Odisha. The groundwater recorded a wide range in TDS. Chloride is one of the most important parameter in assessing the water quality and higher concentration of chloride indicates higher degree of organic pollution **(Yogendra andPuttaiah, 2008).Khare et.al [2010]** carried out on water quality assessment of Mahanadi, Sambalpur. He was done water analysis for the parameters like pH, DO, BOD, COD, TDS, calcium, Magnesium and Hardness for lake water. **Venkatesharaju *et al.*, [2010]** signifieswater recourses have critical importance to both natural and human development. It is essential for agriculture, industry and human existence. Water is one of the most abundant compounds of the ecosystem. **Mona A. Hagras et.al [2011]** assessed the quality of groundwater and to characterize the hydrochemical characteristics of the surface water in Odisha, surface water samples were collected from different cities of Odisha analyzed for 15 water quality parameters. **Lohani et.al [2011]** depicts drinking water quality management through various physicochemical parameters and health hazard problems with their remedial measures in Bhubaneswar city of Odisha. **Sahu [2015]** describes the effect of poor water quality on human health was noted for the first time in 1854 by John Snow, when he traced the outbreak of cholera epidemic in London to the Thames river water which was grossly polluted with raw sewage. **Rout [2016]** carried out an analysis was carried out by taking certain important parameters like pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), Chloride, total dissolved oxygen (TDS), Nitrate, sulphates, total hardness (TH), electrical conductivity (EC) and Fluoride. **Vega et al., [2016]**signifies the application of different multivariate statistical techniques, such as cluster analysis (CA), principal component analysis (PCA) helps in the interpretation of complex data matrices to better understand the water quality and ecological status of the studied systems.

## III. Study Area And Data Collection

**STUDY SITE:**

The river Mahanadi is one of the major inter-state east flowing rivers in peninsular India. Itoriginates at an elevation of about 442 m. above Mean Sea Level near Pharsiya village in the Amarkantak hills of Bastar Plateau lying extreme south of Raipur district of Chattisgarh. The basin extends over an area approximately 141,600 $km^2$, out of which 65,628 $km^2$ lies in Odisha, occupying 42.15% of the state geographical area.

In the recent past a lots of work has been carried out on the role of different urban and industrial effluents upon the water quality of the Mahanadi river system, as well as other water bodies in India. The present study deals with the loading of 19 different physicochemical parameters in Mahanadi waters covering a short range, a station located further downstream of Cuttack, within the course of the river in the state of Odisha. The physicochemical parameters such as $NO_2$-N, $NO_3$-N, $NH_4$-N, TKN and total phosphorous (TP) were analysed, along with pH, DO, BOD, COD, TSS, TDS, and other metals such as Zn, Ni, Pb and Cu etc., in order to assess the impact of different effluents upon the quality of the river water.

