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Monitoring of Seasonal Variation in Physicochemical Water Parameters in Nalasopara Region

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Abstract

The main objective of the present study was to assess physicochemical parameters in different water samples in various parts of Nalasopara region. Different water samples collected from sampling sites in Nalasopara region were use to determine the various physicochemical properties on a seasonal basis from July 2012 to May 2013. In sea water turbidity, fluoride, conductance and calcium is highest in winter, chloride and magnesium is increasing in summer whereas sodium, sulfate, nitrite, dissolved oxygen, pH and temperature are highest in monsoon season. High values of these parameters may have health implications and therefore are of great importance to public health. Highly positive correlation is observed between TH and Mg^{2+} (R^{2}=0.998), Mg^{2+} and Cl^- (R^{2}=0.992) and TH and Cl^- (R^{2}=0.990). Our results revealed that the systematic calculations of correlation coefficient between water parameters and regression analysis provide a useful mean for rapid monitoring of water quality.

Keywords: Physico-chemical parameters; Seasonal; Correlation coefficient; Regression equation

Introduction

Water is basic to life and health of all living beings. Adequate drinking water quality is essential for the well-being of all humans who use water not only for drinking but also for municipal, agricultural, industrial and recreational purposes [1]. Water quality of surface, stored and groundwater sources deteriorates by natural phenomena and as a result of human activities making it less suitable for drinking and other uses as water pollutants could highly affect human health along with other living organisms. This essentially requires that the quantitative analysis of major pollutants in water be continuously monitored [1].

Nalasopara as a residential as well as commercial area free from industries altogether is a region in Vasai Taluka in Thane district. After samples are collected from sea water as well as ground and pond water, physicochemical parameters of all water samples were studied. These water quality parameters were used to determine the quality of water and compared it to drinking water standards prescribed by WHO [2], European Standards [3] and Indian Standards: 10500 [4]. The main aim of this study was to analyze whether or not groundwater is safe for domestic purposes, pond water is getting polluted by the anthropogenic activities and the sea water quality is safe for recreational purposes.

Materials and Methods

About study area

Samples were collected from different sites in Nalasopara (NSP). Nalasopara is a part of Vasai Taluka, in Thane district, Mumbai (Figure 1). Mumbai has hot and humid weather throughout the year. Summer (March to May) is the hottest and most humid time of year. Temperatures range from about 30°C to 33°C during the day time. The city sees winter from November to February. January is considered to be the coolest month of the year with mean daily being 16.4°C and mean daily maximum being 28.6°C. Monsoon season (June to September) Mumbai weather is characterized by heavy rain and winds. The season is responsible for the deposition of more than Mumbai's total precipitation of around 1800 mm [5]

Selection of sampling areas and sampling stations

The samples were collected from three sites for sea water on high and low tides, from one site for pond water and from four sites for groundwater. The sea water sites from NSP W are S-1 Karam beach (S1a, S1b) S2 Rajowdi Beach (S2a, S2b) and S3 Rajowdi+1 km (S3a, S3b), where a and b are high and low tides, respectively. The pond water site from NSP (E) is Achole Talao (S8). The groundwater sites S4, S5, and S6 from NSP W lie at Samel Pada, Nala road and Nirmal, respectively, and S7 from NSP E at Tulinj road (Table 1). The groundwater from site S4 is used only for domestic purposes but water at sites S5, S6 and S7 are used for drinking. Pond water (S8) is not served for drinking or any other domestic purposes. Instead, the pond is used for religious

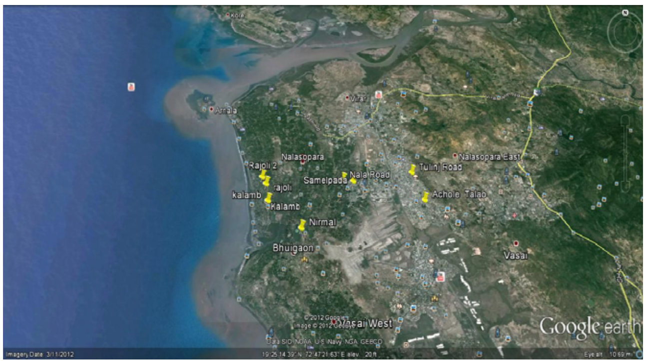

Figure1: Sampling locations in Nalasopara region (Image source: Google earth).

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purposes i.e. Ganpati idol immersion and other holy purposes. Also the pond is cleaned from time to time.

Sampling strategy

The samples were collected seasonally in between July 2012 and May 2013. Water samples were collected in fresh 1L polyethylene bottles previously washed with soap solution and rinsed with DDW. DO samples were collected separately in DO bottles and 2 ml of Manganous sulfate ($MnSO_4$) and 2 ml of Alkali Azide Iodide was added to it to entrap the oxygen. Care was taken while collecting the samples so as to let no air bubble enter.

