Studies on seasonal trend in sea water quality of Ratnagiri coast, Maharashtra, India

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Abstract

Coastal areas are ideal locations for many industries, particularly power plants, both nuclear and conventional. Thermal and chemical pollution are two important ecological problems associated with this because of the effluents containing harsh chemicals in drastic levels which may endanger the endemic population of marine life. The present investigation was carried out to assess sea water quality of Ratnagiri coast. Water samples were collected from five selected sampling stations along the coast for the monsoon, pre monsoon and post monsoon period during February 2011 to January, 2012. Various physicochemical parameters such as Temperature, pH, Conductivity, Total Solid (TS), Total Dissolve Solids (TDS), Turbidity, Salinity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and nutrients like sulphate (SO_4^-) phosphate (PO_4^-), Nitrate (NO_3^-) and Ammonia (NH_3) were analyzed to assess the spatial and temporal variation in the quality of sea water. Present study revealed that Ratnagiri coastal water is polluted from diffuse and direct sources of agricultural, urban and industrial pollutants.

INTRODUCTION:

The marine environment is a complex system mainly influenced by physical, chemical and biological processes. The chemistry and biology of coastal waters are very vulnerable to additions of biodegradable and stable compounds from land. Marine environmental management is assessed by proper assessment of water quality. Marine water quality monitoring is required to predict changes in the quality of a particular marine environment, so that curative or prevention measures can be taken to restore and maintain the ecological balance in the habitats. Estuarine and coastal areas are complex and dynamic aquatic environment (Morris, *et. al*. 1995). Domestic sewage and industrial effluents are discharged in the water courses in and around India in untreated or partially treated form. These, add a variety of pollutants which include certain toxic heavy metals and metalloids (Sankpal and Naikwade, 2012a). The total volume of all discharges from the environs of Mumbai was around 365 million tons (MT) per year (Sabnis, 1984). Similar discharges from the environs of Kolkata are around 350MT every year (Ghose *et al.,* 1973). India is predominantly an agricultural country hence large quantities of pesticides, herbicides, fungicides, etc. are used in agriculture which indirectly causes water pollution.

Hydro biological studies by Ganpati (1960), Sinha and Shrivastava (1992), have shown that urbanization is the root cause of water pollution. Rapid industrialization and tourism related activities in the coastal zone, disposal of municipal wastes, industrial wastes and numerous recreational and commercial activities that not only degrade the quality of coastal water but also pose a serious health hazard to marine biotas and human (Rama Devi *et al*., 1996). Pollution of marine water affect on biodiversity of mangroves and other aquatic flora and fauna (Naikwade and Sankpal 2012, Naikwade *et al*., 2012). The fluxes of trace elements that have been modified biogeochemically in estuaries and coastal waters are transported to the open ocean and the original composition of seawater is altered (Ackroyd *et al.,* 1986; Saager *et al*., 1997). Nutrients are the dissolved inorganic forms of Sulphate, Nitrates, Phosphates etc. utilized by photosynthetic organisms in the formation of organic matters (Saha *et.al*., 2001). Nitrogen and phosphorus are described as being biolimiting elements because the concentrations of these elements limit biological growth (Ghosh *et. al.*, 1992).

Ratnagiri district is one of the most important maritime districts of the state with the coastal belt extending to about 200 Km. Ratnagiri is an important coastal area of Maharashtra with average rainfall about 2500 mm. Most of the activities in this area are connected with sea. Recently several chemicals, pharmaceuticals companies and some power plants are grown up along the coastal region. Developmental activities like Konkan Railway Project, Enron electricity project, proposed marine highway, Cargo Ports are attracting more tourism industries in this region which directly or indirectly causes Environmental Pollution. The marine area is presently receiving water with a variety of effluents which may be potentially contaminating, including elevated levels of pollutants (Agard *et al.*, 1988). Very little work is done on the spatial and temporal quality of water of Ratnagiri coast. The present study evaluates the influence of various physicochemical parameters on coastal water quality of Ratnagiri coast.

