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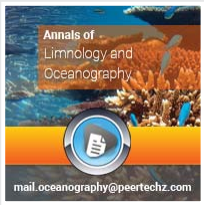

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Research Article

Analysis of physicochemical parameters of the Hebbal, Shivpura, Elemallappa Shetty Lakes in Bengaluru City, India

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Abstract

A comparative physicochemical study was done by collecting water from three lakes in Bengaluru City, India. Most of the collected water samples were observed to be within the prescribed limits suggested by World Health Organization and Indian Standard Institute for drinking purpose. Seasonal variations are seen in physical and chemical parameters like color, odour, pH, temperature, dissolved oxygen, Biological oxygen demand, turbidity, electrical conductivity, chlorine content, metals present etc. We have studied for a period of 12 months during 2019. Statistical analysis was carried on the studied parameters using SPSS software.

Abbreviations

DO: Dissolved oxygen; BOD: Biological Oxygen Demand; L: Litre; mg: milli gram; mg/L: milligram/Litre; mm: milli meter; ppm: parts per million; km: kilo meter; µS: micro Siemens; C: Celcius; º: Degree; WHO: World Health Organization; WQI: Water Quality Indian; BSI: Bureau of Indian Standard.

Introduction

Water is the most important compound in shaping the land and regulating the climate. It is one of the crucial compound that is believed to influence life. The water quality is usually described according to the physical, chemical and biological characteristics. The indiscriminate release of chemical fertilizers, pesticides, industrial effluents are causing heavy and varied pollution in the aquatic environment leading to the deterioration of water quality which in turn depletes the aquatic biota.

The use of the contaminated water by human population results in water borne diseases. Hence it is important to check the water quality at a regularly. The present paper investigates some important physicochemical parameters of water samples collected and do a statistical inference on the same. Three lakes in Bengaluru city like Hebbal lake in Northern Bengaluru, Shivpura lake and Elemallappa Shetty Lake in Southern Bengaluru were selected to study the physicochemical parameters, as these lake waters were polluted by industrial effluents, agricultural run off, domestic discharges etc. physicochemical parameters like color, odour, pH, temperature, dissolved oxygen, biological oxygen demand, turbidity, electrical conductivity, chlorine content, metals content like Magnesium, Chromium, Iron, Tin, Mercury, Calcium were studied and statistically analyzed for a period of 12 months from January, 2019 to December, 2019. A general applied mathematics study and analysis on the biophysical and chemical parameters of the lake's surface water quality are applied to seek out the interrelatedness among them and conjointly to understand the water quality trends within the lake. The equation has been derived for the surface water quality parameters similar to the correlation coefficients whose value is over 0.8. These equations will be used for the fast observation of the surface water quality of the lake. Similarly, a scientific correlation and regression study on the surface water qualities within the study space showed linear relationship among the chosen parameters. This provides an apparent and fast methodology of observation in qualities of the lakes studied. Water quality of the lakes has been determined. Water quality of the lakes is studied to summarize the collected information into easy terms (e.g., 'Good' or 'Bad', 'Clean' or 'Contaminated') for news to authorities, management and

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therefore the public in an exceedingly consistent manner. It is important to note that no work has been reported on Hebbal, Shivpura and Elemallappa Shetty Lakes earlier.

Materials and methods

Study area

Hebbal Lake is found within the north of Bangalore at the mouth of National main road seven, on the junction of Bellary Road and also the Outer route (ORR). it absolutely was one in all the 3 lakes created in 1537 by Kempe Gowda. The unfold of the lake in a very study in year 2000 was found to be seventy-five angular distance with plans for extending it to create up 143 angular distance. Shivapura is found 5 kilometers north of Maddur city on the bank of Shimsha watercourse. Shivapura is an element of Mandya taluk in Mandya district, Karnataka. the situation coordinates square measure 13°1'24"N 77°30'23"E. settled nearer to 1 of Asia's largest industrial parks–the Peenya Industrial Estate- the Shivapura-Nelagadarenahalli lake goes the Bellandur method. Elemallappa Shetty Lake is within the North-Eastern a part of Bengaluru town close to Whitefield. This lake is about 260 acres. This is one in all the biggest lakes in Bengaluru town. This lake has the recent Madras Road passing through it – a road that has very important property from the central Bengaluru through Indiranagar, KR Puram, Hoskote, Chennai.

