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Physico Chemical Properties of Water Sample Collected From Mangrove Ecosystem of Mahanadi River Delta, Odisha, India

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Abstract In the present study, physico-chemical parameters of water samples were compared with the water quality standard of Bureau of Indian standard and the state pollution control board. Variations of different parameters investigated were as follows: Temperature (24.2-30.9°C), dissolved oxygen (2.9-10.9 mg/L), pH (6.05-8.6), electrical conductivity (5.16–17.33 mS/cm), TDS (4510–11900 mg/L), chloride content (4389-12575 mg/l), nitrate (13.03-24.01 mg/l), phosphate (0.55-2.59 mg/l), calcium (125.4-400.8 mg/l), magnesium (153.16-474.13 mg/l) and total hardness (800-2090 mg/l). The significant variations of p among different study sites with high load of calcium, chloride, nitrate and phosphate in most of the study sites indicating the pollution status of the estuarine water.

Keywords: *mangrove ecosystem, physico-chemical parameter, water quality and water pollution*

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1. Introduction

Estuarine and coastal areas are complex and dynamic aquatic environment [1]. Coastal water has become a major concern because of its values for socioeconomic development and human health. With the growth of human populations and commercial industries, estuarine water has received large amounts of pollution from a variety of sources such as recreation, fish culture and the assimilation and transport of pollution effluents through river [2]. These situations have generated great pressure on the ecosystem, resulting in a decrease of water quality and biodiversity, loss of critical habitats [3].

Mangrove forest ecosystem serves as the base of an elaborate and productive food web in the tropical and subtropical coastal marine environments [4]. Mangrove forest ecosystem in estuarine area of Mahanadi river delta is dynamic, fragile with the plant, and environmental factors interconnect the process of energy fixation, accumulation of biomass, decomposition of dead organic matter, and nutrient cycling. In recent years, a number of industries and aquaculture farms have been developed around the estuaries of Mahanadi delta near its mouth Paradeep. The effluents from these industries and aquaculture are discharged into Mahanadi estuary at the deltaic confluence point of Mahanadi with Bay of Bengal which enters into the Mahanadi estuary and poses threat to the mangrove ecosystem. Hence, the present study was undertaken to assess the water quality of mangroves of Mahanadi delta and its adjoining areas through analysis of physico-chemical parameters of water samples collected from unpolluted river water along with aquaculture and industrial effluent contaminated sites of Mahanadi estuaries with a view to know the pollution status of the estuarine water quality and to predict its possible impact on mangrove ecosystem for future management.

2. Materials and Methods

2.1. Study Area

The mangrove area in the Mahanadi delta (20^0 15'' to 20^0 70'N latitude and 87^0 to 87^0 40'E longitude) extends from south eastern boundary of Mahanadi river to river mouth of Hansua (a tributary of Brahmani) in the north, from the north eastern end of Mahanadi river up to Jamboo river in east. Sampling sites of the present study mainly comprises of six stations covering river water of

Jamboo (Site 1), mangrove forest water near Kharnasi (Site 2), prawn farm at Nuagada (Site 3), prawn farm at Triveni (Site 4), Mahanadi river where IFFCO effluent water enters (Site 5) and Mahanadi river where PPL effluent water enters into Mahanadi river (Site 6) (Figure 1).