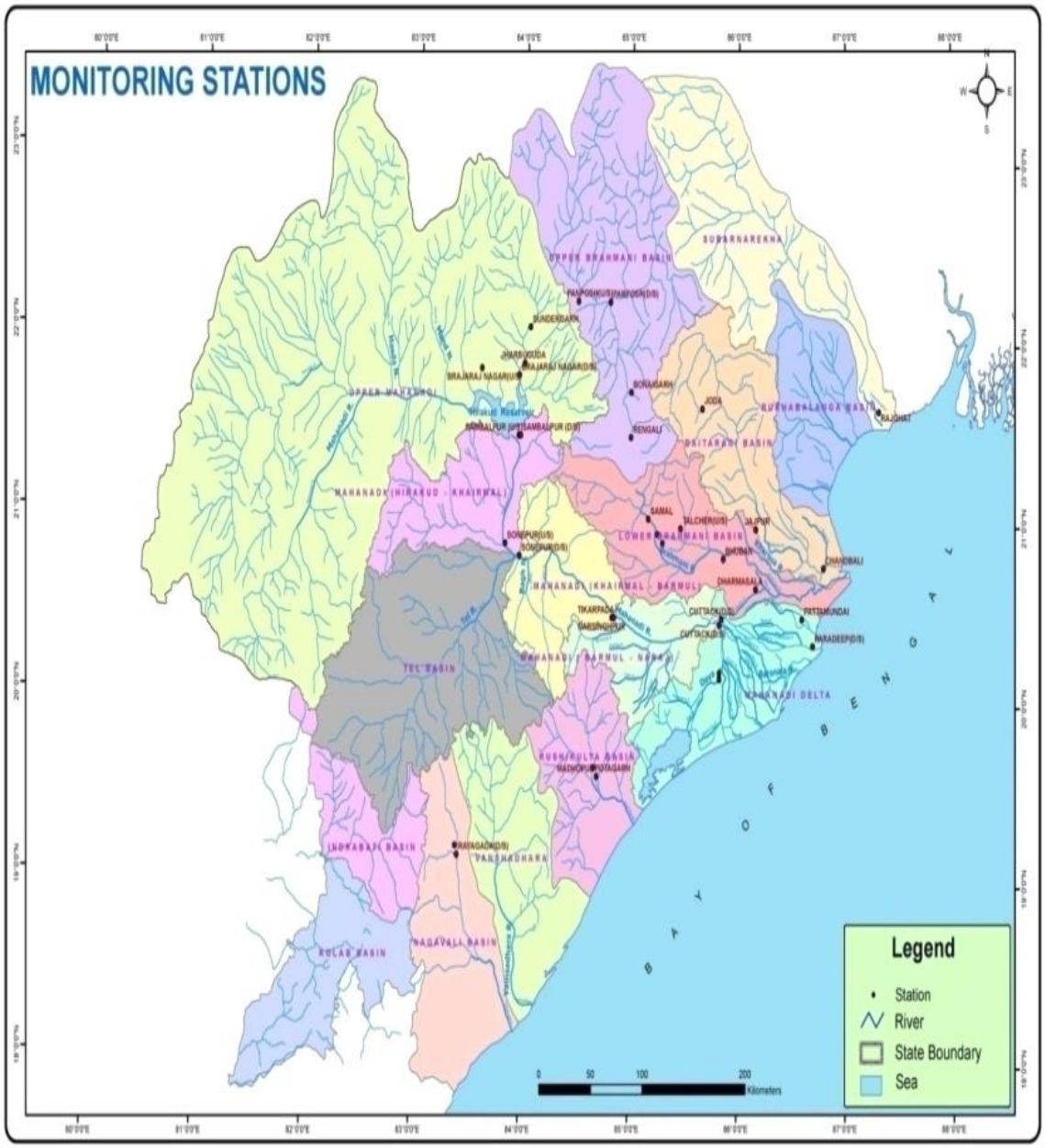



**Figure 1.**Map of Mahanadi basin in Odisha (India), indicating monitoring stations

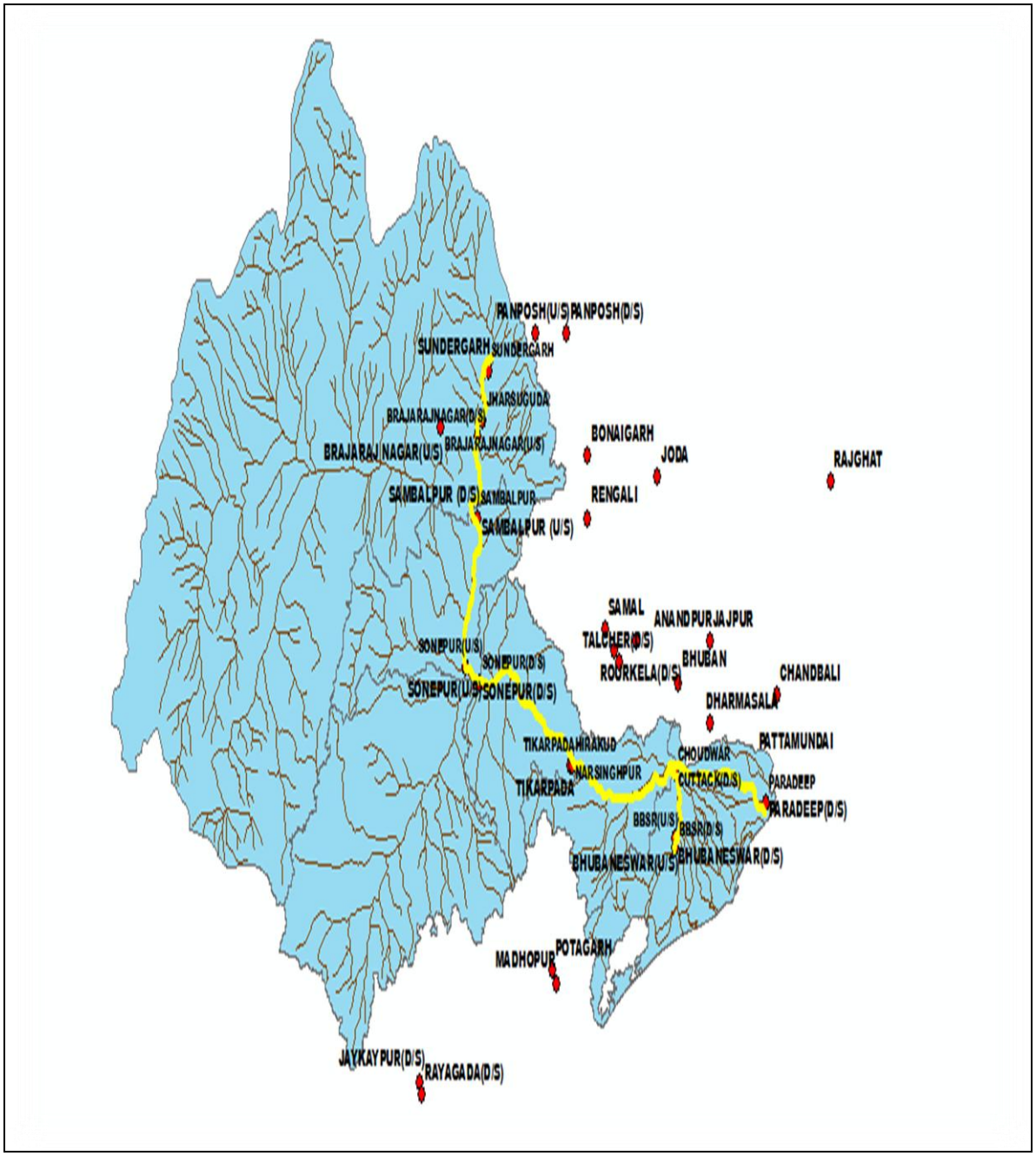



**Figure2.**Plotting of monitoring stations on river map of Odisha

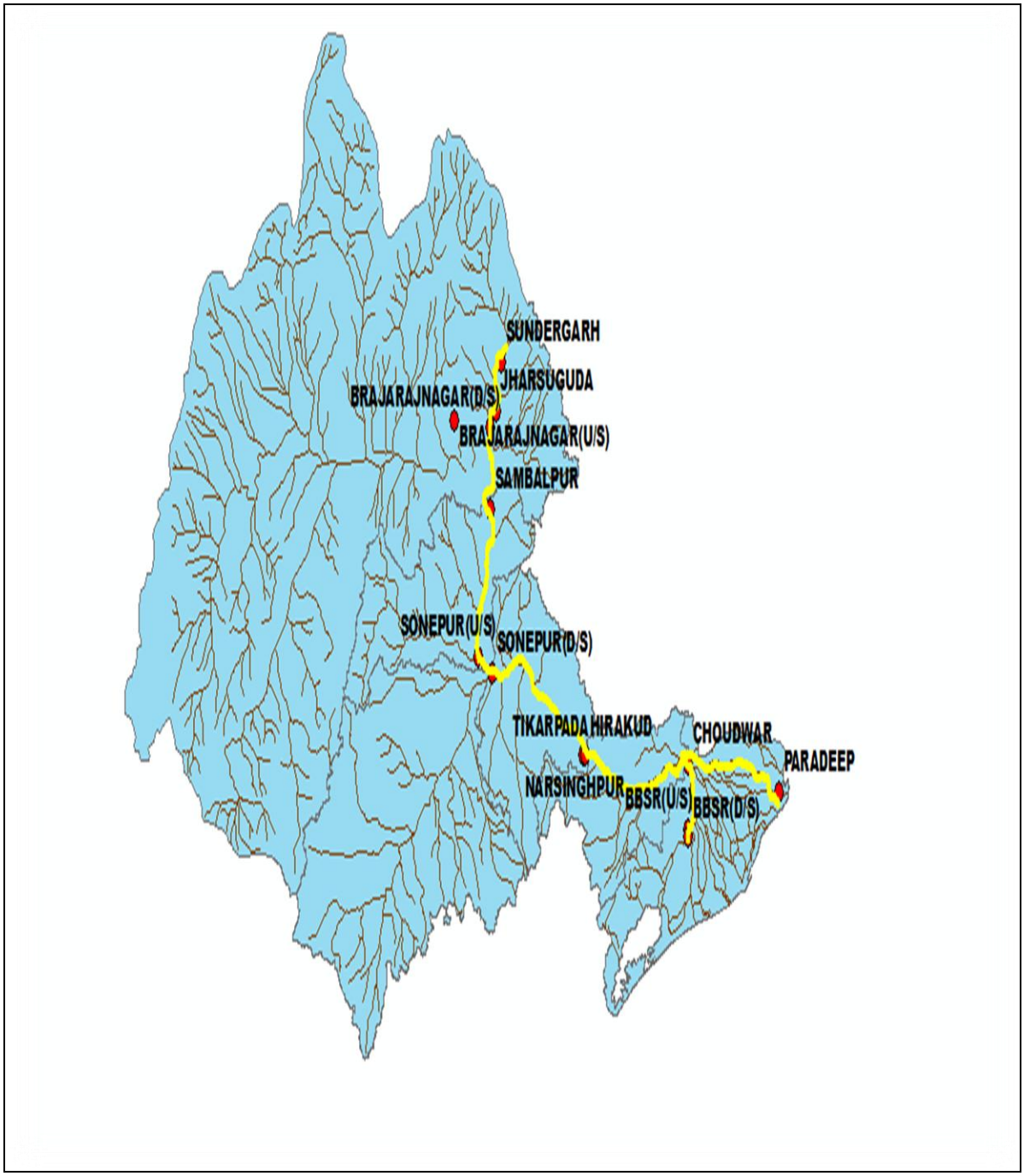



**Figure3.**Plotting of monitoring stations on Mahanadi river basin:

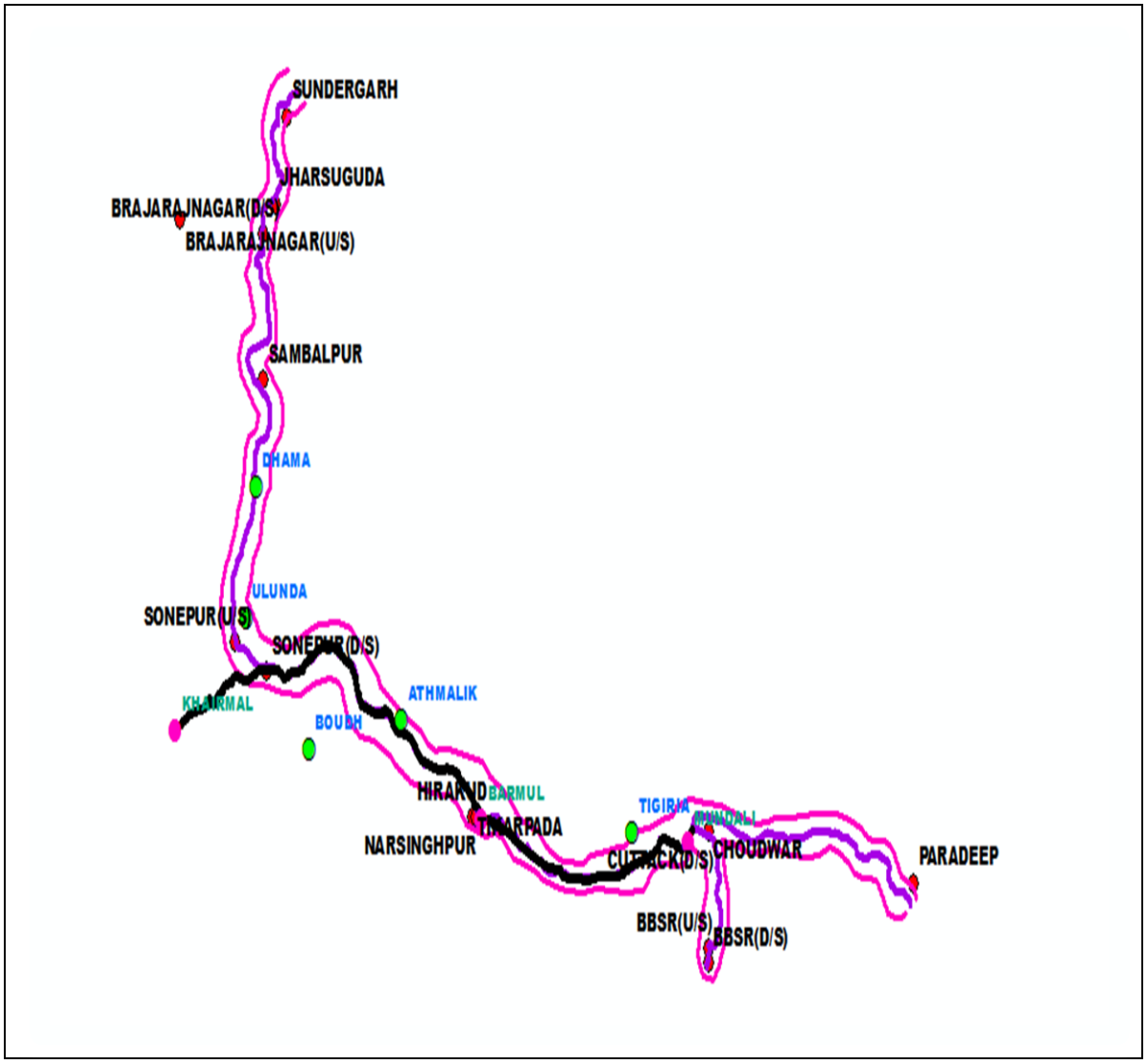



**Figure4.**Flow path of Mahanadi river basin

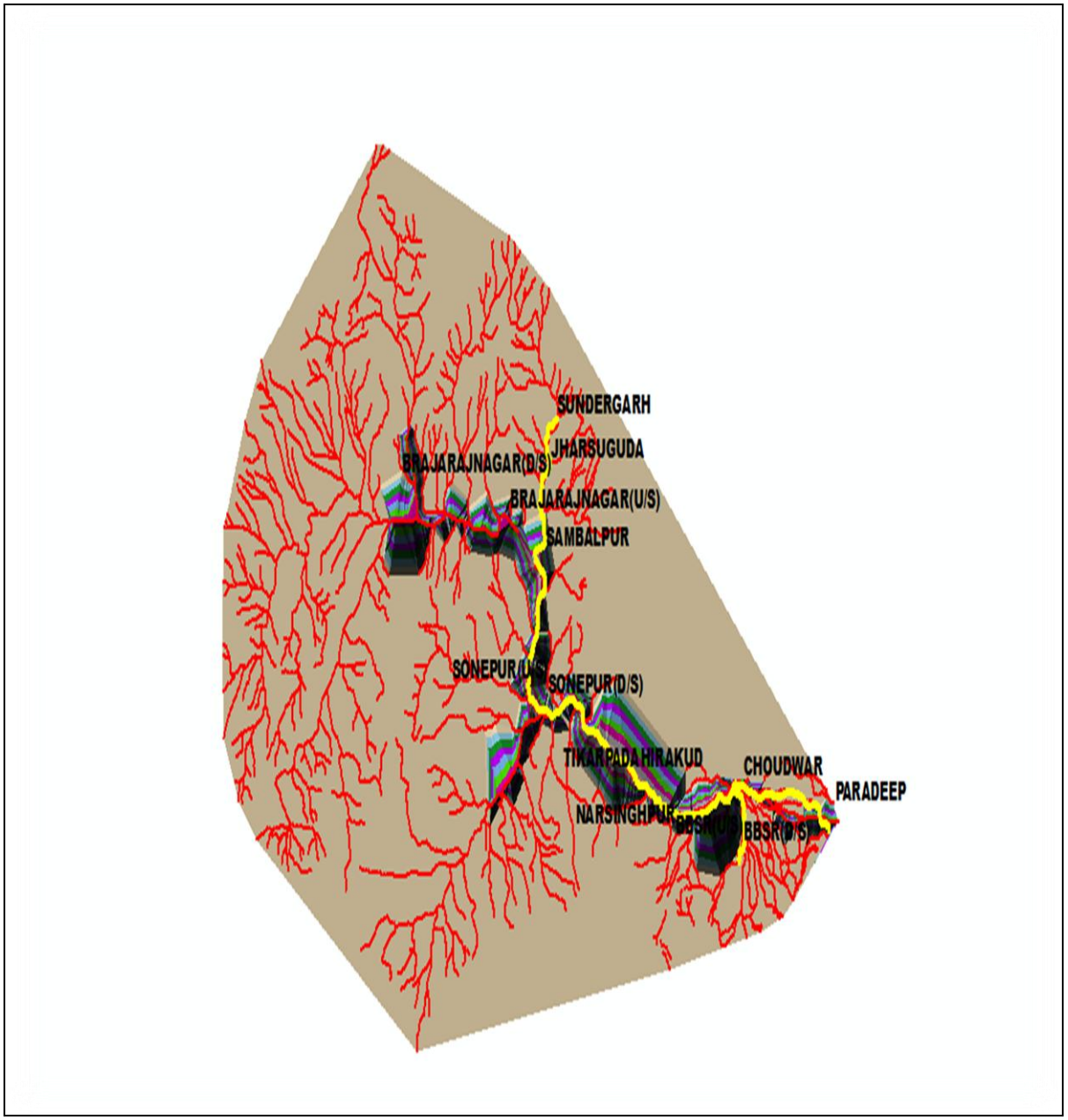



**Figure5.**Tin of mahanadi river basin


**Figure6.**Tin surface contour of Mahanadi river basin

## IV. Methodology

**GIS APPLICATION:**

**Geographic Information System:**

GIS is a system of hardware and software used for storage, retrieval, mapping, and analysis of geographic data. A geographic information system, or GIS, is a