MATERIAL AND METHODS

For the present study, five sampling sites were chosen along the Ratnagiri coast (shown in table no.1). Water samples for physical and chemical parameter determination were collected monthly from the sampling station with the help of clean plastic container well cleaned with non-ionic detergent, rinsed with tap water and finally washed with deionized water prior to usage. The samples were collected during high tides. Monthly samplings were made during forenoon from February 2011 to January, 2012 for three season's viz. monsoon, post-monsoon and pre-monsoon. While collecting samples contamination of the sample was avoided with any foreign material. Collected samples were brought to laboratory and stored to the refrigerator at 4^{o}C temperature. Selected physicochemical parameters such as Temperature, pH, Conductivity, total Solid (TS), Total dissolve solids (TDS), Turbidity, Salinity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and nutrients like sulphate (SO_4^-) phosphate (PO_4^-), Nitrate(NO_3^-) and Ammonia(NH_3) were analyzed according to APHA (1995), Trivedy and Goel (1986) and Strickland and Parsons (1972). Atmospheric and surface water temperatures were measured using thermometer. Turbidity measured using Nephelometer. Salinity was estimated with a hand refractometer. pH value was measured using pH meter. Dissolved oxygen was estimated by the modified Winkler's method. BOD and COD were measured by titration method. The nutrients viz. Sulphate, Phosphate, Nitrate, and Ammonia were determined using UV-Visible spectrophotometer.

RESULTS AND DISCUSSIONS

Physico-chemical Parameters

The climate of Ratnagiri is typical of monsoon regions. The surface water temperature varied from 21^{o} C to 25^{o} C. While low temperatures were recorded in post monsoon, high temperatures were recorded in pre-monsoon season (Summer). The recorded high value during summer could be attributed to high solar radiation (Ajithkumar *et al.*, 2006; Ashok Prabu *et al*., 2008; Rajkumar *et al*., 2009). The temperature plays a crucial role in physical-chemical and biological behavior of aquatic system.

Salinity value decreases in monsoon period and higher in pre and post monsoon season.The high value of salinity was recorded 5.55mg/l at station S1 in pre monsoon while low value was 1.76 mg/l recorded at station S5 in monsoon season due to the heavy rainfall and discharge of river water. High evaporation rates in the presence of low freshwater inflow can lead to higher values of salinity. (Balasubramanian and Kannan, 2005; Sridhar *et al*.,2006; Asha and Diwakar, 2007).

Variation in the pH value can affect the rate of biological reactions. The pH of coastal water responds to changes in dissolved carbon dioxide concentration, alkalinity, hydrogen ion concentration and in a small way to temperature. The decomposition of organic matter in the presence of dissolved oxygen increases the carbon dioxide content of water and lowers the pH. In present study the pH value remains alkaline throughout the year. pH value varied from as low 6.18 in the late monsoon period and high as 7.95 in summer. The recorded high pH values might be due to the influence of seawater penetration and high biological activity (Balasubramanian and Kannan, 2005).

Total Solids value observed high during monsoon period i.e. 40.24 g/l at S2 while lowest in post monsoon period i.e. 32.26 g/l at S1. While total dissolve solids varies between 39.26 to 49.19 g/l. Higher values were observed during monsoon and lower during post monsoon period. The conductivity of an aqueous medium is an indication of its ability to conduct an electric current. The conductivity of seawater in any season is determined by the presence of total concentration ions, mobility, valence, relative concentrations and the temperature of the system.

Conductivity of surface water varied in the range 15.42-17.82mS/cm.The causes of seawater turbidity include waste discharge, urban run-off, bottom feeders that stir up sediments, wave and current actions (especially in less deep areas). Turbidity shows higher value during monsoon period and lower during post monsoon period. Higher value 7.03 NTU at S4 while lower 4.82 NTU at same site.