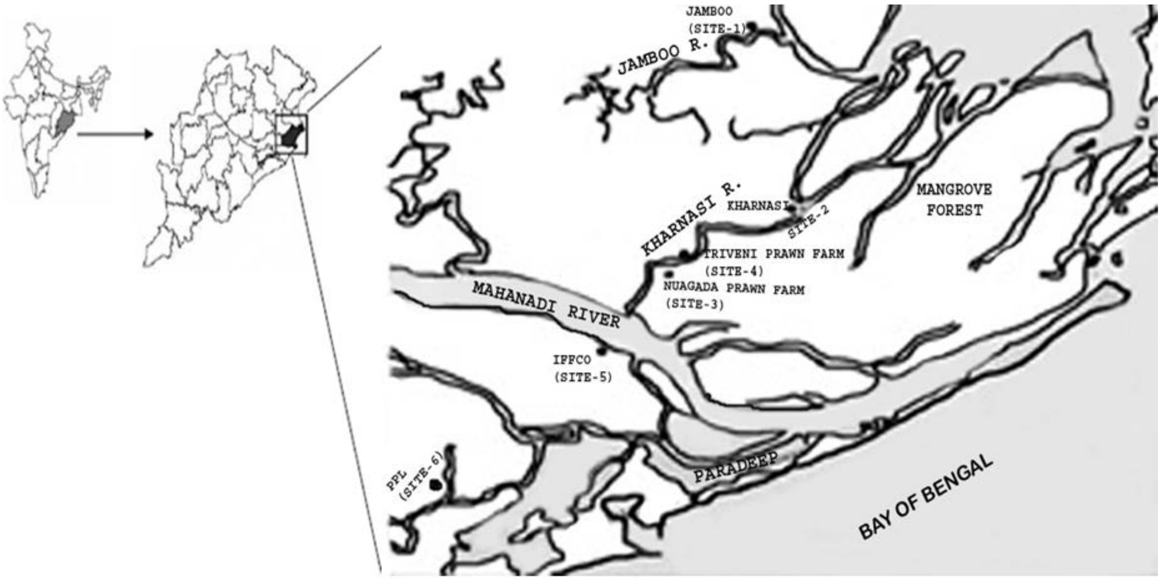

Figure 1. Map of Mahanadi Delta showing six different sampling sites

2.2. Sample Collection and Water Analysis

The surface water samples were collected from 1 to 2 m depth from the water surface. For analysis of dissolved oxygen (D.O.) water samples were collected by biological oxygen demand (BOD) bottles of 300 ml capacity. The manganese sulphate and alkali iodide-azide reagent were added immediately at the collection site to fix the samples for analysis of D.O. The water temperature and pH were measured at the sampling site using standard mercury thermometer and microprocessor based pocket pH meter (water proof pH scan WPI). Immediately after arrival to the laboratory the conductivity of the samples were measured with the help of digital conductivity meter (Systronics model no-341). For the study of nitrate, phosphorus, chloride, total hardness, calcium and magnesium water samples were analyzed in the laboratory following standard method of American public health association (APHA) [5]. Total dissolved solid of the water samples were measured using a digital TDS meter (Systronics model no-341).

2.3. Statistical Analysis

Statistical analysis was performed by SPSS, version 10 for windows (SPSS Inc; Chicago, IL, USA).

3. Results and Discussion

The physico-chemical characteristics of river and estuarine water samples of Mahanadi delta mangrove forest ecosystem are presented in Figure 2A-K. In the present study, water temperature among the study sites showed little variation (24.2°C – 30.9°C). Site-2 showed maximum increase in water temperature in comparison to other sites during all the season (Figure 2A). The observed variation of water temperature among the study sites supports the finding of Mishra et al. [6] who has reported the same trend of water temperature in the mangrove forest of Bhitarkanika, Odisha.

pH of water at all the study sites showed a narrow range of variation (6.05-8.6) (Figure 2B). Throughout the study period the pH (Figure 2B) of the river water Jamboo (Site-1), mangrove forest water (site-2), water from both the Prawn farm such as Nuagada (site-3) and Triveni (site-4) can passed excellent water pH (pH 7.00-8.5) according to the standards for regular monitoring parameters adopted by State pollution control Board (SPCB), Odisha [7]. According to Bureau of Indian standard (BIS) [8], standardization the pH for drinking water should be within 6.5-8.5. Hence, the pH of water of these three sites is found to be within the permissible limit. However, the quality of PPL and IFFCO effluent water are categorized under desirable class water (Figure 2B). Since pH of water of these sites were < 7, it dissolves many metals resulting in their toxicity [7].

