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Quality assessment of water resources from asansol urban areas of West Bengal, India

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Abstract

Water quality assessment is of great importance for ensuring use of safe and fresh water. The water quality can be described by its physical, chemical and biological characteristics. However, condition of the quality is difficult due to the variability of pollutants and biological, physical and chemical substances, which are wide range of indicators to be measured. In our research study, water quality of Asansol (urban areas of West Bengal) was assessed which is deteriorated due to the high level of industrialization and use of chemical fertilizers and pesticides in agriculture. The collected samples were analyzed for pH, electric conductivity, cations and anions. The analytical data was evaluated by the chemical characteristics of the water collected from Asansol urban areas for its suitability for drinking and irrigation uses. For the suitability of the groundwater for drinking purpose, the assessed water quality was compared with the prescribed drinking water standards of BIS (IS: 10500) the irrigation use.

Keywords: Drinking water, chemical characteristics, alkality, drinkable.

Introduction

Of the Earth's whole water, oceans consist of 97%, but this whole is not drinkable. About 2 percent is frozen in frozen form and the remaining 1% is groundwater. The remaining of the freshwater is found at the surface in streams, lakes, rivers and wetlands. Water consists of various chemicals such as nitrogen, phosphorous, oxygen, carbon dioxide, and many more, are essential for growth but there is a chemical, physical or biological change in the quality of water due to the water pollution which has a harmful effect. Pollution is becoming major factor in destroying the fresh water supply which is essential for living being. The increasing population and urbanization is overexploiting the water reserve at an alarming rate due to which India is facing a major problem of natural water resource scarcity[1]. Organic compounds which are manufactured and used by industries, agriculture and municipalities in large quantities, are of most important.

Inorganic contaminants, having harmful effect on health, can be present in the waters[2]. Few countries and there is a need of formulating effective combating strategies for water resource management in recent years[3]. Asansol, being an industrial area and located in the land area between the river Ajoy on northern side and river Damodar on the southern side, is at high risk of water pollution. Usually rivers are polluted by the disposal of sewage and industrial waste in huge amount[4]. In this research study water from different sources of Asansol were investigated for the concentration of various parameters and the comparison of these physico-chemical parameters with reference to water standards specified by Bureau of Indian standard (IS-10500, 2012) was done, for water quality assessment.

Materials and methods

Study area: Asansol, an industrial area, is the second largest city in West Bengal, after Kolkata. The Damodarriver, which is the major source of water supply in Asansol, receives industrial pollutants through two storm water drains – Nunianalah in the Asansol region and Tamla nalah in the Durgapur region and also receives pollutants through some drains of different industry. Sampling was carried out during 27-28 April, 2017 for the assessment of ground and surface water quality. Representative 15 ground water and 6 surface water samples from the various urban areas of Asansol are provided in a Table-1.

Physical-Chemical Analysis: Various parameters such as pH, electric conductivity, bicarbonate, anions, cations and heavy metals were analyzed in each sample. The water samples were collected in polyethylene bottles of 500 ml, which were previously washed. 500 ml of water samples were collected. Although immediate analysis is ideal, but if not possible then storage at 4^0C temperature is found to best way to preserve samples.

pH and Electrical Conductivity were measured using Electrometric Multi-parameter Analyzer (Orion Star A215) while Major Anions and Cations were measured by Ion Chromatograph (DIONEX, DX 120) AAS (Varian AA280FS) spectrophotometer respectively. Heavy metals were evaluated with the help of ICPMS (Perkin Elmer Elan DRC-e).

Table-1: Description of sampling sites of water resources from urban areas of Asansol, Bardhman district.

S.No.	Sample Sites	Longitude	Latitude
Ground Water			
GW -1	Munshi Bazar	23°41'06.8"N	086°59'01.0"E
GW -2	Hassan Nagar	23°41'01.2"N	086 00'01.0"E
GW -3	Ushagram	23°40'48.7"N	086°59'54.8"E
GW -4	Dildar Nagar	23°41'10.8"N	08°6 58'24.1"E
GW -5	Raipada	23°41'24.5"N	086°56'51.0"E
GW-6	Burnpur	23°40'21.4"N	086°56'43.3"E
GW-7	Gopalpur	23°42'18.0"N	086°55'07.7"E
GW-8	Disha gate	23°42'46.1"N	086°53'39.5"E
GW-9	Sitarampur	23°43'12.3"N	086°51'55.8"E
GW-10	Mahisila colony	23°42'14.6"N	086°57'52.9"E
GW-11	Chandrani	23°42'14.6"N	086°57'57.8"E
GW-12	South dhadka	23°42'11.8"N	086°58'46.4"E
GW-13	Gobindapur	23°42'58.0"N	086°57'24.3"E
GW-14	Kanyapur	23°43'36.4"N	086°55'41.1"E
GW-15	Pathak bari	23°39'53.5"N	086°03'13.6"E
Surface Water			
SW -1	Rabindra Nagar	23°41'58.9"N	086°56'04.0"E
SW-2	Fatehpur, NH-2	23°42'18.6"N	086°55'09.2"E
SW-3	Neamatpur,	23°43'06.5"N	086°52'35.4"E
SW-4	Kultoda	23°43'22.1"N	086°51'55.2"E
SW-5	Sitla	23°42'33.3"N	086°58'26.4"E
SW-6	Chalbalpur	23°44'35.6"N	086°53'22.8"E