pH

pH is that the measure of acidity of any water solution [1-3]. The pH unremarkably ranges from 0 to 14 [1-4]. the size isn't linear rather it's logarithmic. as an example , a solution with a pH of 6 is 10 times additional acidic than a solution with a pH of seven [1,3,4,5]. Pure water is claimed to be neutral, with a pH of 7 . Water with a pH below 7.0 is taken under consideration acidic whereas water with pH bigger than 7.0 is taken under consideration basic or alkalic [6]. The measure of Ph was done on the location of water collection. Ph meter was used for detection of Ph of the collected water samples [7-18].

Temperature

The temperature of all collected water samples from 3 locations were at intervals of 23ºC to 31ºC. The minimum temperature was found to be 23.2ºC in Shivpura Lake within the month of January. Temperature range is found to be low during the post monsoon periods of July and August [19-21]. Pre monsoon months and summer months have an increase in temperature to 30.7ºC. the general seasonal variation in temperature is being observed all-round the year [21,22]. The temperature fluctuations don't provide a drastic shock to the sustaining aquatic life [23]. Surface water temperature could also be influenced by factors like geographical position, seasonality, diurnal amount, circulation of air, amount of inclemency, depth of water and its rate [11-16].

Electrical conductivity

Conductivity is the measure of amount of electric charge which can pass through the water samples [18]. This ability depends on the presence of ions, their total concentration, mobility, valence and relative concentrations, and on the temperature of the liquid [23]. Solutions of most inorganic acids, bases, and salts square measure comparatively smart conductors. The EC of all collected water samples from 3 locations were at intervals of 0.6 to 2.3 µS/cm with a mean of 1.43 (SD±0.85). The maximum and minimum of EC was found to be 0.61 µS/cm and 2.7 µS/cm respectively during the monsoon months. From the study, the measured EC of all water samples collected from Hebbal, Shivpura and Elemallappa Shetty Lake was lower than acceptable range. Within the monsoon season, the flow of the watercourse will increase which can cause the dilution of the salinity of the water, whereas in season, the flow of the watercourse decreases which ends up in increase of EC [21].

Dissolved oxygen (DO)

DO is defined as the amount of oxygen dissolved in the water samples. It's essential for respiration of fish and other aquatic organisms [3]. DO enters water by diffusion from the atmosphere, as a by product of chemical process by protists or through photosynthesis performed by plants [24-30]. The concentration of DO in waters depends on the organisms surviving in it, because all metabolic processes taking place utilizes the dissolved oxygen available [9]. Excessive protist or other microorganism in the aquatic environment depletes the amount of dissolved oxygen and it affects the metabolic processes performed by other macro organisms [10-16]. Other processes like decomposition of dead performed by different scavengers in the aquatic environment utilizes the dissolved oxygen [11,12]. Fish want a minimum of 3-5 mg/L of DO to survive [21,23,30-34]. DO is observed to vary within the range of 13.13 mg/L to 28.28 mg/L with the mean of 19.98 mg/L. Winkler's method was carried out on the site of sample collection to measure the DO [25]. About 1 ml of manganous sulphate, 1 ml of potassium/sodium azide are added to 120 ml of sample water samples from the three distinct sites [25]. Brown precipitation was observed which indicated the presence of dissolved oxygen in the collected water samples [9,25,29,35]. About 1 ml of concentrated H_2SO_4 was added and titrated against sodium thiosulphate and starch solution was used as an indicator [25,29]. The colour change from blue to pale yellow marked the level of DO content [25,11].

Turbidity

Turbidity is defined as the cloudiness or haziness of a fluid. It can be caused by large numbers of individual particles that are generally invisible to the naked eye [36-38]. Water samples were collected from three distinct lakes and a nephelometer or turbidimeter was used to measure turbidity of each water sample[39]. Nephelometer or turbidimeter is an instrument which measures the intensity of light scattered at 90 degrees as a beam of light passes through a water sample [40]. It is observed that turbidity varied within the range of 0.35 NTU to 10.9 NTU. The mean is found to be 4.822 NTU (SD±4.522).

