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Urban Pond Water Contamination in India

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Abstract

The stagnant water reservoirs in urban area of India are severely contaminated with surfactant and microbe due to anthropogenic activities. In this work, water quality of pond water of the most industrialized city: Raipur, CG, India is described. The concentration of surfactant in the term of sodium lauryl sulfate (SLS) in water (n = 16) is ranged from 7.0 - 27 mg/L with mean value of 17 ± 3 mg/L. All ponds are found to be contaminated with microbes *i.e.* bacteria, algae and fungi at elevated levels. The physico-chemical characteristics of the pond water are discussed.

Keywords

Surfactant, Water Quality, Microbe, Pond

1. Introduction

Pond is stagnant water reservoir used for various purposes *i.e.* bathing, drinking and washing for humans and other animals. The contaminants *i.e.* surfactants, microbes, nutrients, heavy metals, organic toxicants, etc. are brought to the pond by the streams, runoff water, municipal waste, etc. [1]-[3]. The water contaminants (*i.e.* facial coliforms, facial streptococci, *Salmonella*, algae and fungi) and surfactants cause health hazards [4]-[6]. Many animals that live in the surrounding area, such as migrating birds, and nearby plants depend on these ponds for a rich source of nutrients and water. However, the stagnant water bodies such as ponds, lakes and rivers are contaminated with the microbes and surfactants at hazardous levels [7]-[25]. In this work, the water quality of ponds of Raipur city with emphasis on microbial and surfactant contamination is assessed.

2. Materials and Methods

2.1. Area of Study

Raipur (22˚33'N to 21˚14'N and 82˚6'E to 81˚38'E) is a capital of Chhattisgarh state, India with population of 2

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million. Several ponds >20 occurs over ≈1000 km^2 area in the city for drinking, bathing, washing and fishing purposes. All pond waters are eutrophied with the decreased aquatic biodiversity. They recharge the groundwater resources by transporting the contaminants.

2.2. Sample Collection

The water from 16 ponds during April 2014 was sampled, **Figure 1**. The composite water sample (100 mL) from five points of each pond was collected into sterile glass bottles (500 mL) as prescribed in the literature [26]. The physical parameters *i.e*. pH, temperature (T), electrical conductivity (EC), dissolved oxygen (DO) and reduction potential (RP) were measured at the spot.

2.3. Analysis

The water samples were filtered with glass micro filter of pore size, 2 µm. The total dissolved solid (TDS) value of the sample was determined by evaporation method [26]. The total hardness (TH) and total alkalinity (TA) values were analyzed by the titration methods [27]. The anionic surfactant concentration in the term of sodium lauryl sulfate (SLS) was determined by the flow injection spectrophotometric method [28]. The fluoride content of the water was analyzed by the ion selective method using Metrohm-781 ion meter using the total ionic strength adjustment buffer (TISAB) in the 1:1 ratio. The concentration of ions was analyzed by the Dionex-1100 ion chromatography. The iron content of the water was monitored by the GBC flame AAS-932AA. The sodium adsorption ratio (SAR) and sodium hazard (SH) indices were calculated by using following equations.

$$\text{SAR} = \left[\text{Na}^{+}\right] \Big/ \sqrt{\left\{\left(\left[\text{Ca}^{2+}\right]+\left[\text{Mg}^{2+}\right]\right)/2\right\}}$$

$$\text{SH} = \left(\left\{[\text{Na}]+[\text{K}]\right\} \Big/ \left\{[\text{Na}]+[\text{K}]+[\text{Mg}]+[\text{Ca}]\right\}\right)\times 100$$

