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Evaluation of water quality using physico-chemical parameters of Riverine Areas of Baddi (H.P), India

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ABSTRACT

The present paper is focused on monitoring of surface water quality of Baddi area in Himachal Pradesh. The research work was carried out for the assessment of various physico-chemical parameters at twelve sampling location. A systematic study of fifteen physico-chemical parameters for water quality monitoring is done by evaluating - pH, electrical conductivity, turbidity, TDS, total hardness, major ions (Cl^-, F^-, NO_3, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+, K^+), biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The results obtained were compared with the Bureau of Indian Standards (BIS: IS: 10500, 2012) guidelines. It was found that some of the parameters like electrical conductivity, turbidity, sodium, potassium, BOD and COD are not in the permissible limit of the BIS. A strong correlation was observed between the industrial activities and water pollution. The dense unplanned industrialization has negative effect on water quality of the study area. Therefore, the strict compliance of regulatory standards should be followed for disposal of sewage and untreated effluents to protect water resources.

Key words : *Baddi, Industrialization, Physico-chemical parameters, Water quality.*

Introduction

As water is a precious natural resource and life cannot imagine without it. Although water covers 75% of the world's surface in liquid and frozen form but still we are struggling for the availability of pure water. India is facing a problem of natural resources scarcity especially in terms of river water (Sharma and Walia, 2016). Rising population leads to urbanization and industrialization and these factors cumulatively increasing the stress over natural resources (Mohamed *et al.*, 2009). Contamination of water bodies are the result of both natural processes and anthropogenic activities (Carpenter *et al*., 1998; Jarvie *et al*., Yisa and Jimoh, 2010). There are three major natural sources of dissolved and soluble matter carried by rivers, atmospheric inputs of material, the degradation of terrestrial organic matter and weathering of surface rocks (Sharma and Walia, 2016). Surface water is most vulnerable to pollution due to their easy accessibility for disposal of municipal waste water, industrial waste water and agricultural runoff (Singh *et al.,* 2004). Rivers play a major role in assimilation or transporting multitude of pollutants (Qadir *et al.,* 2008; Wang *et al.,* 2013; Malik and Hashmi, 2017). Water pollution negatively affected our environment, health and economy so its protection should be the priority of everyone around the world. River water pollution is a major global concern and it's important to check this threat [United Nation Environment Program (UNEP) 2000; Bhutiani *et al.,* 2016). Protection of water is difficult task but strongly required in the present time so we need to implement proper water management strat-

egies to ensure the restoration of quality of water (Chun *et al.*, 1999; Venkatramanan *et al.*, 2014).

Baddi of Solan district in Himachal Pradesh has been rated as fastest industrial growth in the last decade; particularly in the BBN area (Herojeet *et al.*, 2013a; Kamaldeep *et al.*, 2011). Rapid industrialization in the study area has adverse affect on the surface water quality.

Water pollution can be evaluated by monitoring water chemistry in terms of physico-chemical parameters and these parameters have been assessed to check the water quality.

Materials and Methods

Study area: Baddi of Himachal Pradesh is located in the foothills of Shivalik range of the Himalayas. It lies between the northern latitude of 30^0 59ˆ 11.98ˆ N and eastern longitude of 76^0 45ˆ 56.06ˆ E Sirsa river is the main perennial river which flows southwest in the area. There are numerous streams or riverine emerging from the northeast flank through industrial belt often loaded with industrial and sewage discharge and join Sirsa River (Herojeet *et al.*, 2017). The important riverine among them are Balad Khadd, Ratta Khadd, Manpura Khadd and Bagbania Khadd.

Sampling Station: Sampling sites of the study area were chosen on the riverine of industrial area by identifying the pollution sources. Surface water samples were collected from twelve sampling stations around the industrial belt of Baddi to appraise the surface water quality. The details of the sampling stations are given below in Table 1.

Table 1.

Sampling Station	Riverine name
S.S.A-SRB-1	Balad Khadd
S.S.B-SRR-2	Ratta Khadd
S.S.C-SRM-3	Manpura Khadd
S.S.D-SRBB-4	Bagbania Khadd

Methodology: To investigate the surface water quality of Baddi area, Solan of Himachal Pradesh, forty eight samples were collected from twelve sampling station over the four riverine for the months from June 2021 to September 2021. During the sampling, two litre sample bottles were used for collecting the water sample and these were thoroughly rinsed twice with water to be sampled. Then the samples were subjected to analysis of different physico-chemical parameters in MS ECO Laboratories & Consultants Pvt. Ltd. Mohali (Punjab). Samples were collected, preserved and analysed as per standard methods (APHA/AWWA/WEF, 2012). For analysis of physico-chemical parameters-pH, E. Conductivity, total hardness, T.D.S, Turbidity, chloride, fluoride, nitrate, sulphate, calcium, magnesium, sodium, potassium, BOD and COD were determined according to standard analytical methods as shown in Table 2. The analytical data quality was ensured through careful standardization and the results obtained were compared with standard values of Bureau of Indian standards (BIS: IS: 10500, 2012) guidelines as shown in Table 3.