The conductivity of water samples at different study sites was found variable (5.16 -17.3 mS/cm). There is a sharp increase in conductivity was observed from October to November in all the sites during the study periods (Figure 2C). Thereafter, conductivity showed gradual increase up to march. BIS has recommended a drinking water conductivity limit of 750 μS/cm at 25°C which can be extended to a conductivity about 3000 μS/cm at 25°C in case of no alternate source. The higher value of conductivity registered during the study period indicating the pollution level in the water.

The value of TDS content in all the sites except site-5 and site-6 remains almost same during the first three months i.e. from October to January (Figure 2D). Thereafter, the TDS value in all the sites showed steady increase with a maximum value in March. Site-5 and Site-6 showed increase in TDS content from October to November then sharply declined towards December. TDS is generally associated with inorganic salt and there is a close parallelism between TDS and conductivity. Though there is no generally valid exact quantitative relationship between TDS and conductivity but high conductivity indicates high TDS. BIS [8] standard value for TDS is 500-1000 mg/l. In the present investigation the TDS are found in the range of 4510 – 11900 mg/l indicating the pollution of the water which are mostly due to the mixing of sea water with the river water [9].

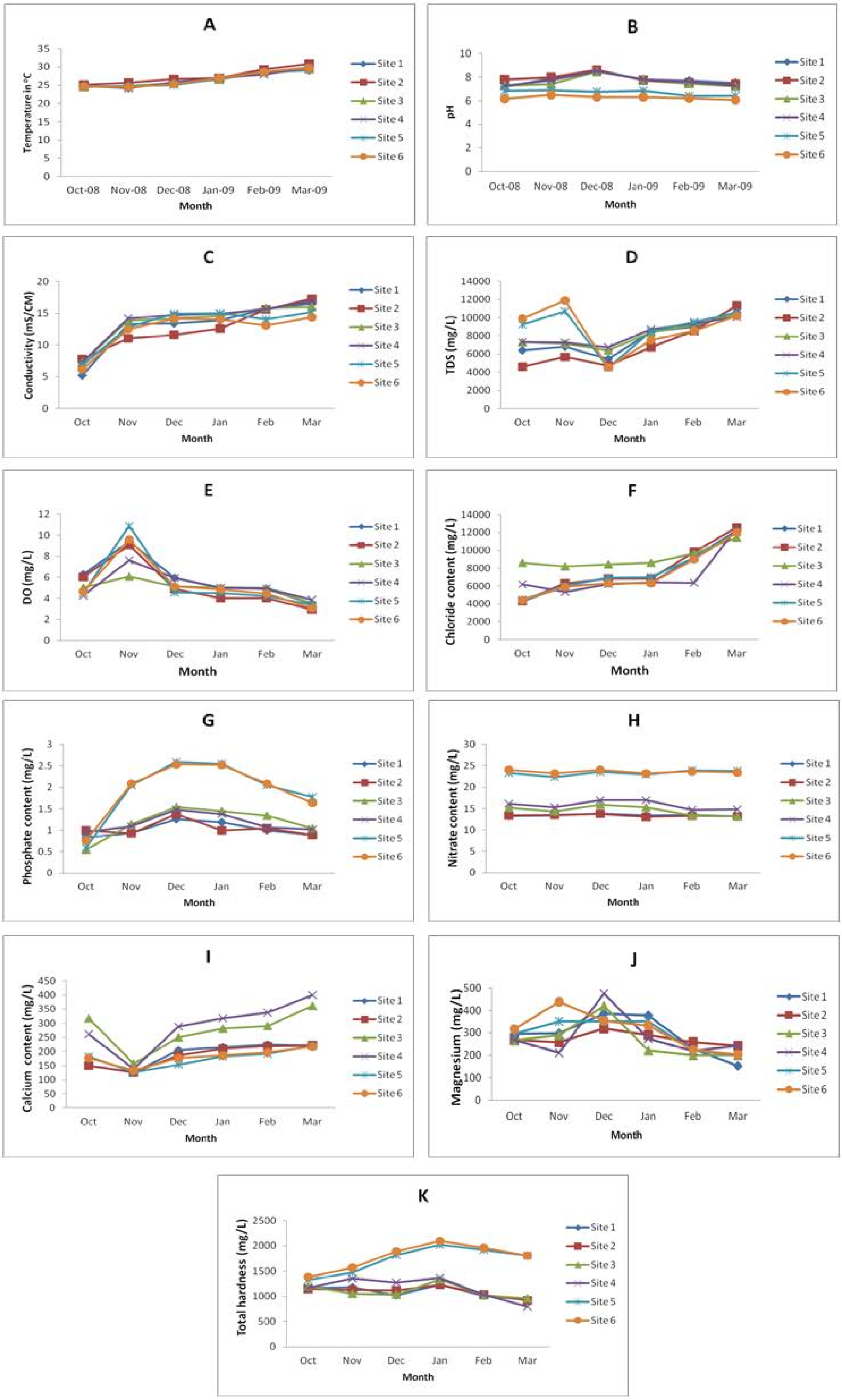

Figure 2. Monthly variation of Physico-chemical parameters (A= Temperature, B= pH, C= Conductivity, D = total dissolved solid, E= DO and F= Chloride content) of water at six different sites of mangroves of Mahanadi delta

The total amount of dissolved oxygen (DO) among the different sites and seasons are ranged from 2.9 mg/L to 10.9 mg/L. The values of DO increased sharply from October to November and decreased gradually till March (Figure 2E). The solubility of oxygen or its ability to dissolve in water decreases as the water temperature and salinity increases [10]. Higher Dissolved oxygen (DO) concentration observed during these two months might be due to the heavy rainfall and freshwater mixing [11]. BIS [8] standard value for dissolved oxygen for drinking purpose is 6 mg/L. Lower values of dissolved oxygen were found in most of the sites indicating higher pollution level due to the daily anthropogenic activity.

