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ASSESSMENT OF SPATIO-TEMPORAL VARIATIONS IN MARINE WATER QUALITY - A COMPARATIVE STUDY

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Abstract: In Marine water, Assessing the spatiotemporal variations of water quality and Physico-chemical qualities of water is very important for water quality environmental management and it is critical for the health of biodiversity. Due to climatic change and over-exploitation, marine ecosystems are exposed to a range of environmental and anthropogenic stressors. Because of the rapidly changing world, the current knowledge on water availability across a range of spatial and temporal scales is still limited. The anthropogenic factors trigger the natural hydro-climatic variability and global changes so the water availability is changing both spatially and temporally. For water resources protection and its sustainable utilization, Spatiotemporal variation analysis of water quality and identification of water pollution sources in marine water is very important. The water quality monitoring studies on spatiotemporal variations focused on the physicochemical parameters as well as some biological factors including Dissolved Oxygen. Biological Oxygen Demand, Chemical Oxygen Demand, PH, Conductivity, Salinity, Temperature, Nitrogen, Turbidity, Dissolved Solids, Total Solids, Nitrates, Chlorides and Phosphates for scoring water quality status. This review article highlights the comparative study of the spatiotemporal variations in water quality.

Keywords: Spatiotemporal Variations, Water Quality, Physicochemical Parameters.

INTRODUCTION

The true nature of water is determined by the water quality assessment. It is done by estimating the parameters present in water and its limits by many experiments. Water quality in the marine environment has a distinct prominence than water quality in the freshwater environment. For the presence and concentration of many forms of bacteria, nitrite, nitrate, ammonium, orthophosphate, silicate, and other Physicochemical properties in the water samples are analyzed in the laboratory. The term "Marine" encompasses the salty waters of the earth, and is simply known as a saltwater ecosystem. Over 70% of the earth's surface is covered in water, and the largest type of ecosystem on the planet is the marine ecosystem. Heavy metals frequently enter the Ocean residues from burning fossil fuels through industrial pollution. Mercury and lead are most dangerous to the ecosystem which causes neurological disorders in humans and animals. It is necessary to check the Physicochemical properties of water. Both natural processes and anthropogenic activities influence surface quality within a region. Physicochemical characteristics are indeed vital for monitoring water quality, where significant variations in physicochemical parameters affect the quality of water resources. Water quality diversifies both spatially and temporally. The temporal variations in precipitation, surface runoff, interflow, and groundwater flow vary due to river discharge and pollutant concentration in water bodies and results in seasonal variations. To evaluate temporal variations in marine pollution caused by natural or anthropogenic inputs, seasonal changes in surface water quality are used from point and non-point sources.

R.M Narayanan et al. (2016) studied on Evaluation of marine water quality-A case study between Cuddalore and Pondicherry coast, India. To assess water quality status, the physicochemical parameters were determined at 19 stations. The largest interseason differences in PH were observed values were well within the permissible range for the parameters PH ranged from 6.5-8.5, and these values are considerably lower than expected marine PH values. Salinity was higher than the adjacent coastal waters and offshore waters and Dissolved Oxygen was higher and undersaturation typically about 65% concerning atmospheric equilibrium in post-monsoon compared to monsoon period. In the hotspot locations, Nitrate concentrations were considerably higher (5.5-7.1 µmol/l) compared to nearshore coastal waters where the values were about 2 µmol/l and Ammonium concentrations were considerably higher (4.36-6.34 µmol/l). Total phosphorous concentrations were above 0.21 µmol/l and especially 0.315 µmol/l which Favour the growth of cyanobacteria. During the observation period, it was found the N/P ratio ranged from a low value of 4.32 (Porto-Novo 10 km station) and a high (13,11) nearly reaching the ratio of 16:1 at the Pondicherry hotspot in the post-monsoon period and during the monsoon period, the N/P ratio was the low value of 4.23 (Cuddalore 10 km station) with a maximum of 11.06 at Cuddalore hotspot during low tide.