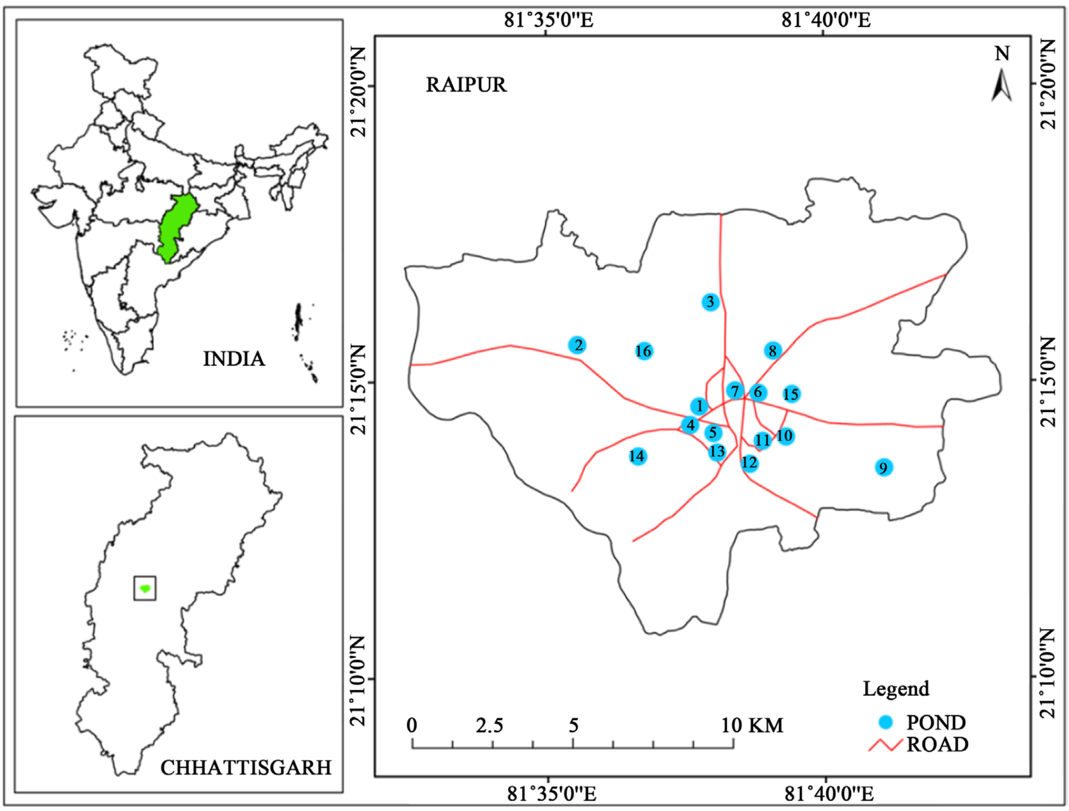


Figure 1. Representation of pond location in Raipur city, Chhattisgarh, India.

where, all ions are expressed in meq/L.

The indicative microbes *i.e*. total coliforms (TC), fecal coliforms (FC), *Pseudomonas* aeruginosa, yeast and fungi were determined by the plate method prescribed by Rakiro Biotech System Pvt. Ltd [29]. The bactaslyde is a presterilized slide coated with specially developed media of lactose and indicator. The slide no. BS-101, BS-102 and BS-103 were used for detection of *E. coli* + TC, *Pseudomonas* + TC and yeast-fungi + TC, respectively. The slide was plunged into the test liquid vertically for 20 - 25 sec. The excess water of slide was removed by shaking, and incubated for 24 hrs at 37˚C. The grown colonies of the slide was compared with the standard chart. The *Salmonella* bacteria in the water was detected by the pouch pack method [29]. The content (10 g) of two pouches (*i.e*. containing organics and sulfite material)were added into a 150-mL sterilized bottle filled with 100 mL of contaminated water, and incubatted for 24 hrs at 37˚C. The presence of *Salmonella* species was confirmed by changing of light blue color of the solution into dark black due to reduction of sulfite into sulfide.

3. Results and Discussion

3.1. Physical Characteristics

The physical characteristic of 16 ponds is summarized in **Table 1**. Among them, three ponds are in larger size, ranging in order of 1 - 3 × 10^5 m^2. All ponds are eutrophied and coloured due to algal blooms. The pH and T values of pond water (n = 16) was varied from 6.5 - 8.2 and 29.6˚C - 31.3˚C with mean value of 7.0 ± 0.2 and 30.4 ± 0.2˚C, respectively. The water of all ponds was found to be neutral with high value of TH, TA and TDS, ranging (n = 16) from 140 - 450, 232 - 546 and 1288 - 2475 mg/L with mean value of 280 ± 45, 391 ± 34 and 1659 ± 164 mg/L, respectively. The DO, RP, EC values (n = 16) were ranged from 6.1 - 8.3 mg/L, 90 - 195 mV, 453 - 1225 µS/cm with mean value of 7.2 ± 0.3, 145 ± 15 mV and 800 ± 124 µS/cm, respectively. The DO value of all pond water was found above the recommended value of 4.0 mg/L. The DO value in the summer (May-June) was reduced to the recommended value due to higher water temperature (40˚C). However, RP value was found to be several folds lower than recommended value of 650 mV, may be due to excessive organics load in the water.

Table 1. Physical characteristics of pond and pond water.