The analytical data was evaluated by the chemical characteristics of the water sample, collected from the Asansol urban areas for its safe usage. Plotting of geochemical data on Piper diagram is done for determining relationships of different dissolved constituents and identification of dominant hydro-geochemical facies. The assessed water quality was compared with the prescribed drinking water standards of BIS (IS: 10500).

Results and discussion

The analytical data of ground and surface water collected from study area of Asansol of Bardhman district has been evaluated in terms of major ion chemistry, spatial variation in concentration of measured chemical species and water quality for its suitability to drinking and irrigation uses.

Physiochemical characteristics: The pH of the analyzed ground water and surface water samples varies from 6.91 to 7.75 and 7.1 to 8.06 respectively, with an average of 7.26 for the former and 7.47 for later which indicates the alkaline nature of water of the study area[5]. V. Mane et al.[5] had studied the physicochemical properties such as pH, conductivity, TDS, fluoride and had compared for each treated and untreated water samples individually.

Electrical conductivity (EC), measures the total dissolve solid (TDS) i.e. it depend upon the ionic strength of solution. The Electrical Conductivity (EC) value in the analyzed ground water is given a Table-2. EC measures salinity of a solution due to which it affects the taste and has a significance impact on the use of water.

Total Dissolve Solid (TDS) is numerical sum of all mineral constituents dissolved in water and is expressed in mg/l. Out of 21 sample, the TDS of 11 water samples (52%) exceeded the desirable limit of IS: 10500 for drinking water (500mg/l). Carrol[6] proposed four classes of the water such as fresh (0-1000 mgl^{-1}), brackish (1000-10,000mgl^{-1}), saline (10,000-100,000 mgl^{-1}) and brine (>100,000mgl^{-1}) water based on TDS. All the water samples fall in the fresh water category according to the carrol's classification.

TDS of the water resources are well within the maximum permissible limit i.e. 2000mg/l of BIS (2012). Properties of hardness of water, prevents the formation of foam with the soap and increase the boiling point of the water and is classified into four categories as soft water (0-75mg/l), hard water (150-300 mg/l), moderately hard water (75-150mg/l) and very hard water (> 300mg/l).

The total hardness of 10 ground water samples (47%) were exceeding the maximum desirable limit (200mg/l) of IS: 10500. The result of the physicochemical analysis of 21 samples of Asansol area is given Tables-2 and 3.

Analysis of major anions (HCO_3^-, Cl^-, SO_4^{2-}, NO^{3-} and F^-) and cation (Ca^{2+}, Mg^{2+}, Na^+, K^+): Ground samples were analyzed for the anion chemistry which shows that HCO_3- and Cl are the dominant anions followed by SO_4^{2-} , NO_3^-, and F^-. Piper diagram of the analyzed data, relating HCO_3^-, Cl^-, SO_4^{2-} shows that plotted points fall into bicarbonate and no dominant zones (Figure-1) and for cations majority of them falls in 'no dominant zone' relating Ca, Mg and (Na+K), indicating significant contribution of Ca, Mg and Na (Figure-2).

In a study conducted by Zakaria[7] piper diagrams is used to assess the water quality and according to them dominant type of water is in effect of soluble salts in soil layers and the decomposition of organic material. The percentage contribution of cations and anions in total cation and anionic charge balance is described in a pie chart (Figure-3, 4).

Table-2: Physicochemical characteristics of Ground water samples of urban areas of Asansol. Unit: Concentration in mg/l except in pH, EC (µS/cm), TH=Total hardness, ND* = Not Detected.