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Prakash Raj Kannel et al. (2007) studied Spatio-temporal variation and comparative assessment of water qualities of urban river system: A case study of the river Bagmati (Nepal). Along the Bagmati river and its tributaries in the Kathmandu valley of Nepal, the variation of water quality assessment, monitoring network classification, and pollution sources detection were studied and 17 stations were monitored for 23 physical and chemical parameters in pre-monsoon, post-monsoon, and winter seasons (1999-2003) were selected. The increased industrial activities in rural areas result in a higher ratio of COD and BOD (3.74 in rural and 2.06 in urban). DO was above 6.2 mg/l and BOD, COD, TIN, TP, and TSS was below 15.9, 31, 5.24, 0.41, and 134.5 mg/l respectively and Increased amount of nitrate was found in the rural areas and the urban areas, DO was below 4 mg/l and BOD, COD, TIN, TSS above 39.1, 59.2, 10.1, 0.84 and 199 mg/l respectively and increased amount of phosphorous was detected. The main river and its tributaries were equally polluted as shown by the comparative study for the variables in the urban areas and the other comparison showed that the urban water qualities were significantly poor while compared with the rural areas. The spatiotemporal variation of water qualities along the Bagmati river was investigated and it demonstrated high variability in water quality for many parameters. In the urban areas, most of the parameters showed higher concentrations to the downstream sections of the river and it showed heavy water pollution. There was no significant difference in water qualities compared between the river and its tributaries except higher levels of ca, mg, hardness, HCO3, EC, Alkalinity, TDS, CL, and PH in tributaries. The monitoring groups were detected by cluster analysis and the major groups of variables for the water pollution in the river and its tributaries were revealed by the factor analysis.

Baskar et al. (2013) studied Physicochemical, spatiotemporal variation of marine water and pollution of Ostracoda, East off Rameswaram Island, Palk Bay, Tamilnadu, Southeast coast of India. The study was carried out to seasonal observation on Physicochemical parameters and microorganisms in the marine waters of Rameswaram during four different seasons of a year, from October 2010 to September 2011 with the population of Ostracoda. Most of the parameters revealed a significant spatial and seasonal variation. PH, DO, Salinity, Turbidity, EC, Nitrate, and Phosphate showed a positive correlation. whereas, TDS, Nitrate, and Silica showed a negative correlation with the population of Ostracoda. 31% was recorded during the summer season and 21% was recorded during the winter season. 25% was recorded during the southwest monsoon and 23% was recorded during the northwest monsoon of the population of Ostracoda and it was done by cluster analysis.

Harshad Salvi et al. (2014) studied on Assessment of Coastal Water Quality Parameters of Selected Areas of Marine National Park & Sanctuary and the study was carried to assess the water quality and the objective is to analyze water samples to spatiotemporal variation at selected sites and the analysis of Physico-chemical and plankton in the study has achieved some important findings. There were no significant changes in pH value, the values ranged from 7.2 to 8.5. From the coastal marine region, there was a considerable decrease in DO with an average value of 32°C. The temperature has shown a temporal variation, highest during summer followed by monsoon and winter. For the growth and survival of the corals in marine water, the temperature is one of the most important parameters. Total hardness, Conductivity, Turbidity decreased (From Okha<Sikka<Khijadiya). The phosphate and nitrate showed a spatial variability which is maximum at Okha during March, minimum at Sikka during February. With variation in season and geographical location, the obtained results highlight that there is a notable variation in most of the water quality parameters and felt that the selected sampling sites have good biodiversity and are fit for marine life.

Najafpour et al. (2008) studied the Evaluation of Spatial and Temporal Variation in River Water Quality. To evaluate spatial and temporal variations in the water quality of the Shiroud River basin, multivariate statistical techniques were used in this study. With 92.7% correct assignations, DA spatial identified only four parameters to discriminate between eight sites (mean river depth, DO, NH4+, and EC). With 93.8% correct assignations, only seven parameters to discriminate between four sites to explain the temporal variation (mean river depth, water temperature, Ca+, TDS, silicate, Total hardness, and BOD5). To know and understand the source of spatial and temporal variations, discriminate analysis was helpful. For analyzing a huge and complex environmental data matrix, the application of multivariate statistical techniques has been proved to be an effective tool and it gave the best result both spatially and temporally.