Biological oxygen demand (BOD)

Biological oxygen demand (BOD) is that the quantity of dissolved oxygen element required (i.e. demanded) by aerobic

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biological organisms to break down the organic materials at a certain temperature over a specified time interval [41-43]. The water samples were collected from each study site in 120 ml BOD bottles and kept in kept in incubation for 5 days [40,44]. After 5 days the DO was measured using Winkler's method. The difference between the readings of DO (Day 1) and DO (Day 5) gives the BOD reading [40,45-47]. The difference between the two DO levels represents the amount of oxygen required for the decomposition of any organic material in the samples [48-50]. The mean of BOD was observed to be 8.08 (SD±10.456). The decrease in DO level in the water sample of Elemallappa Shetty Lake was more compared to other water samples. This may be because the organic material content in the water sample collected from Elemallappa Shetty Lake is more comparatively.

Platinum cobalt unit test

Water samples from three distinct sites were collected and kept at room temperature [8]. The collected water samples were analyzed within 7 days of collection. Samples were filtered using filters of defined pore size. The 0.45 ~m filters were used for routine filtration. Standard color solutions were prepared by dilution of standard platinum chloride (I ms/ml,) and cobalt chloride ($CoCl.6H_20$) solution. The molar ratio of Pt :Co its the standard color solution is 2:1 ~ the concentration of Pt in mg/i is equal to the "color" in PTU [8]. Color was determined using turbidimeter. The detection of water color specify the extent to which collected water samples are polluted [8]. Shivpura lake water samples had the highest NTU compared to other water samples.

Metal analysis

The acid-available fraction of metals (Sn, Mg, Hg, Fe, Ca, Cr, Pb) was determined [6,24,51-53]. The data quality was checked by careful standardization, procedural blank measurements, spiked and duplicate samples [54,55]. Atomic Absorption Spectroscopy was used for detection and analysis of metal traces present in the water samples collected [24, 29,56,57].

Statistical analysis

The correlation analysis on surface water quality parameters reveals that all parameters are more or less correlated with each other. The correlation coefficient (r) of > 0.8 was taken in to account to find the regression equations. The SPSS and Windows Excel were used as the statistical analysis tool. The term correlation (or co-variation) indicates the relationship between two variables such that the changes in the values of one variable cause the value of the other variable to change. We can establish inter-relationship between variables by statistical methods with a few sets of observations. It gives a rough but fairly useful indication of the water quality and also facilitates a rapid monitoring of the status of water pollution. Statistical investigation offers more attractive options in environmental science, though the results may deviate more from real situations. The correlation provides an excellent tool for the prediction of parametric values within a reasonable degree of accuracy [58]. The quality of water is described by its physical, chemical and microbial characteristics. But, if some correlations are possible among these parameters, then the more significant ones would be useful to indicate fairly the quality of water [10,59,60].

Discussion

One of the troublesome task faced by the scientists is to transfer their interpretation of complicated environmental knowledge into information that is graspable and helpful to technical, policy makers and the general public. This can be significantly necessary in examination of the condition of the surroundings. Internationally, there are variety of pacts to provide a way that means absolutely integrates data and converts them into information. This study is administered to gauge the connection between different physicochemical parameters, metal content and assess the water quality of Hebbal, Shivpura and Elemallappa Shetty Lakes. The standard of water is that the resultant of all the processes and reactions that act on the water from the instant it condensed within the atmosphere to the time it gets discharged by a well or spring and varies from place to place and with the depth of the water table. The correlation coefficients of studied parameters are tabulated in Tables 1.0 to 2.1. The study reveals the following relationships. pH has significant relationship between dissolved oxygen (DO), biological oxygen demand (BOD). There is no significant relationship between pH and Temperature, Turbidity, Chlorine content, platinum cobalt unit (PCU). There is significant relationship between dissolved oxygen (DO) with temperature, Electrical conductivity. There is significant relationship between Electrical conductivity and chlorine content. There is significant relationship between platinum cobalt unit (PCU) and biological oxygen demand (BOD), chlorine content and Electrical conductivity. Significant relationship is observed between metals like Sn, Mg, Fe, Hg, Ca and Cr with parameters such as Electrical conductivity, Turbidity, platinum cobalt unit (PCU). According to Indian Standard drinking water specifications (2012), pH of water from all the lakes are within permissible range 6.5-8.5, Chlorine content in water should be or less than 4 mg/l or 4 ppm for considering it safe

Table 1.0: Physico-chemical parameters observed in Hebbal Lake water.