Sr. No.	Sampling location(Name of the area)	Type of water	Sampling points
1	Karam beach	Sea	S1
2	Rajowdi beach	Sea	S2
3	Rajowdi beach+1 km	Sea	S3
4	Samel Pada	Ground	S4
5	Nala road	Ground	S5
6	Nirmal	Ground	S6
7	Tulinj road	Ground	S7
8	Achole road	Pond	S8

Table1: Sampling locations and sampling points.

Physicochemical and microbial analysis

The samples were analyzed for 15 parameters. The physical parameters like pH and temperature were determined on site using pH paper and thermometer (± 0.1) respectively. The chemical and microbial parameters were analyzed using Standard Methods (APHA) [1]. The parameters and their technique of analysis are listed in Table 2. All chemicals used were of A.R. grade and double distilled water was used throughout this study.

Note: All parameters in ppm except pH, temperature in °C, conductance in mS/cm and turbidity in NTU (nephelometric turbidity unit). Table 3 showed minimum, maximum and average data obtained from *average data of whole study i.e. from July 2012 to May 2013.

Results and Discussion

Drinking water standards by WHO Standards (1993) [2]; EU

Sr. No.	Physicochemical parameters	Method/Instrument used	WHO Standards (1993)	EU Standards (1998)	IS: 10500	
					Desirable limit	Permissible limit
1	Temperature	Thermometer	—	—	—	—
2	pH	pH paper	No guidelines	Not mentioned	6.5-8.5	No relaxation
3	Turbidity	Turbidimeter	No guidelines	Not mentioned	5	10
4	Electrical conductance	Conductometer`	250	250	No guidelines	No guidelines
5	Total Hardness	Titrimetric	No guidelines	Not mentioned	300	600
6	Calcium	Titrimetric	—	—	75	200
7	Magnesium	Titrimetric	—	—	30	100
8	Sodium	Flame Photometer	200	200	—	—
9	Potassium	Flame Photometer	—	10	—	—
10	Chlorides	Titrimetric	250	250	250	1000
11	Nitrites	Spectrophotometer	—	0.5	—	—
12	Sulfate	Turbidimeter	250	250	200	400
13	Fluorides	Spectrophotometer	1.5	1.5	1	1.5
14	E coli	Hydrogen Sulfide Production Test	Not mentioned	0/ 250 ml	—	—
15	Dissolved Oxygen	Winkler's Method	No guidelines	Not mentioned	—	—

Table 2: Methods used to determine physicochemical parameters along with WHO, IS and EU standards.

Season	Monsoon				Winter				Summer			
Parameter	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
pH	6	8	7	0.775	5	7	6	0.632	6	8	6.455	0.688
EC	0.65	30.46	17.23	14.680	0.292	48.257	26.590	23.925	0.352	38.199	21.114	18.635
Temp	25	29	27.182	1.250	21	27	24.455	1.440	26	31	28.818	1.471
Turbidity	1.68	8.28	2.856	1.920	0.4	25.4	10.29	7.730	1.2	11.3	4.864	3.206
TH	120.1	6184.94	4153.775	2492.657	80.071	6430.718	3660.528	3133.711	80.064	6580.26	3726.615	3159.816
Ca.H.	60.05	980.85	622.365	386.239	60.053	1100.979	658.840	444.576	60.053	1000.89	643.299	400.133
Mg. H.	50.58	4883.86	2524.022	2205.117	16.861	4531.394	2528.384	2274.263	16.861	4700.004	2585.864	2327.682
Ca	24.05	392.76	248.832	154.330	24.047	440.858	263.786	178.019	24.047	400.78	257.592	160.222
Mg	14.58	1263.86	711.916	619.128	4.861	1306.394	728.929	655.666	4.861	1355.004	580.844	647.196
Na	26.64	14532	7438.623	6985.897	18.934	12106.5	6458.677	6043.764	16.77	11854.75	6453.932	6066.17
K	2	446.55	250.375	1293.783	3.258	443.45	240.208	1164.968	1.125	466.75	257.031	226.375
SO4	17.864	750.8	405.361	290.097	10.658	2872.8	1497.336	1283.105	10.288	2920.0	1547.194	1325.773
NO2	0.25	5.2	1.745	1.707	0.2	0.7	0.409	0.176	0.027	0.12	0.064	0.028
Cl	7.09	18079.5	9792.025	9253.296	35.45	19213.9	10448.726	9828.407	35.45	20135.6	10914.088	9456.36
F	0.07	1.04	0.742	0.284	1.00	1.533	1.288	0.190	0.238	1.676	0.843	0.436
DO	1.536	5.376	3.072	1.190	1.76	3.52	2.592	0.935	1.152	3.456	1.711	0.651

Table3: High, low and average values from average values* of physicochemical parameters.