Oxygen solubility varies inversely with salinity and water (Saravanakumar *et al*., 2008). Dissolved oxygen consumption and production are influenced by plant and algal biomass, light intensity and water temperature. In present study DO varied from 6.34 to 8.23 mg/l. The low values are found in post monsoon when temperature is high. Highest values are found in monsoon period. Coastal discharges of wastes rich in organic carbon from sewage treatment plants and other industries are produced in large quantities in urban population centers, and can substantially reduce dissolved oxygen concentrations.

The BOD value is high during pre monsoon period i.e. 0.95 mg/l at S1 compared to the post monsoon 0.51 mg/l at S4. These BOD values are in the range normally recorded for healthy costal water. The low value indicates low organic pollution in study area. Biochemical Oxygen Demand (BOD) depends on temperature, extent of biochemicalactivities, concentration of organic matter and such other related factors. Maximum value of BOD was observed in Premonsoon period due to the maximum biological affinity at elevated temperature and low in winter (Ghavzan, *et. al.* 2006) due to reduced flow of riverine water.

The chemical characteristics of seawater provide an insight into the existing health status of the marine environment. Nitrate ions (NO_3^-), ammonia (NH_4^+, NH_3), phosphate ions (PO_4^{3-}) and sulphate ions (SO_4^{2-}) are the ionic forms of the essential nutrients nitrogen, phosphorous and sulphur respectively, which are essential to growth and reproduction of plants and animals. Generally, nutrients enter the marine environment through urban storm water run-off, irrigation drainage, agricultural run-off, etc. via creeks, rivers and estuaries.

Aquatic species depend on the surrounding water to provide their nutrients. Although a wide variety of minerals and trace elements can be classified as nutrients, those required in most abundance by aquatic species are nitrate and phosphate (Peavy *et.al.*, 1985). While nitrogen and phosphorus occur in nature and are critical to plant life in the marine environment, too much of the nutrients cause an excessive growth of phytoplankton and other organisms, which deprive marine life including fish and plants of oxygen.

Nitrogen exists in water both as inorganic and organic species, and in dissolved and particulate forms. Inorganic nitrogen is found both as oxidized species nitrate (NO_3^-) and nitrite (NO_2). During pre-monsoon period, Nitrate values ranged from11.21 to 12.02 mg/l, while during post-monsoon period it was 13.47 to 14.53 mg/l and in monsoon period 16.67 to 21.27 mg/l. The concentration of nitrate is very high during monsoon season. Levels of nutrients, such as nitrogen, affect the overall health of an aquatic ecosystem and can have both positive and negative effects, depending on their concentrations (Caffrey *et al*., 2003). Presence of NO_3^- ion could be due to the anthropogenic sources like domestic sewage, agricultural wash offs and other waste effluents containing nitrogenous compounds.

During pre-monsoon, the phosphate values ranged from 0.07 to 0.09 mg/l and 0.11 to 0.14 mg/l during post-monsoon and 0.14 to 0.27 mg/l during monsoon period. L. Mathew and Pillai (1990) reported that the higher concentration of phosphate in coastal waters might be enriched by freshwater drainage. The addition of super phosphates applied in the agricultural fields as fertilizers and alkyl phosphates used in households, as detergents can be other sources of inorganic phosphates during the season (Bragadeeswaran *et al.*, 2007).

Sulphate value observed higher during monsoon region while lower during post monsoon period. Value ranger form 3.27 mg/l to 2.97 mg/l during pre monsoon, 2.86 to 2.92 during post monsoon and 3.28 to 3.82 during monsoon period.

The occurrence of the different forms of ammonia depends on pH value of the coastal water. In this study observed concentration of ammonia was less than nitrate and phosphate. Ammonia concentration was minimum in pre monsoon period and maximum was observed in monsoon period. Lower concentration of ammonia indicates minimal influence of industrial effluents.

Correlation Analysis:

For the purpose of further discussion, correlation analyses were performed on the water physicochemical parameters to see how they all relate with each other during the period of this study. The study of correlation reduces the range of uncertainty associated with decision making.