Months	pH	DO	Tempe--rature	Turbi- dity	BOD	Electrical Conduct -ivity	Chlorine Content	PCU
January	7.0	21.21	24	0.34	4.04	2.3	0.03	77
February	6.8	18.18	26.5	0.38	2.02	2.0	0.02	73
March	7.6	17.17	26	0.38	11.11	2.61	0.01	68
April	7.2	15.15	31	0.37	8.08	1.08	0.02	69
May	7.6	16.16	27.5	0.35	9.09	2.82	0.01	71
June	7.4	18.18	29	0.36	12.12	2.5	0.03	73
July	6.9	19.19	30.7	0.35	7.07	2.6	0.01	76
August	7.2	22.22	29	0.37	4.04	2.41	0.02	67
September	7.2	36.36	27	0.36	20.2	2.5	0.03	77
October	7.5	26.26	25	0.39	8.08	2.7	0.01	80
November	6.9	16.16	26	0.36	9.09	2.62	0.02	75
December	7.1	23.23	25	0.37	4.04	2.5	0.02	76

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for consumption, agriculture and fisheries. The average of chlorine content in water samples was 0.03 mg/l thus, safe for use. Iron content in water should be within 0.3 mg/l but in water samples collected from Elemallappa Shetty Lake is 1.4

Table 1.1: Metals (ppm) observed in Hebbal Lake.

Months Sn	Mg	Hg	Fe	Ca	Cr	
January 3.57	1.52	0.92	0	0.62	0.12	
February	4.23	1.71	0.98	0.3	0.31	0
March 25	1.62	2.1	0.1	0.12	0.02	
April 24.09	0.12	2.63	0.02	0.32	0	
May 24.6	0.76	2.31	0.09	0.34	0	
June 23.4	0.54	2.72	0.07	0.19	0	
July 22.93	0.21	2.42	0.06	0.21	0	
August 24.32	1.44	0.98	1.24	0	0	
September	29.5	1	0	0.23	0.88	0
October 25.93	1.678	2.24	0.1	1.72	0.12	
November 22.54	1.76	0.84	0	12.73	0.125	
December	3.33	1.65	0.62	0	15.34	0.42

Table 1.2: Physico-chemical parameters observed in Shivpura Lake.

Months	pH	DO	Tempe--rature	Turbi-dity	BOD	Electrical Conduct-ivity	Chlorine Content	PCU
January	6.9	19.19	22.3	10.6	9.09	1.03	0.01	218
February	7.4	21.21	22.6	10.9	9.09	1.02	0.01	215
March	6.8	20.2	32.5	10.6	3.03	1.05	0.02	219
April	7.1	18.18	33.5	10.9	5.05	2.7	0.03	216
May	7.8	17.17	25	11	9.09	1.08	0.02	216
June	7.4	21.21	25.4	10.7	4.04	1.07	0.02	217
July	7.2	20.2	27	11	4.04	1.03	0.02	218
August	7.5	16.16	26.7	10.5	4.04	1.06	0.02	213
September	7.2	15.15	29	10.6	6.06	1.09	0.01	215
October	7.1	16.16	29	10.8	4.04	1.06	0.02	217
November	6.8	13.13	24	12	5.05	1.07	0.03	217
December	7.4	17.17	24.8	10.7	8.08	1.05	0.02	220

Table 1.3: Metals (ppm) observed in Shivpura Lake.

Months Sn	Mg	Hg	Fe	Ca	Cr	
January 22.67	1.54	1.82	0.1	0.5	0	
February	23.17	1.51	2.13	0.13	0.13	0
March 24.32	1.64	2.4	0.02	0.04	0.3	
April 24.13	1.54	2.1	0.01	0.21	0	
May 23.9	1.9	2.92	0.12	0.12	0	
June 23.7	2.7	2.52	0.11	0.21	0	
July 23.1	2.34	2.71	0.17	0.3	0	
August 29.62	1.89	0.44	0.54	0	0	
September	20.23	0.6	0.98	0.02	1.54	0
October 24.98	1.67	2.61	0.02	1.49	0.06	
November	23.18	1.83	1.08	0	6.72	1.225
December	22.92	1.39	1.05	0	7.39	1.31

Table 1.4: Physico-chemical parameters observed in Elemallappa Shetty Lake.