Chloride content was observed minimum (4389 mg/l) at site-5 in the month of October. Among the different study sites, site-2 showed maximum chloride content (12575 mg/L) than all other sites (Figure 2F). According to the tolerance limit standardized by State Pollution Control Board [7] the standard limit of chloride for drinking purpose is (250 mg/L) and can be extended up 1000 mg/L. In the present investigation the observed Chloride contents at all the sites are beyond permissible limits. In the present investigation the higher chloride content was observed may be due to the contamination of inflow of wastes from terrestrial runoff or of anthropogenic in origin.

There is a significant variation of phosphate content was observed both at site-5 and site-6 during the sampling period. Phosphate content showed gradual increment from October to December then it decreased slowly towards the rest of the months. On an average, the phosphate content ranged from 0.55 mg/L to 2.59 mg/L throughout the study period (Figure 2G). The total phosphorus concentration are found higher at PPL (site-5) and IFFCO (site-6) effluent sites in comparison to other site during the investigation period and comparatively low in mangrove, river water as well as both of the aquaculture ponds.

Nitrate content did not show any significant variations during the sampling periods. Among the six study sites, nitrate content of water sample was found to be highest in site-6. It ranges from 13.03 mg/L (site-2) to 24.01 mg/L (site-6). (Figure 2H). The IS (Indian standard) for nitrate in drinking water is 45 mg/L. As the estuarine mangrove water have relatively low content of dissolved inorganic nitrogen [12], the investigated nitrate concentration are observed very lower in all the six sites which are below the permissible limits (45 mg/L).

There is a significant variation in calcium content during the six month period of investigation in all the sites which varied from 125.4 (mg/L) to 400.8 (mg/L). According to Bureau of Indian Standards [8], standard value for calcium is 75 mg/L and can be relaxed upto 200 mg/L. The higher value of calcium registered during the study period may be due to the influx of industrial waste and sewage to the river water (Figure 2I). In estuarine water, the variation of concentration of calcium is quite significant due to land drainage, high rates of biological uptake, precipitation and dissolution process characteristics of shallow system [13].