Table No.1 : longitude and altitude of selected sites along the coast

Sr. No.	Name of the sites	Longitude and Latitude
S1	Kasarwelly	17^0 03'10.04" N 73^0 17'10.56" E
S2	Sadamirya	17^0 02'16.53" N 73^0 16'25.56" E
S3	Mirya	16^0 59'32.93" N 73^0 16'40.98" E
S4	Bhatye	16^0 58'48.00" N 73^0 17'37.90" E
S5	Ranpar	16^0 59'32.93" N 73^0 17'10.52" E

Table No 2: Physicochemical parameters along the study sites during monsoon season.

Parameters/Sites	S1	S2	S3	S4	S5	Mean	SD
Temperature(^{0}C)	23.22	23.57	23.47	23.67	22.78	23.34	0.356
pH	6.65	6.46	6.7 0	7.38	7.15	7.27	0.428
Conductivity (mS/ cm)	16.82	16.92	16.91	16.28	16.42	16.67	0.299
TS (g/l)	39.72	40.24	39.61	39.43	39.98	39.8	0.318
TDS (g/l)	48.54	48.30	49.19	48.73	48.52	48.66	0.335
Turbidity (NTU)	6.16	6.27	6.73	7.03	6.92	6.62	0.389
Salinity(mg/l)	1.86	2.10	1.92	1.82	1.76	1.892	0.130
DO(mg/l)	7.95	7.96	8.02	7.89	8.23	8.01	0.131
BOD(mg/l)	0.65	0.67	0.62	0.56	0.65	0.63	0.043
Nitrate (mg/l)	16.67	16.77	20.25	21.12	21.27	19.22	2.312
Sulphate (g/l)	3.32	3.82	3.62	3.81	3.28	3.57	0.259
Phosphate (mg/l)	0.27	0.23	0.19	0.24	0.23	0.23	0.029
Ammonia (mg/l)	0.06	0.09	0.04	0.05	0.06	0.06	0.018

Table No 3: Physicochemical parameters along the study sites during pre monsoon season.

Parameters/Sites	S1	S2	S3	S4	S5	Mean	SD
Temperature(^{0}C)	25.72	25.17	25.47	25.37	24.98	25.34	0.283
pH	7.45	7.86	7.78	7.78	7.95	7.76	0.189
Conductivity (mS/ cm)	17.82	17.12	17.81	17.58	17.32	17.53	0.307
TS (g/l)	33.62	34.24	34.51	34.23	34.28	34.18	0.331
TDS (g/l)	42.34	43.30	42.69	42.33	42.542	42.64	0.398
Turbidity (NTU)	5.86	5.67	5.83	6.03	5.92	5.86	0.132
Salinity(mg/l)	5.55	5.13	5.17	5.44	5.43	5.34	0.184
DO(mg/l)	7.15	7.15	7.0	7.09	7.72	7.22	0.285
BOD(mg/l)	0.95	0.84	0.87	0.72	0.86	0.85	0.082
Nitrate (mg/l)	11.21	11.29	10.82	11.06	12.02	11.28	0.451
Sulphate (g/l)	3.27	3.15	3.17	3.15	2.97	3.14	0.108
Phosphate (mg/l)	0.09	0.11	0.07	0.08	0.08	0.09	0.015
Ammonia (mg/l)	0.01	0.04	0.03	0.02	0.03	0.03	0.011

Table No 4: Physicochemical parameters along the study sites during post monsoon season.