S. No.	Location	Area, m^2	pH	EC, µS/ cm	T, ˚C	RP, mV	DO, mg/L	TDS mg/L	TH, mg/L	TA mg/L
P1	Telibandha	1.0 × 10^5	7.6	589	30.1	187	8.1	1323	150	380
P2	Budhatalab	3.0 × 10^5	7.2	623	30.4	180	7.8	1934	200	346
P3	Tikarapara	1.6 × 10^5	6.6	1115	30.6	132	7.6	1567	140	402
P4	Kankalipara	1 × 10^4	7.1	771	29.8	195	8.0	1460	190	360
P5	Gudhiyari	1 × 10^4	6.8	1225	31.3	167	7.5	2012	360	546
P6	Dudhadhari	1 × 10^4	7.0	727	29.6	162	7.0	1340	320	326
P7	Rajatalab	5 × 10^4	7.1	872	30.9	129	6.7	1913	370	372
P8	Aamapara	3 × 10^4	8.2	960	30.1	118	7.2	1726	280	468
P9	Awanti Vihar	1 × 10^4	7.1	474	30.8	107	6.8	2475	450	442
P10	Amlidih	1 × 10^4	6.5	1149	30.2	90	7.4	1879	330	380
P11	Katoratalab	1 × 10^4	6.7	630	31.1	114	6.1	1633	360	424
P12	Sonjharapara	5 × 10^4	6.9	610	30.5	147	7.0	1504	250	436
P13	Mathpara	1 × 10^4	7.0	870	30.0	131	6.3	1323	200	408
P14	P. Colony	2 × 10^4	6.8	608	29.7	151	8.3	1400	350	340
P15	Rohinipuram	1 × 10^4	7.0	453	30.4	160	6.8	1320	200	388
P 16	Kota	2 × 10^4	7.1	1128	30.2	152	7.3	1288	330	232

P = Professor.

3.2. Chemical and Microbe Characteristics

The chemical characteristics of the pond water are shown in **Table 2**. The concentration of F^-, Cl^-, NO_3^-, SO_4^{2-}, NH_4^+, Na^+, K^+, Mg^{2+}, Ca^{2+}, Fe and SLS was ranged (n = 16) from 0.9 - 1.7, 12 - 97, 13 - 64, 13 - 152, 5 - 23, 33 - 177, 8 - 83, 6 - 24, 22 - 64, 0.33 - 1.14 and 7 - 27 mg/L with mean value of 1.3 ± 0.1, 33 ± 12, 26 ± 7, 49 ± 19, 8 ± 2, 112 ± 18, 39 ± 10, 15 ± 2, 42 ± 5, 0.51 ± 0.11 and 17 ± 3 mg/L, respectively. Among16 pond investigated, the water of Awanti Vihar pond was found to be the most polluted due to mixing of sewage waste, **Figure 2**. The-contaminants in the pond water of Raipur city was found to occur in the following decreasing sequence: $Na^+ < SO_4^{2-} < Ca^{2+} < K^+ < Cl^- < NO_3^- <$ SLS $< Mg^{2+} < NH_4^+ < F^- <$ Fe.

The chromatograms of indicative bacteria (*i.e.* total coliform, *E. coli* and *Pseudomonas*, yeast and fungi) are shown in **Figure 3**, **Figure 4**. Their extreme concentrations were observed in all pond water reservoirs, ranging from 10^2 - 10^7 count/mL in **Table 3**. The positive test for *Salmonella* bacteria was marked for all water reservoirs in **Figure 5.**