Table 2. Water quality parameters along with their abbreviation, units and analytical methods used.

Parameter	Abbreviations	Units	Analytical methods
pH	pH	pH unit	IS: 3025 (P- 11): 1984 RA2017
Electrical Conductivity	EC	µmho/cm	IS: 3025 (P- 14): 1984 RA 2019
Total Hardness	TH	mg/L	IS: 3025 (P- 21): 2009 RA 2019
Total Dissolved Solids	TDS	mg/L	IS: 3025 (P- 16): 1984 RA 2017
Turbidity	Turbidity	NTU	IS: 3025 (P- 10): 1984 RA 2017
Chloride	Cl^-	mg/L	IS: 3025 (P- 32): 1988 RA 2019
Fluoride	F^-	mg/L	IS: 3025 (P- 60): 2013 RA 2019
Nitrate	NO_3^-	mg/L	APHA - 23rd Ed 2017-4500 B
Sulphate	SO_4^{2-}	mg/L	IS: 3025 (P- 24): 1986 RA 2019
Calcium Hardness	Ca^{2+}	mg/L	IS: 3025 (P- 40): 1991 RA 2019
Magnesium Hardness	Mg^{2+}	mg/L	APHA-23rd Ed 2017-3500-Mg B
Sodium	Na^+	mg/L	IS: 3025 (P- 45): 1993 RA 2019
Potassium	K^+	mg/L	IS: 3025 (P- 45): 1993 RA 2019
Biological oxygen demand	BOD	mg/L	IS: 3025 (P- 44): 1993 RA 2019 BOD 3-days
Chemical oxyygen demand	COD	mg/L	IS: 3025 (P- 58): 2006 RA 2017

Results

Water quality monitoring of surface water of Baddi in terms of physico-chemical parameters was done for four months from June 2021 to September 2021. Forty eight samples were collected and analysed for fifteen physico-chemical variables viz. pH, electrical conductivity, turbidity, TDS, total hardness, major ion like Cl^-, F^-, NO_3^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+, K^+, biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The tabulated form of results with mean value and standard deviation values are shown in Table 4 to 7. The analyzed result was compared with standard values of BIS: IS: 10500, 2012 guidelines.

Discussion

pH: The pH in the water samples studied in the range between 6.96 to 7.75. This shows the water sample varies from slightly acidic to basic but that was in the prescribed limit of 6.5 to 8.5 pH.

Electrical Conductivity (E.C): The E.C values of water samples varied from minimum 1035.7 µmho/cm of sampling station S.S.B-SRR-2 to maximum 1778 µmho/cm of sampling station S.S.C-SRM-3. The results showed that E.C values for four sampling stations were above the permissible limit of 1500 µmho/cm indicating temporal variation during the period of investigation (WHO, 2011).

Total Hardness (TH): Total hardness of water de-

Table 3. Limits Prescribed by BIS (IS: 10500: 2012).

Parameter	Acceptable Value	Permissible Limit
pH	6.5	8.5
Electrical Conductivity (µmho/cm)	< 1500	
Total Hardness (mg/l)	200	600
Total Dissolved Solids (mg/l)	500	2000
Turbidity (NTU)	1	5
Chloride (mg/l)	250	1000
Fluoride (mg/l)	1	1.5
Nitrate (mg/l)	45	No relaxation
Sulphate (mg/l)	200	400
Calcium Hardness (mg/l)	75	200
Magnesium Hardness (mg/l)	30	100
Sodium (mg/l)	200	
Potassium (mg/l)	12	
Biological oxygen demand (mg/l)	30	No relaxation
Chemical oxyygen demand (mg/l)	250	

Table 4. Analysis of physico-chemical parameters at sampling station S.S.A-SRB-1.