Pawan Kumar Singh et al. (2015) studied on Analysis of water quality of River Narmada. A total of 16 water quality parameters were analyzed for the investigation. The objective of this study was to understand the water quality of River Narmada and the study revealed that the water quality of River Narmada has deteriorated. The recorded values are, The air temperature (25°C to 31.3°C), water temperature (22.4°C to 29°C), turbidity (8.6 NTU to 40.2 NTU), pH (7.63 to 8.76), electrical conductivity (230 µs/cm to 398 µs/cm), total dissolved solids (146 ppm to 274 ppm), free carbon dioxide (4mg/l to 22.4 mg/l), total alkalinity (112 mg/l to 226 mg/l), chloride (12.38 mg/l to 44.56 mg/l), total hardness (104 mg/l to 212 mg/l), calcium hardness (63.84 mg/l to 118.44 mg/l), dissolved oxygen (4.16 mg/l to 8.8 mg/l), nitrate (0.542 mg/l to 4.824 mg/l), orthophosphate (0.112mg/l to 0.546 mg/l), biochemical oxygen demand (4.16 mg/l to 19.2 mg/l), chemical oxygen demand (10.4 mg/l to 46 mg/l) respectively.

Ahmed et al. (2019) studied Spatio-temporal variations of water quality and phytoplankton diversity of the different rivers flowing within the Sundarbans mangrove wetland ecosystem of Bangladesh. The pH of the waters of all the rivers showed a range of variation (6.60-7.8 in 2015 and 6.3-7.5 in 2016) which indicates the buffering capacity of different rivers and the values of pH showed a slightly decreasing tendency which might be due to increase of global CO2 concentration in the atmosphere. The temperature (27.6°C to 30.8°C), conductivity (8.00 mS/cm to 32.30 mS/cm), salinity

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(5.50 to 23.00%, DO (ppm) (3.5 ppm to 6.35 ppm), DO (% sat) (46.60 % to 82.00 %), K (125.00 mg/l to 630.00 mg/l), Na (600 ppm to 4300 ppm), and the values of Ca, Mg and Fe were 210 to 500 ppm, 320.0 mg/l to 892.0 mg/l, 0.25 to 0.050 mg/l, respectively in April 2015 and the values ranged from 28.8°C to 31.0°C, 9.48 to 31.60 mS/cm 5.00 to 24.00%, 0.11 to 5.33 ppm, 1.2 to 95.2 % saturation, 110 to 670 ppm, 4683.5 to 13456.10 ppm respectively and the amount of DO was very low in March 2016. A maximum number of phytoplankton taxa was recorded from the Sela River. With the value of 6.825, the maximum Shannon-Weaver index of diversity was found in Homra Khal and with a value of 0.0, the minimum was found in the Sela River. Only one phytoplankton was found. Whereas, With the value of 14.81, maximum species richness (d) was observed in Passur river at Mongla ferry ghat and with the value of 5.437, maximum evenness (e) was found in Homra Khal.

Arivoli Appavu et al. (2016) studied on Water Quality Parameters of Cauvery River Water in Erode Region. The study focused on the determination of Physico-chemical parameters like temperature, pH, EC, hardness, chlorides, alkalinity, DO, BOD5, COD, phosphate, and sulfate of water samples from different sampling sites. The results showed variations and the average value of pH (7.86), Electrical Conductivity (920 µS/cm-1, Total Solids (1580 mg/l), Total Dissolved Solids (1004 mg/l), Total Suspended Solids (690 mg/l), Total hardness (340 mg/l), Chloride (380 mg/l), Dissolved Oxygen (5.59 mg/l), BOD5 (38 mg/l), COD (304 mg/l), Phosphate (6.0 mg/l) and Sulphate (60 mg/l) of the river sample was recorded. The study revealed that the Cauvery River water is contaminated by effluents, dumping of wastages, and domestic use wastages.

L. Jagadeesan et al. (2011) Studied the Temporal variations of water quality characteristics and their principal sources in Tropical Vellar Estuary. In two different zones of Vellar Estuary (From September 2006 to August 2008), Physico-chemical parameters like temperature, pH, salinity, dissolved oxygen, nitrate, nitrite, inorganic phosphate, and silicate were carried out. Nitrate (3.98-6.55 µM and 4.15-7.42 µM), Silicate (19.96-50.13 µM and 24.16-53.96 µM), and Dissolved Oxygen were high in monsoonal months than the non-monsoonal months. Salinity (20.3-35.56 and 3.65-36.41 ppt), pH (7.46 to 8.52 and 7.15 to 8.47), atmospheric and water temperatures (23.5-29.5 and 24.0-9.8°C) showed their maximum in the middle of summer and onset of pre-monsoon. whereas, their values were minimum in monsoon. Nitrite values varied from (0.34-0.98 µM and 0.83-0.29 µM) and Inorganic phosphate ranged between (0.56-2.82 µM and 1.96-0.40 µM) The Two-way ANOVA point outs, spatial and temporal variation of salinity which revealed notable variations, but the other parameters revealed notable temporal variations particularly. In Vellar Estuary, Factor analysis contributes 84.47% of total variances in the Physico-chemical characteristics.