Standards (1998) [3] and Indian Standard: 10500 Desirable limits and Permissible limits [4] are summarized in Table 2.

High, low and average values obtained from July 2012 to May 2013 of physicochemical parameters of different water samples from different locations are showed in Table 3.

pH of water affects many chemical and biological processes in water. Most natural water in the study region has pH values in between 5 to 10 with the greatest frequency of values falling in between 6.5 to 9 [6]. The pH of water samples was seen from 5 to 8 with the minimum value recorded in winter season. pH is seen to be the highest in monsoon season in sea water. pH is higher in pond water in summer but no significant pattern is seen for the groundwater samples and lies in the range as per IS.

Specific conductance as an indicator of the total concentration of dissolved ions is a valuable tool in assessing water quality [7]. Conductance was seen to range from 0.292 to 48.257 mS/cm. It was highest in sea water for winter season. In pond water conductance is higher in rainy season. The values were in the range as per standards. Cool water is generally more palatable than warm water, and temperature will impact the acceptability of a number of other inorganic constituents and chemical contaminants that may affect taste. High water temperature enhances the growth of microorganisms and may increase taste, odour, color and corrosion problems [2]. The temperature ranged from 21 to 31°C, as expected it increased from winter to monsoon and from monsoon to summer in all the water samples. Turbidity in water is caused by suspended and colloidal matter such as clay, silt, fine organic and inorganic matter, and plankton and other microscopic organisms [1] and was in the range of 0.4 to 25.4 NTU.

Water hardness in most groundwater is naturally occurring from weathering of limestone, sedimentary rock and calcium bearing minerals. Hardness can also occur locally in groundwater from excessive application of lime to the soil in agricultural areas [8] and was in the range of 80.064 to 6580.26 mg/L. Total hardness was higher in summer in all the sea water samples and was in the range as per the standards for all the groundwater and pond water samples except in S5 groundwater sample whose hardness was higher in all the seasons exceeding the permissible limit (600 mg/L) by IS.

The average abundance of Ca and Mg in groundwater was from 1 to >500 mg/L and >5 mg/L respectively [1]. The presence of calcium and magnesium in groundwater is mainly due to its passage through or over deposits of limestone, gypsum and other gypsiferous materials [9]. Ca was in the range of 24.047 to 400.858 mg/L. Calcium was highest in winter in all the sea water samples and was highest in summer for pond water, whereas no significant difference was observed for the groundwater samples. Mg was in the range of 4.861 to 1355.004 mg/L. Magnesium concentration rose in summer in all the sea water samples and was more in rainy season for the pond water sample. No significant difference was seen for the groundwater samples; however, the value for S5 was more than the permissible limit set by IS.

The average abundance of Na in groundwater was >5 mg/L, while that of K ranged from 0.5 to 10 mg/L. High Na concentrations in water were reported to adversely affect human cardiology [1]. Na was in the range of 16.77 to 14532 ppm and was higher in rainy season in the pond and all the sea water samples. No significant difference was observed for the groundwater samples. Na concentrations were above the range recommended by WHO and EU in the groundwater sample S5. Potassium is an essential element in both plant and human nutrition, and occurs in groundwater as a result of mineral dissolution, from decomposing plant material, and from agricultural runoff [1]. K was in the range of 1.125 to 446.75 ppm in the groundwater samples, except in S7 whose K value was slightly higher than the EU threshold (10 ppm) and in S5 whose K value was exceptionally high reaching up to 78.59 ppm. In sea water, no significant difference was observed, while the value in pond water was higher in the rainy season.

The presence of sulfate in drinking water can cause noticeable taste, and very high levels might cause a laxative effect in unaccustomed consumers [2]. It was seen in the range of 10.288 to 2920 ppm. SO_4^{2-} concentration was higher in the rainy season for the sea water samples and in the summer season for the pond water sample and was within the permissible limit for all the groundwater samples, as per IS. Nitrite in water is either due to oxidation of ammonium compounds or due to reduction of nitrate. As an intermediate stage in the nitrogen cycle, nitrite is unstable [10]. Nitrite was in the range of 0.027 to 5.2 ppm and was higher in the rainy season for the sea and pond water samples. Chloride is the common anion found in groundwater and gives brackish taste to the water and was in the range of 7.09 to 20135.6 ppm. Fluoride ions are significant in water supplies in that high concentration of F-causes dental fluorosis (disfigurement of the teeth), whereas a concentration less than 0.8 mg/L results in 'dental caries'. Hence, it is essential to maintain F-concentration between 0.8 to 1.0 mg/L in drinking water [10]. F^- was in the range of 0.07 to 1.676 ppm and was highest in all the water samples in the winter season.