Parameters/Sites	**S1**	**S2**	**S3**	**S4**	**S5**	**Mean**	**SD**
Temperature(^{0}C)	21.62	21.82	21.27	21.45	21.18	21.468	0.260
pH	6.62	6.18	6.23	6.42	6.23	6.336	0.183
Conductivity (mS/ cm)	15.42	15.62	15.92	15.72	15.78	15.692	0.187
TS (g/l)	32.26	32.32	32.87	32.43	32.35	32.446	0.245
TDS (g/l)	39.26	39.82	38.98	39.72	39.82	39.52	0.380
Turbidity (NTU)	5.11	4.98	4.92	4.82	4.92	4.95	0.106
Salinity(mg/l)	3.55	2.23	2.12	2.34	2.18	2.48	0.601
DO(mg/l)	6.45	6.34	6.53	6.35	6.37	6.408	0.081
BOD(mg/l)	0.54	0.56	0.61	0.51	0.52	0.548	0.040
Nitrate (mg/l)	13.67	13.47	13.72	14.53	13.82	13.842	0.405
Sulphate (g/l)	2.92	2.92	2.86	2.91	2.91	2.904	0.025
Phosphate (mg/l)	0.11	0.14	0.13	0.12	0.14	0.128	0.013
Ammonia (mg/l)	0.06	0.05	0.05	0.06	0.06	0.056	0.005

Table No 5: Correlation between Physicochemical parameters along the study sites during monsoon season.

	Temp.	pH	Conductivity	TS	TDS	Turbidity	Salinity	DO	BOD	Nitrate	Sulphate	Phosphate	Ammonia
Temp.	1												
pH	-0.14	1											
Conductivity	0.19	-0.97	1										
TS	-0.30	-0.55	0.40	1									
TDS	0.21	0.16	0.07	-0.70	1								
Turbidity	-0.08	0.87	-0.79	-0.48	0.43	1							
Salinity	-0.13	-0.25	0.20	-0.17	-0.24	-0.63	1						
DO	-0.89	0.16	-0.17	0.39	-0.05	0.31	-0.33	1					
BOD	-0.47	-0.75	0.64	0.87	-0.52	-0.70	0.18	0.42	1				
Nitrate	-0.20	0.83	-0.72	-0.48	0.51	0.98	-0.61	0.42	-0.63	1			
Sulphate	0.91	-0.04	0.05	-0.06	0.07	0.11	-0.47	-0.66	-0.41	-0.03	1		
Phosphate	-0.16	0.07	-0.22	0.02	-0.66	-0.42	0.81	-0.27	0.10	-0.47	-0.32	1	
Ammonia	0.04	-0.49	0.30	0.87	-0.88	-0.58	0.02	-0.05	0.65	-0.65	0.21	0.33	1

Table No 6: Correlation between Physicochemical parameters along the study sites during Pre monsoon season

	Temp.	pH	Conductivity	TS	TDS	Turbidity	Salinity	DO	BOD	Nitrate	Sulphate	Phosphate	Ammonia
Temp.	1												
pH	-0.93	1											
Conductivity	0.84	-0.71	1										
TS	-0.57	0.82	-0.28	1									
TDS	-0.43	0.45	-0.69	0.38	1								
Turbidity	0.08	-0.05	0.40	-0.04	-0.88	1							
Salinity	0.31	-0.51	0.38	-0.71	-0.85	0.70	1						
DO	-0.70	0.48	-0.47	0.02	-0.10	0.18	0.33	1					
BOD	0.37	-0.51	0.30	-0.51	0.03	-0.46	0.13	0.12	1				
Nitrate	-0.71	0.44	-0.58	-0.08	0.00	0.08	0.32	0.98	0.13	1			
Sulphate	0.92	-0.87	0.59	-0.55	-0.10	-0.20	0.07	-0.83	0.29	-0.77	1		
Phosphate	-0.15	-0.04	-0.65	-0.35	0.67	-0.68	-0.23	-0.04	0.11	0.15	0.19	1	
Ammonia	-0.74	0.82	-0.74	0.74	0.87	-0.59	-0.86	0.16	-0.22	0.18	-0.52	0.32	1

The correlation coefficient analysis was done by using VBA Analysis tools and the data were depicted in Table Nos 5, 6 and 7. Correlation between two parameters provides a strong indication for a single reason for their variation.