computerized data management system used to capture, store, manage, retrieve, analyze, and display spatial information. GIS is an interdisciplinary tool, which has application in various fields such as Geography, Geology, Cartography, Engineering, Surveying, Rural & Urban planning, Agriculture, Water resources, etc.

**Inverse Distance Weight (IDW):**

The IDW function can be use when the set of points is dense enough to capture the extent of local surface variation needed for analysis.IDW determines cell values using a linear-weighted combination set of

sample points. The weight assigned is a function of the distance of an input point from the output cell location. The greater the distance, the less influence the cell has on the output value.

**MANN-KENDALL TREND ANALYSIS**

The yearly average data of water quality parameters collected over a period of 14 years (2000-2014) of 16 monitoring stations were obtained from State Pollution Control Board, Odisha. The water quality trend analysis was conducted for all the districts of Orissa on yearly basis. The trend was analyzed using non-parametric Mann-Kendall test (Mann1945;Kendall, 1975). The MK test has been employed by a number of researchers to ascertain the presence of statistically significant trend in hydrological climatic variables such as temperature, precipitation with reference to climate change. The MK test checks the null hypothesis of no trend versus the alternative hypothesis of the existence of increasing or decreasing trend. The regional water resources study was done by analyzing the yearly water quality data for 16 stations of Odisha for the period of 2000 to 2014.