Months	pH	DO	Tempe--rature	Turbi-dity	BOD	Electrical Conduct-ivity	Chlorine content	PCU
January	6.2	17.17	24.3	3.2	1.01	0.63	0.02	5
February	7.4	9.9	23.7	3.3	3.8	0.68	0.02	7
March	7.1	21.21	27	3.5	2.02	0.64	0.03	6
April	6.9	20.2	34	3.2	12.12	0.6	0.01	8
May	7.3	23.23	31.5	3.4	3.18	0.68	0.03	7
June	7.1	19.19	27	3	7.07	0.69	0.03	8
July	6.8	24.24	27.9	3.3	3.03	0.73	0.03	9
August	7	34.34	31.3	3.4	4.31	0.63	0.01	7
September	7	7.07	28	3	18.18	0.61	0.02	6
October	7.3	19.19	27.5	3.1	1.01	0.71	0.03	8
November	7	18.18	25.5	3.3	12.12	0.66	0.03	9
December	7.3	28.28	25	3	11.11	0.62	0.03	7

Table 1.5: Metals (ppm) observed in Elemallappa Shetty Lake.

Months	Sn	Mg	Hg	Fe	Ca	Cr
January	23.72	1.52	0.98	1.13	0.13	1.20
February	24.34	1.49	1.32	2.12	0.10	1.1
March	24.21	1.31	1.9	3	0.02	0.04
April	24.19	0.3	2.72	2.3	0.16	0
May	24.2	0.64	2.66	3.2	0.52	0
June	23.89	0.7	2.53	1.83	0.41	0
July	22.84	0.16	2.37	1.37	0.32	0
August	28.21	1.67	0.23	2.21	0	0
September	25.2	0.8	0.71	0.06	0.54	0
October	24.38	1.29	2.61	3.52	1.45	0.22
November	23.53	1.81	0.81	0	25.31	2.35
December	22.12	1.73	0.51	0	31.26	2.51

Table 1.6: Correlation matrix of Hebbal Lake physico chemical parameters.

	pH	DO	Tem-per-ature	Turb-idity	BOD	Electrical Conduct-ivity	Chlorine Content	PCU
Ph	1.00							
DO	0.022	1.00						
Tem- per ature	-0.030	-0.275	1.00					
Turb- idity	0.250	0.08	-0.126	1.00				
BOD	0.409	0.498	0.127	-0.09	1.00			
Electrical Conduc-tivity	0.289	0.253	-0.417	-0.14	0.206	1.00		
Chlorine Content	-0.331	0.344	-0.099	-0.35	0.218	-0.259	1.00	
PCU	-0.267	0.518	-0.476	-0.12	0.116	0.332	0.155	1.00

mg/l in average thus, should not be considered for direct use in homes, fields and fishery sectors without prior treatment. Magnesium (Mg^{2+}) content should be within 30 mg/l and all the collected samples had 2.32 mg/l of Mg^{2+} in average, thus safe for other uses. Chromium content should be 0.1 mg/l or

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less, Hebbal Lake water samples are safe for use since the Chromium content was less, but for Shivpura and Elemallappa Shetty Lake water, pre use treatment is required before use.

Table 1.7: Correlation matrix of Hebbal Lake metals observed

	Sn	Mg	Hg	Fe	Ca	Cr
Sn	1.00					
Mg	-0.415	1.00				
Hg	0.377	-0.591	1.00			
Fe	0.164	0.171	-0.26	1.00		
Ca	-0.348	0.426	-0.43	-0.271	1.00	
Cr	-0.565	0.467	-0.375	-0.286	0.846	1.00

Table 1.8: Correlation matrix of Shivpura Lake physico chemical parameters.

	pH	DO	Tem-per ature	Turb-idity	BOD	Electrical Conduct -ivity	Chlorine Content	PCU
pH	1.00							
DO	0.113	1.00						
Tem-perature	-0.280	-0.024	1.00					
Turb- Idity	-0.267	-0.446	-0.239	1.00				
BOD	0.373	0.055	-0.643	-0.008	1.00			
Electrical Condu-ctivity	-0.112	0.003	0.596	0.038	-0.124	1.00		
Chlorine Content	-0.173	-0.336	0.394	0.568	-0.485	0.521	1.00	
PCU	-0.4026	0.230	0.008	0.068	0.010	-0.135	0.124	1.00

Table 1.9: Correlation matrix of Shivpura Lake metals observed.