The magnesium content of water sample generally increased from October to December then the values remains almost same during January after which a gradual decrease in value of magnesium content was observed in all the sites (Figure 2J). The highest content of magnesium (474.13 mg/L) was observed at site-4 in the month of December and least value (153.16 mg/L) was observed at site-1 in the month of March (Figure 2J). As per BIS [8], prescribed standard limit for magnesium is 30-70 mg/L and hence the observed values were beyond the permissible limit. As estuaries receive inputs from multiple sources of organic and inorganic matter such as materials exported from agricultural, urban development through drainage basin in to the river and intrusion of marine water from ocean during high tidal periods which contain multiple ionic sources such as Ca^{+2}, Mg^{+2}, Cl^{-} etc may increase the magnesium content in the study sites [14]. Our finding is also similar to the finding of Palanichamy and Balsubramanian [14], who registered 238 to 371 mg/l of calcium content in Vellar estuary.

All the six sites showed nearly the similar value of total hardness in the month of October (Figure 2K). Maximum value of total hardness was observed in the month of January (2090 mg/L at site-6) then showed marginal decline towards the rest of the month (Figure 2K). BIS [8] standard value for total hardness is at 300 mg/L and can be relaxed up to 600 mg/L. Hardness is most commonly expressed as milligrams of calcium carbonate equivalent per litre. So the high value of hardness is mostly due to the high value of calcium and magnesium in all the sites during the period of investigation.

The results of the principal component analysis and correlation analysis between different months around the Mahanadi delta in six different sites are shown in Figure 3. It includes loading for the rotated component matrix, eigen values for each component, percent of variance and cumulative percent of variance explained by each component indicating the portion of variance of each variable controlled by the set of components. The principal component analysis (PCA) and the correlation matrix of six different sites were done separately. The PCA for the site 1 in different months were carried out and the result along with the eigen values and percentage of variance is presented in Figure 3. The three factors or the PCs explain 92.912 % of the total variance. PC-1 accounts for 33.089 % of the total variance, which is due to strong positive load of pH (0.966), nitrate (0.939), phosphate (0.927) and magnesium (0.694) and strong negative load of TDS (-0.496). Besides, the significant positive correlations between magnesium, phosphate and nitrate indicates a common source for both and suggests that the magnesium, phosphate and nitrate content increases in low pH water, which may be from the effluents of different factories near the delta [2]. Thus the effluents from the factories, agricultural runoff etc. adds magnesium, phosphate and nitrate to the coastal region. PC-2 explains 30.929 % of the total variance with strong positive loading of chloride (0.853) and conductivity (0.770) and a moderate positive loading of temperature (0.591) with significant positive correlations. PC-3 contributed 28.894 % of the total variance which is strongly loaded positively by temperature (0.789) and calcium (0.894); weekly loaded positively by chloride (0.467) and conductivity (0.343), with no significant correlations between them [2]. The PC analyses of the parameters in rest of the sites (site 2 to site 6) are shown in Figure 3. The result shows that there is significant increase in phosphate and nitrate content in industrial effluents where as all other parameters exhibit the similar trend throughout the study period.