**Table1.**Normalized Values Of Monitoring Stations Of Mahanadi River Basin From The Year 2000-2014

| | | CLASS A | | | | | | CLASS B | | CLASS C | | | CLASS D | | | CLASS E | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STATIONS | PARAMETERS | PH | DO | $NO_3$ | TSS | TDS | TH | BOD | FE | TC | COD | ALKALINITY | $NH_4$-N | FREE $NH_3$ | TKN | EC | SAR | $CL_2$ | $SO_4^{2-}$ | F |
| 1 | HIRAKUD | 0.514 | 0.897 | 0.143 | 0.098 | 0.0018 | 0.01 | 0 | 0.185 | 0.011 | 0.0931 | 0.3053456 | 0.04444 | 0.1132 | 0.055 | 0.00427 | 0 | 0 | 0.00606 | 0.0549 |
| 2 | SAMBALPUR | 0.514 | 0.863 | 0.262 | 0.01 | 0 | 0.011 | 0.1366 | 0.155 | 0.078 | 0.2733 | 0.3638399 | 0.22222 | 0.2264 | 0.581 | 0.0049 | 0.0009 | 0.00026 | 0.00703 | 0.0503 |
| 3 | SONEPUR(U/S) | 0.595 | 0.94 | 0.066 | 0 | 0.0028 | 0.014 | 0.0275 | 0 | 0 | 0.1485 | 0.4987406 | 0 | 0.0377 | 0.089 | 0.00535 | 0.0023 | 0.00108 | 0.00408 | 0.0595 |
| 4 | SONEPUR(D/S) | 0.773 | 0.94 | 0.114 | 0.027 | 0.0039 | 0.016 | 0.2597 | 0.189 | 0.07 | 0.3561 | 0.7455919 | 0.24444 | 0.3774 | 0.263 | 0.00943 | 0.0029 | 0.00025 | 0.00642 | 0.1174 |
| 5 | TIKARPADA | 0.595 | 0.88 | 0.143 | 0.146 | 0.0044 | 0.012 | 0.0476 | 0.411 | 0.021 | 0.1528 | 0.4657151 | 0.04444 | 0.239 | 0.29 | 0.0068 | 0.0041 | 0.00024 | 0.00572 | 0.0259 |
| 6 | NARSINGHPUR | 0.622 | 0.931 | 0.066 | 0.036 | 0.0035 | 0.011 | 0.03 | 0.417 | 0.076 | 0.1974 | 0.5927792 | 0.08889 | 0.1635 | 0.263 | 0.00595 | 0.0014 | 0.00018 | 0.00553 | 0.0976 |
| 7 | CUTTACK(U/S) | 0.811 | 1 | 0 | 0.089 | 0.0031 | 0.01 | 0.0919 | 0.581 | 0.035 | 0.1737 | 0.2059894 | 0.46667 | 0.4623 | 0.052 | 0.00421 | 0.0031 | 0.00029 | 0.0107 | 0.1189 |
| 8 | CUTTACK(D/S) | 0.757 | 0.494 | 0.163 | 0.301 | 0.0037 | 0.014 | 0.5773 | 0.411 | 1 | 0.6934 | 0.4377274 | 0.44444 | 0.5597 | 0.342 | 0.00639 | 0.0042 | 0.0007 | 0.01003 | 0.0976 |
| 9 | PARADEEP | 1 | 0.459 | 0.365 | 1 | 1 | 1 | 0.2614 | 1 | 0.266 | 0.4276 | 1 | 0.13333 | 0.1101 | 1 | 1 | 1 | 1 | 1 | 0.5665 |
| 10 | SUNDERGARH | 0.405 | 0.991 | 0.097 | 0.492 | 0.0005 | 0 | 0.0406 | 0.658 | 0.02 | 0 | 0 | 0.06667 | 0.3931 | 0.476 | 0 | 0.0071 | 0.00011 | 0 | 0.0351 |
| 11 | JHARSUGUDA | 0.324 | 0.897 | 0.095 | 0.226 | 0.0011 | 0.002 | 0.0726 | 0.303 | 0.042 | 0.0323 | 0.2213826 | 0.08889 | 0 | 0 | 0.00075 | 0.0054 | 0.00019 | 0.001 | 0.0381 |
| 12 | BRAJARAJNAGAR(U/S) | 0.324 | 0.914 | 0.22 | 0.197 | 0.0009 | 0.003 | 0.048 | 0.224 | 0.014 | 0.0816 | 0.1754828 | 0.06667 | 0.0849 | 0.328 | 0.00167 | 0.0086 | 0.0002 | 0.00025 | 0.0335 |
| 13 | BRAJARAJNAGAR(D/S) | 0.405 | 0.721 | 0.235 | 0.395 | 0.0019 | 0.005 | 0.2655 | 0.22 | 0.067 | 0.1931 | 0.1754828 | 0.24444 | 0.1918 | 0.587 | 0.00226 | 0.0077 | 0.00045 | 0.00039 | 0.0747 |
| 14 | BBSR(U/S) | 0.378 | 0.797 | 0.154 | 0.274 | 0.0032 | 0.009 | 0.2491 | 0.518 | 0.167 | 0.2937 | 0.1449762 | 0.35556 | 0.2138 | 0.187 | 0.00466 | 0.0081 | 0.00074 | 0.00195 | 0.0091 |
| 15 | BBSR(D/S) | 0 | 0 | 1 | 0.483 | 0.0063 | 0.013 | 1 | 0.647 | 0.669 | 1 | 0.3638399 | 1 | 0.2484 | 0.475 | 0.01071 | 0.0164 | 0.00227 | 0.01637 | 0 |
| 16 | CHOUDWAR | 0.622 | 0.759 | 0.286 | 0.297 | 0.0063 | 0.023 | 0.1055 | 0.529 | 0.17 | 0.433 | 0.4783095 | 0.17778 | 1 | 0.098 | 0.00544 | 0.0013 | 0.00179 | 0.01184 | 1 |

## V. Results And Discussion

**WATER QUALITY MODELLING USING GIS APPLICATION:**

Spatial patterns of water quality trends for 16 sites in the Mahanadi River basin of Odisha were examined for nineteen parameters. This study suggests that spatial analysis of watershed data at different scales should be a vital part of identifying the fundamental spatial distribution of water quality.