Sr. No.	Parameters	Units	Collection of Samples				Mean	(±)(S.D)
			June	July	Aug	Sep		
1	pH	-	7.52	7.43	7.503	7.5267	7.495	0.0444
2	Electrical Conductivity	µmho/cm	1281	1183.3	1130	1106	1175	77.721
3	Total Hardness	mg/l	176	153.33	154.7	153.33	159.33	11.129
4	Total Dissolved Solids	mg/l	841.33	802.33	765.7	749.67	789.75	40.849
5	Turbidity	NTU	51.8	54.967	54.93	55.8	54.375	1.7629
6	Chloride	mg/l	136.67	133	151	148.33	142.25	8.7618
7	Fluoride	mg/l	0.6933	0.61	0.573	0.5267	0.6008	0.0705
8	Nitrate	mg/l	6.5	6.0667	6.367	6.5667	6.375	0.2217
9	Sulphate	mg/l	107.67	106.33	113.7	116	110.92	4.6538
10	Calcium	mg/l	120.33	110.33	102.7	101.33	108.67	8.7305
11	Magnesium	mg/l	41	43	50	52	46.5	5.3229
12	Sodium	mg/l	143.67	138.67	123.3	125.33	132.75	9.9643
13	Potassium	mg/l	12.867	10.733	12.83	13.467	12.475	1.197
14	BOD	mg/l	51.667	44.667	45	49.333	47.667	3.4102
15	COD	mg/l	153	153.33	158.7	165.33	157.58	5.7823

scribes the effect of dissolved minerals (mostly Ca and Mg), determining suitability of water for domestic, industrial and drinking purposes (Sharma and Walia, 2016). The TH content of riverine water samples varies from minimum value of 143.3 mg/l of S.S.B-SRR-2 to maximum value 242 mg/l of sampling station S.S.D-SRBB-4. The standard deviation of TH varies from ± 5.20 to ± 26.07. The values of total hardness were within the prescribed limit of 600 mg/l.

Total Dissolved Solid (TDS): TDS is the measure of dissolved inorganic and organic salts and suspended particles. The observed concentration Of TDS was minimum 697.6 mg/l to maximum 1210 mg/l. The increased value may be attributed due to more dissolution of salts with industrial effluents (Herojeet *et al.,* 2013b).

Turbidity: It is the cloudiness of liquid due to colloidal and suspended particles in it. The value of turbidity is above the permissible limit for all the samplings stations and it rises maximum 322.1 NTU. Turbidity of water also increased due to soil erosion (verma *et al.,* 1984).

Cation Chemistry (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}): Among the cations sodium ion was found to be dominant. In the water samples Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} were analysed in the range of 101.33 to157 mg/l, 30 to 77.3 mg/l, 112 to 259.33 mg/l and 10.73 to 26.7 mg/l respec-

Table 5. Analysis of physico-chemical parameters at sampling station S.S.B-SRR-2.

Sr. No.	Parameters	Units	Collection of samples				Mean	(±)(S.D)
			June	July	Aug	Sep		
1	pH	-	7.4667	7.3333	7.397	7.39	7.3967	0.0546
2	Electrical Conductivity	µmho/cm	1065.7	1063.3	1049	1035.7	1053.3	13.976
3	Total Hardness	mg/l	169	159.67	144.7	143.33	154.17	12.354
4	Total Dissolved Solids	mg/l	723.33	725	707	697.67	713.25	13.186
5	Turbidity	NTU	322.1	317.67	317.6	315.33	318.17	2.8348
6	Chloride	mg/l	115.33	114	118.3	122.67	117.58	3.843
7	Fluoride	mg/l	0.83	0.75	0.783	0.8	0.7908	0.0334
8	Nitrate	mg/l	6.6	6.4333	7.467	7.33	6.9575	0.5166
9	Sulphate	mg/l	142.67	140	142.3	147.33	143.08	3.0717
10	Calcium	mg/l	125.67	119.67	114	113.33	118.17	5.751
11	Magnesium	mg/l	41.333	40	30.67	30	35.5	5.9969
12	Sodium	mg/l	124	121.33	115	112	118.08	5.5403
13	Potassium	mg/l	15.333	16.567	26.7	53.4	28	17.683
14	BOD	mg/l	75.533	68.333	70.2	69.833	70.975	3.1444
15	COD	mg/l	204	203.67	208	212	206.92	3.9193

Table 6. Analysis of physico-chemical parameters at sampling station S.S.C-SRM-3.

Sr. No.	Parameters	Units	Collection of Samples				Mean	(±)(S.D)
			June	July	Aug	Sep		
1	pH	-	6.9667	6.967	7.177	7.14	7.0625	0.11167
2	Electrical Conductivity	µmho/cm	1776.7	1778	1755	1733.7	1760.9	20.9256
3	Total Hardness	mg/l	226.33	216.7	214.7	221.33	219.75	5.20239
4	Total Dissolved Solids	mg/l	1201	1210	1189	1185.7	1196.4	10.9895
5	Turbidity	NTU	65.567	69.13	73.27	80.7	72.167	6.501
6	Chloride	mg/l	296.67	284.3	281.3	274.33	284.17	9.32738
7	Fluoride	mg/l	0.93	0.887	0.867	0.8667	0.8875	0.02986
8	Nitrate	mg/l	8.2	7.567	6.767	7.0333	7.3917	0.63326
9	Sulphate	mg/l	95.333	88.33	79.33	81.667	86.167	7.20339
10	Calcium Hardness	mg/l	157	156	154	154.67	155.42	1.34371
11	Magnesium Hardness	mg/l	60.333	60.67	60.67	66.667	62.083	3.05959
12	Sodium	mg/l	259.33	246.7	242.7	240.67	247.33	8.37987
13	Potassium	mg/l	14.367	15.67	22.07	25.8	19.475	5.39509
14	BOD	mg/l	197	189.7	173.3	173.33	183.33	11.9288
15	COD	mg/l	605.67	599	560	573.33	584.5	21.4726