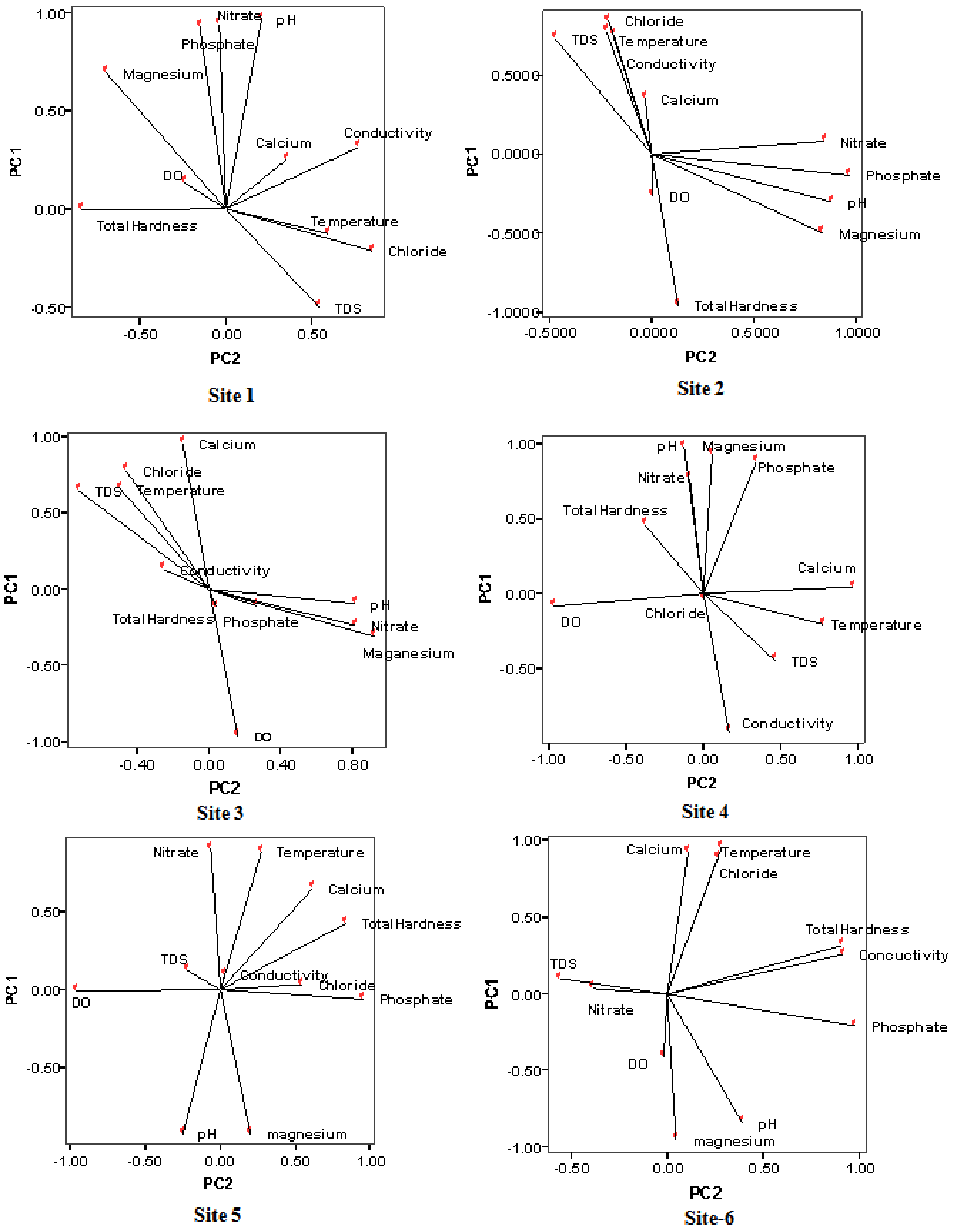

Figure 3. Interactive graph of principal component analysis of six sites at Mahanadi delta, Odisha

4. Conclusion

In this case study, different physico-chemical parameters were successfully applied and compared with the respective standards to monitor the water quality of Mahanadi river delta. Water analysis of pH, conductivity, TDS, D.O, chloride, calcium, magnesium, total hardness are the most important parameters represent the pollution status of the water. The pollutants are due to the release of effluents from several sources into the estuary, which causes significant changes in the quality of water and pose some deleterious effect to the mangrove ecosystem in a long run. The immediate need is to maintain existing sewage treatment plants so that effluent discharge has a minimum of suspended solids. As a result, it is essential that Mahanadi mangrove health in coastal environment monitoring is urgently required.

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