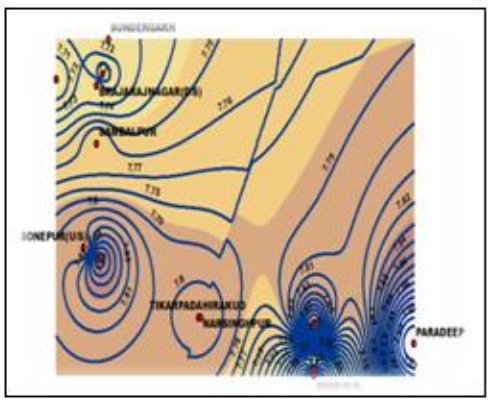
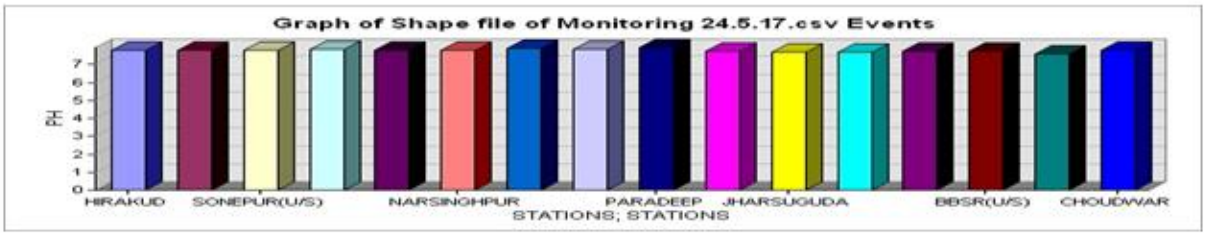



**Figure7.**Interpolation of PH using IDW



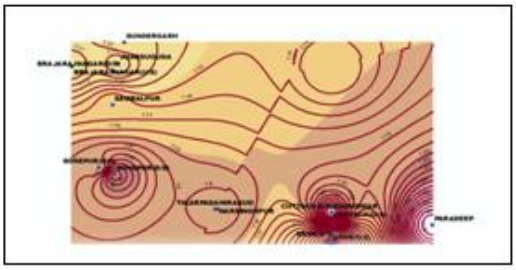
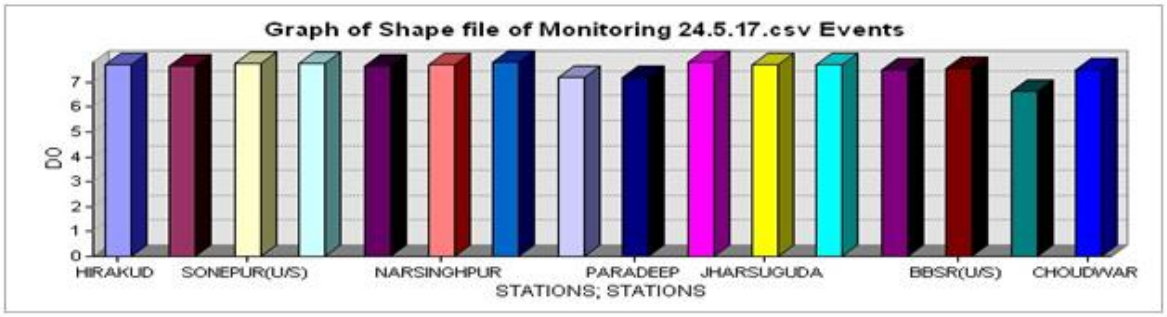


**Figure8.**Interpolation of DO using IDW



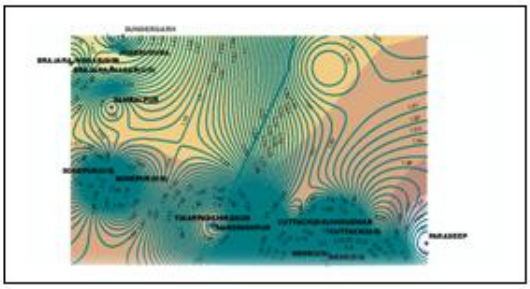
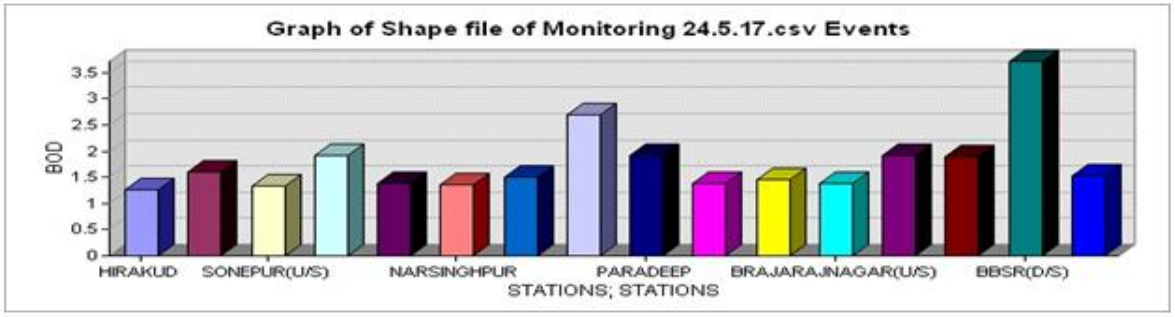



**Figure9.**Interpolation of BOD using IDW technique



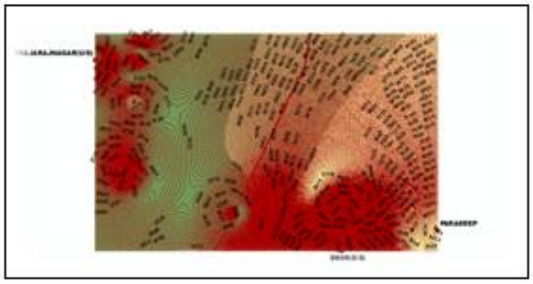
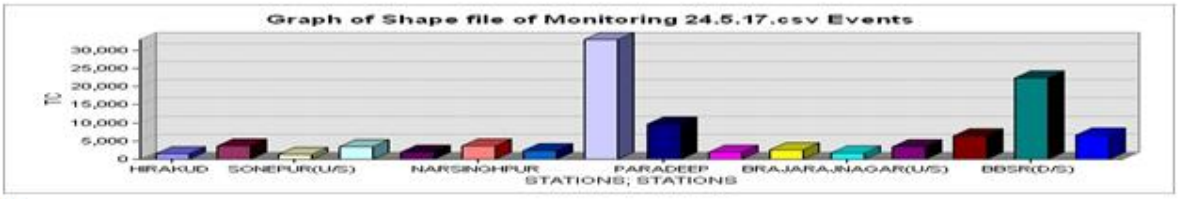