During monsoon season the high positively correlated ($p < 0.01$) value was found between the Turbidity and pH (0.87), Nitrate and pH (0.83), Sulphate and Temperature (0.91), TS and BOD (0.87), TS and Ammonia (0.87), Nitrate and Turbidity (0.98 and Phosphate and Salinity (0.81). Strong negative correlation observed between DO and Temperature (-0.89), Conductivity and pH (-0.97), Turbidity and Conductivity (-0.79), TS and TDS (-0.70), TDS and Ammonia (-0.88) and BOD and Turbidity (-0.70).

During Pre monsoon season the temperature shows high positive correlation with Conductivity and sulphate (0.84 and 0.92), pH with TS and Ammonia (0.82 and 0.82), TS with Ammonia (0.74), Ammonia with TDS (0.87) and DO with Nitrate (0.98) while high negative correlation was observed between Temperature with pH, DO and Nitrate (-0.93, -0.70,-0.71) pH with Conductivity and Sulphate (-0.71, -0.87), Conductivity with ammonia (-0.74), TS with Salinity (-0.71), TDS with Turbidity and Salinity (-0.88,-0.85), Salinity with Ammonia (-0.86), DO with sulphate (-0.83) and Nitrate with sulphate (-0.77).

In post monsoon season the temperature shows high positive correlation with salinity (0.76), pH with TS with DO and BOD (0.72 and 0.76) and DO with BOD (0.76) while high negative correlation was observed between Temperature with Conductivity (-0.71) pH with Conductivity and Phosphate (-0.71, -0.96), Conductivity with Turbidity and Sulphate (-0.74, -0.79), TS with Sulphate (-0.99), TDS with DO (-0.98), Turbidity with Nitrate (-0.72), DO with Sulphate (-0.78), BOD with sulphate and Ammonia (0.77, -0.85).

Table No 7 Correlation between Physicochemical parameters along the study sites during Post monsoon season

	Temp.	pH	Conductivity	TS	TDS	Turbidity	Salinity	DO	BOD	Nitrate	Sulphate	Phosphate	Ammonia
Temp.	1												
pH	0.20	1											
Conductivity	-0.71	-0.71	1										
TS	-0.51	-0.39	0.81	1									
TDS	0.21	-0.28	-0.15	-0.67	1								
Turbidity	0.47	0.46	-0.74	-0.40	-0.32	1							
Salinity	0.76	-0.38	-0.14	0.04	0.01	0.25	1						
DO	-0.35	0.15	0.27	0.72	-0.98	0.28	-0.07	1					
BOD	-0.01	-0.38	0.40	0.76	-0.73	0.18	0.53	0.76	1				
Nitrate	-0.33	0.28	0.21	0.05	0.21	-0.72	-0.58	-0.27	-0.56	1			
Sulphate	0.57	0.36	-0.79	-0.99	0.72	0.32	0.03	-0.78	-0.77	0.02	1		
Phosphae	-0.16	-0.96	0.55	0.13	0.46	-0.34	0.31	-0.31	0.18	-0.35	-0.12	1	
Ammonia	-0.27	0.65	-0.38	-0.56	0.29	0.00	-0.83	-0.31	-0.85	0.56	0.51	-0.49	1

The sample sites were selected depending upon the industrial activities taken place around the coast. This study reveals that all sites show higher fluctuation in physicochemical parameters. Waste water discharge from sewage and industries are major component of water pollution in Ratnagiri coast (Sankpal and Naikwade, 2012 b). The impact of waste from power plant also plays an important role in sea water pollution (Govindraju *et. al.*, 2011).

The health of Ratnagiri coastal water is at verge of pollution. All the hydrographical and physicochemical parameters studied showed noticeable seasonal as well as spatial variations. Several parameters shows significant high value which is attributed due to direct discharge of effluent from chemical industries which are located along the coast. Proper precautions should be taken by pollution controlling authority to avoid further pollution of Ratnagiri coast. Appropriate management strategies are needed to ensure the sustainable development and management of coastal areas and their resources.

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