Ahmed Barakat et al. (2016) studied on Assessment of spatial and seasonal water quality variation of Oum Er Rbia River using multivariate statistical techniques. From fourteen sampling stations, the water quality data were collected during 2000-2012. Temperature, pH, EC, turbidity, TSS, DO, NH4+, NH4-, TP, BOD5, COD, and F.coli were used as water quality indicators. Using multivariate statistical methods including Pearson's correlation, the water quality data were analyzed. In the study, the results showed that the obtained physicochemical resulted from some variables at most stations showed average concentration. The Temperature values ranged between 9.5 and 39.2°C. Turbidity concentration showed a wide-ranging between 0 and 61107 NTU. TSS concentrations ranged between 1.4 and 37043 mg/l and the mean EC values were 521 µS cm-1 and 714 µS cm-1. NH4+ values vary between 0 - 0.39 mg/l in winter and between 0- 2.20 mg/l in summer and NO3- concentrations ranged from 0-24.2 mg/l in summer and 15 mg/l in winter. Mean concentrations of DO level were below 7 mg/l generally. But the level remained significant with values of 2.80 - 21.80 mg/l. TP showed concentrations from 0.01 to 8.85 mg/l. BOD5 showed values between 0.10 and 15 mg/l between seasons with non-significant variations and COD showed contents between 0.02 and 149 mg/l between seasons with some variations. The monitored concentrations of F.coli ranged between 0 and 120,000 CFU/100 ml.

Yilei Yu et al. (2017) studied on Spatio-Temporal variation and controlling factors of water quality in Yongding River replenished by reclaimed water in Beijing, North China. As it is essential to understand the Spatio-temporal variation and the controlling factors of water quality, in 2015, the samples of Yongding River water were collected seasonally and 24 water quality parameters were analyzed. All the monitoring stations were divided into four groups. The concluded results showed that all waters were alkaline, and the main form of nitrogen was nitrate-nitrogen. Phosphorous was below detection level. The water quality parameters varied in time and space and between winter and other seasons and between the natural river section and the section with reclaimed water, the Cluster analysis showed a distinct difference. The main controlling factor was rock dominance and it was found out based on the analysis of Gibbs plots, PCA, and ionic relationships.

Kaniz Fatema et al. (2014) studied the Spatial and Temporal variation of Physico-chemical parameters in the Merbok Estuary, Kedah, Malaysia. The mean water temperature value ranged from a maximum of 30.75°C and a minimum of 27.50°C. Mean pH values varied from the maximum value of 8.3 (Dry season) and minimum value of 6.2 (Wet season). The mean EC values ranged with a high of 380.00 µS/cm and a low of 70.00 µS/cm and EC values (Highest value) showed temporal variations during the rainy season compared to the dry season. Average DO concentrations varied with a maximum value of 13.65 mg/l and a minimum value of 0.80 mg/l. Average Salinity values ranged with a maximum value of 35.00 ppt and a minimum value of 5.50 ppt. Mean value for Nitrate with a high of 0.41 mg/l and low of 0.01 mg/l, Nitrite with a high of 0.40 mg/l, and a low of 0.01 mg/l. Ammonia values were ranged from 0.10 mg/l to 1.18 mg/l. TSS levels were ranged from 30.28 mg/l to 65.00 mg/l. Mean BOD values varied from 1.33 mg/l to 3.94 mg/l. The mean

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Chla content was ranged from 0.45 µg/l to 1.78 µg/l and average Phosphate values were ranged from 0.06 mg/l to 0.08 mg/l. Kruskal-Wallis H tests were performed and showed that the water quality parameters were significantly different among the sampling sites.