**Figure10.**Interpolation of TC using spline technique




EC

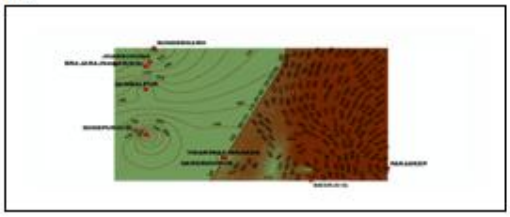


**Figure11.** Interpolation of EC using IDW technique

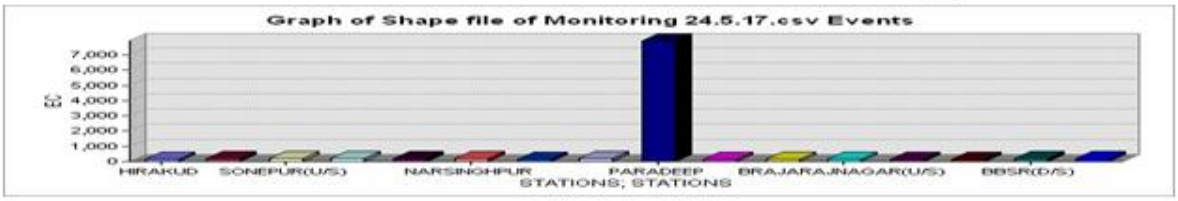



**Table2.**Result of Mann-Kendall Trend Analysis of Monitoring Stations

| | | SIGNIFICANCE LEVEL | | |
|---|---|---|---|---|
| **STATIONS** | **PARAMETER** | **1%** | **5%** | **10%** |
| **BBSR(D/S)** | **TC** | **RISING** | **RISING** | **RISING** |
| | **FE** | **NO** | **NO** | **RISING** |
| | **NITRATE** | **NO** | **NO** | **RISING** |
| | **B** | **NO** | **NO** | **RISING** |
| | **EC** | **NO** | **NO** | **RISING** |
| | **COD** | **NO** | **RISING** | **RISING** |
| | **TOTAL ALKALINITY** | **NO** | **FALLING** | **FALLING** |
| | **TSS** | **NO** | **NO** | **RISING** |
| **BRAJARAJNAGAR D/S** | **BOD** | **FALLING** | **FALLING** | **FALLING** |
| | **$NH_4$-N** | **NO** | **NO** | **FALLING** |
| | **SAR** | **NO** | **FALLING** | **FALLING** |
| | **TDS** | **NO** | **NO** | **FALLING** |
| | **TH** | **NO** | **FALLING** | **FALLING** |
| | **NITRATE** | **NO** | **FALLING** | **FALLING** |
| | **FE** | **NO** | **NO** | **RISING** |
| **CHOUDWAR(D/S)** | **BOD** | **FALLING** | **FALLING** | **FALLING** |
| | **FE** | **NO** | **NO** | **RISING** |
| **HIRAKUD** | **TC** | **RISING** | **RISING** | **RISING** |
| | **COD** | **NO** | **RISING** | **RISING** |
| | **$NH_4$-N** | **NO** | **FALLING** | **FALLING** |
| | **B** | **NO** | **RISING** | **RISING** |
| | **SAR** | **NO** | **NO** | **FALLING** |
| | **CL** | **NO** | **NO** | **RISING** |
| **JHARSUGUDA** | **PH** | **NO** | **NO** | **RISING** |
| | **BOD** | **FALLING** | **FALLING** | **FALLING** |
| | **TOTAL ALKALINITY** | **FALLING** | **FALLING** | **FALLING** |
| | **$NH_4$-N** | **NO** | **FALLING** | **FALLING** |

| | | | | |
|---|---|---|---|---|
| | **TH** | **NO** | **NO** | **FALLING** |
| | **NITRATE** | **FALLING** | **FALLING** | **FALLING** |
| **NARSINGHPUR** | **PH** | **NO** | **RISING** | **RISING** |
| | **BOD** | **FALLING** | **FALLING** | **FALLING** |
| | **TC** | **NO** | **NO** | **RISING** |
| | **TSS** | **NO** | **NO** | **RISING** |
| | **TOTAL ALKALINITY** | **FALLING** | **FALLING** | **FALLING** |
| | **$NH_4$-N** | **NO** | **FALLING** | **FALLING** |
| | **SAR** | **NO** | **FALLING** | **FALLING** |
| | **TDS** | **NO** | **NO** | **FALLING** |
| **SAMBALPUR** | **BOD** | **NO** | **FALLING** | **FALLING** |
| | **TOTAL ALKALINITY** | **NO** | **NO** | **FALLING** |
| | **NITRATE** | **NO** | **FALLING** | **FALLING** |
| **SONEPUR(D/S)** | **BOD** | **NO** | **FALLING** | **FALLING** |
| | **TOTAL ALKALINITY** | **NO** | **NO** | **FALLING** |
| | **$NH_4$-N** | **NO** | **NO** | **FALLING** |
| | **B** | **NO** | **NO** | **RISING** |
| | **SULPHATE** | **NO** | **RISING** | **RISING** |
| **SUNDERGARH** | **PH** | **NO** | **NO** | **RISING** |
| | **BOD** | **FALLING** | **FALLING** | **FALLING** |
| | **AMMONIACAL NITROGEN** | **NO** | **NO** | **FALLING** |
| | **SAR** | **NO** | **FALLING** | **FALLING** |
| | **TKN** | **NO** | **NO** | **FALLING** |
| | **FE** | **NO** | **NO** | **RISING** |
| | **B** | **NO** | **RISING** | **RISING** |
| | **NITRATE** | **NO** | **FALLING** | **FALLING** |
| **TIKARPADA** | **DO** | **NO** | **NO** | **RISING** |
| | **BOD** | **FALLING** | **FALLING** | **FALLING** |
| | **TC** | **RISING** | **RISING** | **RISING** |
| | **TOTAL ALKALINITY** | **NO** | **FALLING** | **FALLING** |
| | **SAR** | **NO** | **NO** | **FALLING** |
| | **TH** | **NO** | **FALLING** | **FALLING** |
| | **NITRATE** | **NO** | **FALLING** | **FALLING** |
| **PARADEEP** | **DO** | **NO** | **NO** | **RISING** |
| | **BOD** | **FALLING** | **FALLING** | **FALLING** |
| | **TOTAL ALKALINITY** | **FALLING** | **FALLING** | **FALLING** |
| | **$NH_4$-N** | **NO** | **NO** | **FALLING** |
| | **TH** | **NO** | **FALLING** | **FALLING** |
| | **CL** | **NO** | **FALLING** | **FALLING** |
| | **F** | **NO** | **FALLING** | **FALLING** |
| **CUTTACK(D/S)** | **BOD** | **FALLING** | **FALLING** | **FALLING** |
| | **TC** | **NO** | **RISING** | **RISING** |
| | **TSS** | **NO** | **RISING** | **RISING** |
| | **TOTAL ALKALINITY** | **NO** | **NO** | **FALLING** |
| | **TDS** | **FALLING** | **FALLING** | **FALLING** |
| | **TH** | **NO** | **FALLING** | **FALLING** |
| | **NITRATE** | **FALLING** | **FALLING** | **FALLING** |