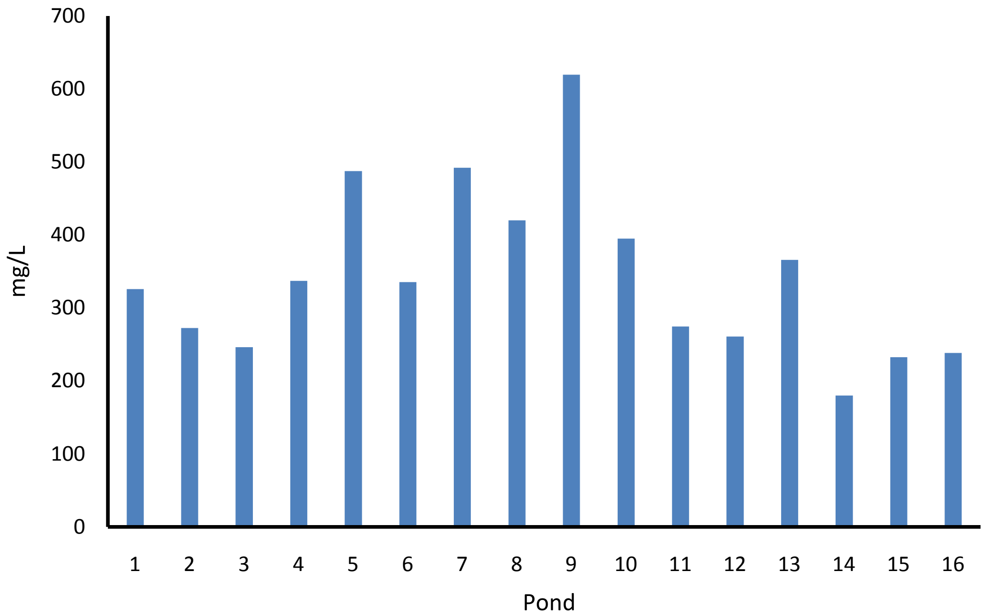
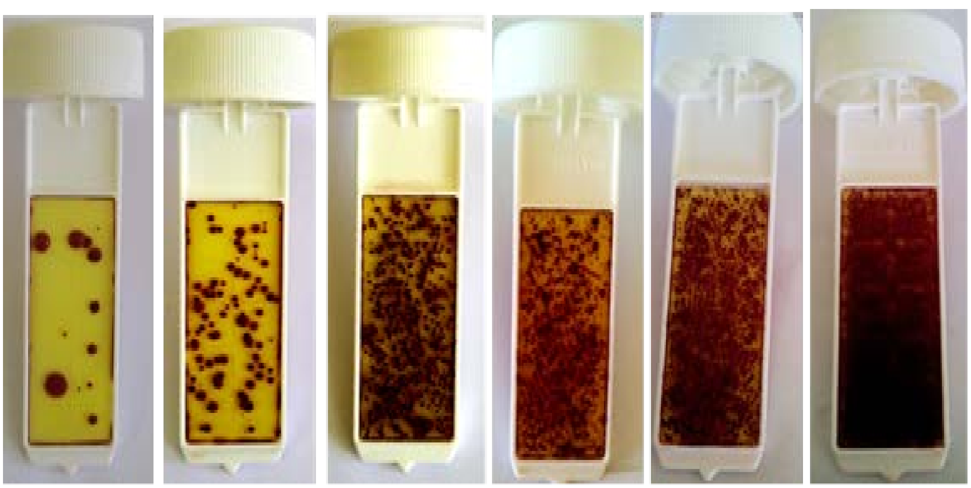


Figure 2. Spatial variation of sum of total concentration of 11 species *i.e.* ions, Fe and SLS.



(a) (b) (c) (d) (e) (f)

Figure 3. Representation of various chromatograms of E Coli + TC (Total coli). A, B, C, D, E and F = 1×10^2, 1×10^3, 1×10^4, 1×10^5, 1×10^6, and 1×10^7 count/mL, respectively.

Table 2. Chemical characteristics of pond water, mg/L.

S. No.	F^-	Cl^-	SO_4^{2-}	NO_3^-	NH_4^+	Na^+	K^+	Mg^{2+}	Ca^{2+}	Fe	SLS
P1	1.3	32	50	27	6.1	106	33	15	38	0.43	17
P2	1.0	21	30	19	6.2	91	34	12	44	0.37	14
P3	1.6	15	18	13	6.2	100	31	6	38	0.37	17
P4	1.3	38	60	31	6.3	96	36	13	40	0.53	15
P5	1.0	44	68	35	8.0	173	70	14	48	0.50	26
P6	1.0	15	21	17	9.1	116	83	14	40	0.42	19
P7	1.6	78	122	56	13	105	37	17	46	0.39	16
P8	1.4	31	47	21	7.4	177	66	20	22	0.34	27
P9	1.7	97	152	64	6.3	144	58	24	50	0.51	22
P10	0.8	41	62	29	23	126	35	16	40	0.91	21
P11	1.1	16	23	14	7.1	93	27	15	64	0.37	14
P12	1.0	17	24	15	5.4	102	37	12	30	1.14	16
P13	1.6	29	42	18	6.5	156	32	12	44	0.75	24
P14	1.3	21	25	17	9.0	33	8.0	18	40	0.51	7
P15	1.6	24	32	19	6.6	75	15	12	36	0.33	11
P16	1.3	12	13	13	6.4	91	15	15	58	0.35	13

Table 3. Microbe contamination of pond water.