Sanjoy Shil et al. (2019) studied on water quality assessment of a tropical river using the Water Quality Index (WQI), Multivariate Statistical techniques, and GIS. For both pre-monsoon and post-monsoon seasons of 2016, the water quality index of the river water was calculated by the Pesce and Wunderlin method. The water quality variables, such as temperature, pH, EC, DO, hardness, TDS, Ca, Mg, chloride, nitrate, phosphate, and sulphate were considered for the calculation of WQI. DO and TDS have prominent effects on water quality and the highest value of 4 was assigned to it. The WQI values ranged from 17.63 to 93.50 (pre-monsoon season) and 18.25 to 94.50 (post-monsoon season). The parameters do not significantly vary along with the sampling stations. For the statistical analysis, the actual values of the variables were taken and signified that the parameters changed with direct proportionality. To analyze the compositional pattern of the variables on the entire data, the principal component analysis (PCA) was conducted.

Xuewei Sun et al. (2019) investigated Analyses of the Temporal and Spatial Characteristics of water quality in a Seagoing River using Multivariate Statistical techniques. Using statistical techniques, the spatial and temporal variations in the river's water quality were identified and revealed that the water quality parameters varied with season and spatial position reasonably. The CA and PCA results revealed that the river was moderately polluted. The Temporal CA results showed that the temporal samples were grouped according to their hydrological characteristics into mean, low, and high flow periods rather than the four seasons. Nitrogen and Phosphorous were mainly the basic factors in all periods and they were indicted by the temporal PCA. The main basic factor influencing water quality in mean and low flow periods was seawater intrusion and it was indicated by significant loadings of EC and TDS in PC1. These results are carried out to temporal and spatial variations in the water quality of a seagoing river ecosystem.

Brenna Sweetman et al. (2018) studied on Coastal Water Quality Assessment of the Port Honduras marine reserve, Belize. The study examined temporal changes in water quality. In the year 1998- 2015, DO, salinity, temperature, and pH were analyzed from ten sites of PHMR and the water quality analysis revealed significant seasonal patterns, a slight increasing trend in DO, and salinity. But overall, relatively stable water quality. With correlations between salinity, temperature, and precipitation, the results of the temporal analysis showed strong seasonal patterns for all of the water quality variables. For certain water comprehensive analysis, this study provides useful baseline information. As a result, human population growth cannot be considered a critical threat to the water of PHMR.

Rosye Hefmi Rechnelty Tanjung et al. (2018) studied on Assessment of Water Quality and Pollution Index in Coastal Waters of Mimika, Indonesia. Based on the physicochemical parameters in Mimika waters, the purpose of the study is to examine the quality of the water and to determine the water pollution. In 2016, the sampling of water quality was carried out at six stations. The results were compared with the quality of seawater for biota marine. In all study stations, the study showed that the physicochemical parameters of the water turbidity, BOD, NH3, and heavy metals (Hg, As, Cd, Pb, Cu, Zn, Ni, and Cr) are then appropriate to the biota marine. Including water salinity for coral and seagrass, NO3, PO4, and H2S, there is a parameter for which the quality standards were exceeded in all locations. The Mimika waters are classified as lightly polluted to moderately polluted (pollution index values of 3.51 to 6.95). By using the water pollution index such as the level of water pollution can be concluded.

CONCLUSION

Water quality measurements of physicochemical parameters, Anthropogenic activities, Spatiotemporal variations of marine water analysis were discussed on various topics. This comparative study highlights, Spatio-temporal variation and comparative assessment of water qualities of an urban river system: A case study of the river Bagmati (Nepal), and the results were reported by Prakash Raj Kannel et al. (2007). The analysis for the data done during the year 1988 to 2003. Many parameters were analyzed and the results were recorded and spatiotemporal variations were detected. By Cluster analysis, three distinct monitoring groups were detected with similar characteristic features. The major groups of variables for water pollution in the river and its tributaries were revealed by Factor analysis. Hence, it is essential to examine the water quality by different parameters as stated above. It is similar to a study, Najafpour et al. (2008), The Evaluation of Spatial and Temporal Variation in River Water Quality. To evaluate spatial and temporal variations in the water quality of the Shiroud River basin, multivariate statistical techniques were used. the application of multivariate statistical techniques has been proved to be an effective tool and it gave the best result both spatially and temporally.

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