## VI. Conclusion

- River Mahanadi is said to be the lifeline of the state Odisha. Most of the agriculture, industry and all round developments are due to rich water resource potential of this river. But the present concern is the increasing deterioration of water quality of the watershed is mainly attributed to the uncontrolled and improper disposal of solid and toxic waste from industrial effluents, agricultural runoff and other human activities. ***This alarming water pollution not only causing degradation of water quality but also threatens human health and balance of aquatic ecosystem, and economic development of the state.***

- From the assessment of physico-chemical study it could be clearly concluded that ***the status and quality of Mahanadi River water in Sambalpur city be an eye opener*** which is very much prone towards alarmed condition for Sambalpur city and its population.
- Mann-Kendall test was applied for three significance levels i.e. 1%, 5%and 10% as shown in (Table 2). On the basis of Z-statistics of each significance level, ***the trends in different stations of River Mahanadi have been determined.***
- In BBSR (D/s) , there is a rising trend occurs at 10% significance level due to these water quality parameters like TC, Fe, Nitrate, Boron, EC, COD and TSS and falling trend occurs due to total alkalinity. This result due to the river receives the city waste water, at least through one organized outfall, the Gangua Nallah, in between, as a consequence of which the water quality is downgraded.
- In Brajarajnagar (D/s), there is falling trend occurs at 10% significance level due to these water quality parameters like BOD, $NH_4$-N, SAR, TDS,TH, Nitrate and rising trend due to Fe. This results as the water quality at Brajarajnagar was a matter of concern due to discharge of effluent from a large paper mill.
- In Choudwar (D/s), there is a falling trend of BOD and rising trend of Fe at 10% significance level. This results due to industrial activities with a textile, a large pulp and paper and a charge chrome industry with its thermal power plant.
- In Hirakud, there is a rising trend occurs due to parameters like TC, COD, B, CL and falling trend occurs due to $NH_4$-N and SAR at 10% significance level. This results due to the Sambalpur city which is famous for bathing and waste water (untreated) disposal which is responsible for deterioration of water quality.
- In Jharsuguda, there is a falling trend occurs due to water quality parameters like BOD, Total alkalinity, $NH_4$-N, TH, Nitrate and rising trend occurs due to PH at 10% significance level. This results as thewater quality of his left bank tributary of IB River is monitored at only one location-Jharsuguda, which is the downstream of M/s Vedanta Aluminium Ltd.
- In Narsinghpur, there is a rising trend due to water quality parameters like PH, TC, TSS and falling trend due to BOD, Total alkalinity, $NH_4$-N,SAR, TDS at 10% significance level. This occurs due to the industrial and human activities.
- In Sambalpur, there is falling trend occurs due to the water quality parameters like BOD, Total alkalinity and nitrate at 10% significance level. This occurs as Sambalpur is the major urban area (population about 1.5 lakhs, districts and division headquarters) immediately downstream of Hirakud reservoir (about 5 km). Apart from being a source of water supply,Mahanadi at Sambalpur is used for bathing and waste water (untreated) disposal which is responsible for the observed deterioration of water quality at sambalpur D/s.
- In Sonepur (D/s), there is a falling trend occurs due to water quality parameters like BOD, Total alkalinity, $NH_4$-N and rising trend due to boron and sulphate at 10% significance level. As sonepur is the district headquarters with all consequent activities, the deterioration in the water quality gets affected.
- In Sundergarh, there is a rising trend occurs due to water quality parameters like PH, Fe, boron and falling trend due to BOD, ammoniacal nitrogen, SAR, TKN and nitrate at 10% significance level. This results due to the paper mill industry near Brajarajnagar D/s.
- In Tikarpada, there is a rising trend occurs due to water quality parameters like DO and TC and falling trend occurs due to BOD, SAR,TH, Total alkalinity, nitrate at 10% significance level. As there is no industry nearby but two small sub-divisional towns-Boudh and Athamalik generally disturb the water quality.
- In Paradeep, there is a rising trend occurs due to water quality parameters like DO and falling trend due to BOD, Total alkalinity, $NH_4$-N, CL, F, TH at 10% significance level. This results due to the presence of oil refinery industries which is the main cause for the deterioration of water quality.
- In Cuttack(D/s), there is a rising trend of TC, TSS and falling trend of BOD,TDS, TH, Total alkalinity, nitrate occurs at 10% significance level. This results as the river enters into its deltaic region, characterized by high population density and intense agricultural activities.

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