Correlation

Correlation is a method used to evaluate the degree of interrelation and association between two or more variables. A systematic study of correlation coefficients of the water quality parameters not only helps to assess the overall water quality but also quantifies the relative concentration of various pollutants in water, thus providing a necessary indicator for the implementation of rapid water quality management programs [8]. The correlation between variables is characterized as strong, in the range of +0.8 to 1 and -0.8 to -1, moderate in the range of +0.5 to 0.8 and -0.5 to -0.8, and weak in the range of +0.0 to 0.5 and -0.0 to -0.5 [10]. Correlation coefficients among water quality variables (Table 4) indicate that magnesium has a strong correlation with hardness and chloride. Also hardness is strongly correlated with chloride.

Regression

Regression analysis allows for not only the calculation of a mathematical equation for a given set of data but also the prediction of water quality indices. The mathematical equation may either be used as a description of any significant association between two variables or to predict values [8]. Our regression results showed that (I) EC and Mg^{2+}, EC and Cl^- (R^2=0.929), (II) TH and Na, Mg^{2+} and Na (R^2=0.974) and (III) Mg^{2+} and SO_4^{2-} , Ca^{2+} and SO_4^{2-} (R^2=0.651) (Table 5).

Conclusion

Analyses of the quality of sea, groundwater and pond water samples collected seasonally indicated that K content was higher in all the groundwater and pond water except in S7.The groundwater sample S-5 had higher values for total hardness, Mg, Na and K than the permissible limit set by WHO. These factors may pose health hazards if consumed regularly and in high amounts. Hence water treatment is essential before water resources of the study region are used for drinking purposes although the other groundwater and the pond water samples were relatively less contaminated.

	pH	EC	Temp	Turbidity	T.H.	Ca	Mg	Na	K	SO_4	NO_2	Cl	F
pH													
EC	-0.165												
Temp	-0.002	0.083											
Turbidity	-0.264	0.52	-0.145										
T.H.	-0.121	0.965	0.214	0.362									
Ca	-0.088	0.95	0.219	0.431	0.976								
Mg	-0.127	0.964	0.212	0.351	0.999	0.969							
Na	-0.099	0.929	0.224	0.299	0.987	0.958	0.987						
K	-0.012	0.409	0.028	0.134	0.42	0.418	0.416	0.431					
SO 4	-0.303	0.888	0.161	0.61	0.808	0.807	0.807	0.718	0.286				
No	0.167	0.189	0.108	-0.218	0.336	0.321	0.334	0.44	0.417	-0.18			
Cl	-0.128	0.964	0.239	0.353	0.995	0.963	0.996	0.981	0.408	0.818	0.306		
F	-0.245	0.48	-0.349	0.467	0.385	0.356	0.388	0.359	0.249	0.452	0.049	0.394	
DO	0.168	-0.186	-0.219	0.051	-0.263	-0.273	-0.26	-0.25	-0.054	-0.227	0.053	-0.284	0.0013

Table4: Pearson's correlation coefficient of various physicochemical parameters in the collected water samples.

R^2 value	Regression equation
0.931	EC=0.064 (TH)-1.142
0.903	EC=0.115 (Ca^{+2})-7.876
0.929	EC=0.029 (Mg^{+2})+0.082
0.863	EC=0.002 (Na^{+1})+2.009
0.789	EC=0.014 (SO_4^{2-})+4.844
0.929	EC=0.002 (Cl^-)+0.246
0.372	Turbidity=0.003 (SO_4^{2-})+2.560
0.953	TH=18.27 (Ca^{+2}) – 1041
0.998	TH=4.735 (Mg^{+2})+194.2
0.974	TH=0.475 (Na^{+1})+426
0.653	TH=2.055 (SO_4^{2-})+1287
0.990	TH=0.320 (Cl^-)+235
0.939	Ca^{+2}=0.245 (Mg^{+2})+77.69
0.918	Ca^{+2}=0.024 (Na^{+1})+89.6
0.651	Ca^{+2}=0.109 SO_4^{2-}+130
0.927	Ca^{+2}=0.016 (Cl^-)+80.01
0.974	Mg^{+2}=0.100 (Na^{+1})+49.27
0.651	Mg^{+2}=0.432 (SO_4^{2-})+232
0.992	Mg^{+2}=0.067 (Cl^-)+8.49
0.516	Na^{+1}=3.791 (SO_4^{2-})+2424
0.962	Na^{+1}=0.657 (Cl^-) – 207.9
0.669	SO_4^{2-}=0.103 (Cl^-)+45.69

Table 5: Linear-regression equations to predict water quality variables.

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