	Sn	Mg	Hg	Fe	Ca	Cr
Sn	1.00					
Mg	0.398	1.00				
Hg	-0.173	0.460	1.00			
Fe	0.772	0.311	-0.317	1.00		
Ca	-0.250	-0.209	-0.490	-0.394	1.00	
Cr	-0.151	-0.110	0.438	-0.363	0.960	1.00

Table 2.0: Correlation matrix of Elemallappa Shetty Lake physico chemical parameters.

	pH	DO	Temp-rature	Turb-idity	BOD	Electrical Conducti -ivity	Chlorine Content	PCU
Ph	1.00							
DO	0.020	1.00						
Temp- Rature	0.051	0.372	1.00					
Turb- Idity	-0.016	0.307	0.220	1.00				
BOD	0.090	0.31	0.137	-0.513	1.00			
Electrical Conduc-tivity	0.242	0.010	-0.20	0.115	-0.55	1.00		
Chlorine Content	0.298	-0.03	-0.458	-0.08	-0.20	0.599	1.00	
PCU	0.303	0.207	0.203	-0.03	0.115	0.541	0.259	1.00

Table 2.1: Correlation matrix of Elemallappa Shetty Lake metals observed.

	Sn	Mg	Hg	Fe	Ca	Cr
Sn	1.00					
Mg	0.159	1.00				
Hg	-0.291	-0.728	1.00			
Fe	0.304	-0.238	0.659	1.00		
Ca	-0.471	0.520	-0.460	-0.637	1.00	
Cr	-0.481	0.683	-0.555	-0.635	0.885	1.00

All the water samples contain Calcium within permissible limit that is 75 mg/l, thus safe for use. Overall, Hebbal and Shivpura Lake water samples are of good quality but Elemallappa Shetty Lake is of poor quality. Elemallappa Shetty Lake water contains most amount of pollutants and need pre use water treatment. Based on this study it is been found that water resources potential analysis in terms of quantification of surface water is important to evolve water resources development plans for the lakes in metropolitan cities like Bengaluru. Initiatives are taken to popularize the programs among the general public, particularly farmers at numerous levels, that ought to be created effective thus on attain self-sufficiency within the property water resources development. Prioritization ought to run within the over-extracted areas in the city thus on conservation of the water and for designing acceptable structures to be placed into action.

Conclusion

The results of seasonal variation and physico–chemical study of the lake water samples, helps us to conclude regarding the quality of the water samples studied. The pH of the water has an effect on the life forms. The samples have carbonate (CO_3^{2-}), traditional salt (SO_4^{2-}) and are moderately alkaline in nature. The comparison of analyzed information with UN agency, ISI and BIS fascinating limit indicates that the water samples are moderately appropriate for drinking. In different sectors like industries, fisheries, micro-irrigation like drip- and sprinkler-irrigation can be done using the water of Hebbal and Shivpura Lakes. Water of Elemallappa Shetty Lake is comparatively polluted due to dumping of industrial wastes. Pre use water treatment is necessary for the water of Elemallappa Shetty Lake. The quality of surface water depends on the different types of rocks present in the area. Major portion of the Shivpura and Elemallappa Shetty Lake is covered with hard and sedimentary rocks. Hardness is due to presence of Calcium, Magnesium, Bicarbonate and Chloride ions from the presence of rocks. The presence of major cations like Calcium, Magnesium, Iron was found to be within the permissible range thus, the water from all the three sites were suitable for using domestically and for agricultural purposes. We should protect the lakes in the city rather than dumping the industrial effluents and domestic wastes in the water bodies carelessly.

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