Table 7. Analysis of physico-chemical parameters at sampling station S.S.D-SRBB-4.

Sr. No.	Parameters	Units	Collection of Samples				Mean	(±)(S.D)
			June	July	Aug	Sep		
1	pH	-	7.5667	7.45	7.467	7.7567	7.56	0.14087
2	Electrical Conductivity	µmho/cm	1419	1400	1371	1382	1393	20.9037
3	Total Hardness	mg/l	242	230	192.7	190.67	213.83	26.0733
4	Total Dissolved Solids	mg/l	935	923.7	901.7	904.33	916.17	15.9292
5	Turbidity	NTU	66.667	64.87	67.67	65.4	66.15	1.26183
6	Chloride	mg/l	132.33	137	137.7	145.67	138.17	5.5344
7	Fluoride	mg/l	0.8167	0.777	0.85	0.8333	0.8192	0.03143
8	Nitrate	mg/l	7.3333	6.8	7.467	7.6	7.3	0.35066
9	Sulphate	mg/l	143.67	140.7	149.7	180.33	153.58	18.2216
10	Calcium Hardness	mg/l	153.33	152.7	125.3	123.33	138.67	16.5731
11	Magnesium Hardness	mg/l	75.333	77.33	67.33	67.333	71.833	5.25991
12	Sodium	mg/l	155	148.3	149	146	149.58	3.83333
13	Potassium	mg/l	18.467	16.07	21.13	22.367	19.508	2.81311
14	BOD	mg/l	113.57	111.7	105.7	108.67	109.89	3.46446
15	COD	mg/l	360.33	375.7	384	400	380	16.5485

tively. The cation dominance is in the order of $Na^+ > Ca^{2+} > Mg^{2+} > K^+$. Out four cations Na^+ and K^+ were above the acceptance limit BIS. High concentration of Mg^{2+} showed a significant possible correlation with total hardness of water (Kumari and Sharma, 2018).

Anion Chemistry (Cl^-, F^-, SO_4^{2-}, NO_3^-): The concentration of Cl^-, F^-, SO_4^{2-} and NO_3^- were found in the range from 114 to 296.67 mg/l, 0.526 to 0.93 mg/l, 79.3 to 180.33 mg/l and 6.06 to 8.2 mg/l respectively. The anion contribution in the riverine samples were in the order of $Cl^- > SO_4^{-2} > NO_3^- > F^-$. All the anions were within the standard limit of BIS. High concentration of nitrate is due to increased industrial effluent and agricultural runoff containing artificial fertilizers.

Biochemical oxygen demand (BOD): BOD represents the amount of oxygen consumed by microorganism while they decompose organic matter. The BOD of the analyzed water sample varied from 45mg/l to 197mg/l. The result shows that BOD of all the sampling station were above the acceptance limit of BIS.

COD (Chemical Oxygen Demand): In our study COD value varies from 153 mg/l to 603.67 mg/l. More than 50% of sampling stations have COD Value above the acceptance limit of BIS i.e. 250mg/l. Increase in COD could be attributed to an increase in addition of both organic and inorganic contamination. This indicates the pollution load in river is due to untreated industrial effluents agricultural runoff (Ogunfowokan *et al.,* 2005; Chaderik and Kumar, 2015).

Conclusion

This study assessed the physico-chemical properties of surface water of Baddi, Himachal Pradesh from twelve different locations, during the month of June 2021 to September 2021. Fifteen parameters were analysed and compared with standard value of BIS 2012. Most of the studied parameters were within the permissible limit of BIS value except electrical conductivity, turbidity, sodium ion and potassium ion. Water quality parameter like BOD and COD has also exceeded the permissible range of BIS value and they were increasing the level of pollution. During the study it was observed that anthropogenic activities including industrial effluents are the cause of disturbance in our water ecosystem. In order to check contamination of surface water it is essential to monitor the water quality parameters time to time. This will help to take strict initiate potential measures and implementation of remediation action to protect the quality of surface water from deterioration.

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Conflict of Interest

There is no conflict of interest for this manuscript.

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