S. No.	*E. coli* + TC	Pseud. + TC	Y + F + TC	*Salmonella*
P1	10^4	10^2	10^4	Positive
P2	10^3	10^2	10^4	Positive
P3	10^4	10^2	10^3	Positive
P4	10^3	10^2	10^4	Positive
P5	10^7	10^4	10^5	Positive
P6	10^4	10^2	10^4	Positive
P7	10^4	10^2	10^4	Positive
P8	10^5	10^3	10^4	Positive
P9	10^4	10^2	10^4	Positive
P10	10^7	10^5	10^4	Positive
P11	10^5	10^6	10^6	Positive
P12	10^4	10^2	10^3	Positive
P13	10^5	10^3	10^5	Positive
P14	10^4	10^2	10^3	Positive
P15	10^5	10^3	10^5	Positive
P16	10^5	10^3	10^4	Positive

(a) (b) (c) (d) (e) (f)

Figure 4. Representation of various chromatogram of PM (*Pseudomonas*) + TC. A, B, C, D, E and F = 1 × 10^2, 1 × 10^3, 1 × 10^4, 1 × 10^5, 1 × 10^6, and 1 × 10^7 count/mL, respectively.

(a) (b)

Figure 5. Test scenario of *Salmonella*. (a) = Reagent blank; (b) = Positive symptoms for *Salmonella*.

3.3. Water Quality Assessment

The SH and SAR values of pond water were ranged from 31% - 77% and 1.7 - 11.3 with mean value of 62% ± 5% and 6.5 ± 1.1, respectively, indicating sodic nature of the water. The value of Fe, SLS, TA and TDS content of all pond waters were found above than recommended value of 0.3, 1.0, 120 and 500 mg/L, respectively [30] [31]. All pond waters were found to be contaminated with TB beyond 100 count/100 mL. The pond water is found to be unsuitable for drinking purpose due to microbe and surfactant contamination at hazardous levels.

The contaminated pond water affect the water quality of the shallow tube well water lie in the nearby area. The SLS and microbe contents in the shallow tube well (n = 16) were ranged from 3.2 - 5.1 mg/L and 1 × 10^3 count/mL, respectively. The surfactant and microbial contamination levels in the water of the studied area was found to be comparable to the contents reported in the water of other region of the country and world [10]-[25].

3.4. Sources

The correlation matrix of the water parameters is summarized in **Table 4**. Among them, Na^+ and K^+ contents were found to be correlated well with the SLS, indicating origin from the $CH_3(CH_2)_{11}OSO_3^-Na^+$. A good correlation among three species *i.e.* NO_3^-, SO_4^{2-} and Mg^{2+} was observed, showing similarity in their origins. The value of $[Na^+]/[Cl^-]$ was found to be ranged from 2 - 13 with mean value of 7 ± 2. It means that Na^+ was found to be originated mainly from the anthropogenic sources *i.e.* use of sodium lauryl sulphate as soap and detergent. The main inventories of the SLS and microbes contamination of the pond water are bathing, cloth washing and mixing of sewage waste and runoff water.

Table 4. Correlation matrix of ions and SLS.

	F^-	Cl^-	SO_4^{2-}	NO_3^-	NH_4^+	Na^+	K^+	Mg^{2+}	Ca^{2+}	Fe	SLS
F^-	1										
Cl^-	0.40	1									
SO_4^{2-}	0.38	1.00	1								
NO_3^-	0.33	**0.99**	**0.99**	1							
NH_4^+	−0.39	0.24	0.23	0.23	1						
Na^+	0.04	0.36	0.38	0.32	0.06	1					
K^+	−0.23	0.29	0.32	0.32	0.04	0.73	1				
Mg^{2+}	0.19	**0.64**	**0.64**	0.61	0.20	0.23	0.26	1			
Ca^{2+}	−0.02	0.12	0.11	0.14	−0.01	−0.15	−0.22	0.09	1		
Fe	−0.28	0.00	0.01	−0.03	0.30	0.13	−0.01	−0.07	−0.26	1	
SLS	0.01	0.35	0.37	0.30	0.13	**0.99**	**0.75**	0.22	−0.21	0.18	1

4. Conclusion

The pond water is polluted tremendously with the surfactant and microbe mainly due to anthropogenic activities *i.e*. bathing, washing and mixing of the runoff and municipal waste. The surfactant contamination of the pond imparts the water to be sodic in nature. In some ponds (≈25%), the F^- content is found to be above the recommended value of 1.5 mg/L. All ponds are eutrophied with green algal blooms due to the nutrient over loadings.

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