Sample code	Location	pH	EC	TDS	TH	Cl^-	HCO_3^-	SO_4^{2-}	NO_3^-	Ca^{2+}	Mg^{2+}	Na^+	K^+
GW-1	Munshi bazaar	7.05	1196	823	300	75.77	445.4	67.9	0.73	85.9	20.7	117.6	7.9
GW-2	Hasan Nagar	7.12	894	620	306	35.2	378.9	60.5	0.78	60.86	37.5	43.29	2.8
GW-3	Ushagram	7.28	1148	814	291	50.1	480.1	62.2	23.1	59.0	34.9	99.0	4.4
GW-4	Didar Nagar	7.36	1150	976	242	187.9	390.4	78.1	46.25	61.35	21.5	184.9	4.4
GW-5	Raipada	6.91	600	407	145	30.61	231.4	30.4	21.12	40.67	10.42	37.78	3.4
GW-6	Burnpur	7.04	896	636	302	33.72	373.1	83.5	ND*	62.48	35.4	47.05	0.7
GW-7	Fatehpur NH-2	7.07	635	485	179	31.36	321	16.3	4.88	51.06	12.53	42.13	5.3
GW-8	Disha Gate	7.34	890	619	291	56.0	378.9	24.5	0.74	61.7	33.2	58.7	3.5
GW-9	Neamatpur	7.75	880	587	206	64.8	361.5	12.9	0.93	49.19	20.28	64.2	11.4
GW-10	Mahisila colony	7.16	843	576	227	38.92	361.5	43.3	1.54	35.24	33.7	58.48	2.7
GW-11	Chandrani	6.92	1121	690	304	114.5	231.4	113.2	46.7	84.4	22.5	71.15	5.6
GW12	South Dhadka	7.81	684	453	183	50.69	219.8	69.4	1.42	41.7	19.05	47.37	2.7
GW-13	Gobindapur	7.17	467	383	132	8.9	242.9	15.6	1.19	22.4	18.45	29.31	43.5
GW-14	Kanyapur	7.13	800	595	239	11.6	445.4	9.37	ND	38.4	34.7	52.48	2.8
GW-15	Pathak Bari	7.48	644	456	182	15.04	295	35.5	ND	41.3	19.1	46.95	1.5
Min.		6.91	467	383	132	8.9	231.4	9.35	0.73	22.4	10.4	29.31	0.7
Max.		7.75	1196	976	306	187.9	480	113.2	46.7	85.9	37.5	184.8	43.5
Mean		7.25	857	608	235	53.67	343.78	48.2	9.96	53.04	24.9	66.7	6.85

Table-3: Physicochemical characteristics of surface water sample of urban area of Asansol. Unit: Concentration in mg/l except in pH, EC (µS/cm), TH=Total hardness, ND* = Not Detected.

Sample code	Location	pH	EC	TDS	TH	F^-	Cl^-	HCO_3^-	NO_3^-	Ca^{2+}	Mg^{2+}	Na^+	K^+
SW -1	Rabindra Nagar	7.27	553	346	108	0.910	46.3	182.2	ND*	20.39	13.77	41.79	11.24
SW – 2	Fatehpur NH-2	7.1	599	395	133	1.04	48.5	234.3	ND	35.36	10.83	51.72	11.14
SW – 3	Sitarampur	7.57	517	378	158	0.48	18.43	260.3	0.75	45.41	10.76	29.8	3.15
SW – 4	Kultoda	7.36	444	318	118	1.065	15.27	205.3	ND	26.65	12.41	35.49	5.43
SW- -5	Sitla	8.06	834	519	81	2.036	74.45	306.6	ND	7.56	15.15	81.07	11.59
SW -6	Chalbalpur	7.47	246.5	175	56	0.952	45.8	107	ND	6.69	4.42	17.56	6.69
Min.		7.1	246.5	175	56	0.91	15.27	107		6.69	4.42	17.56	3.15
Max.		8.06	834	519	158	2.036	74.45	306.6		45.41	15.15	81.07	11.59
Avg		7.47	532.2	355	109	1.081	41.45	213.6	0.75	23.67	11.22	42.905	8.20

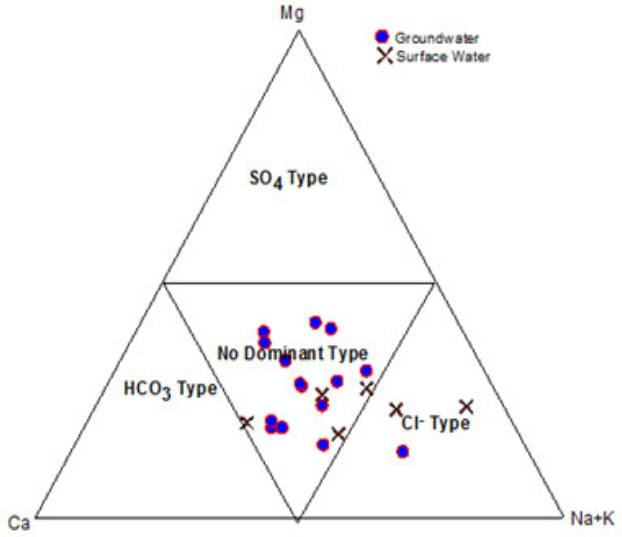

Figure-1: Piper diagram relating bicarbonate, sulphate and chloride.

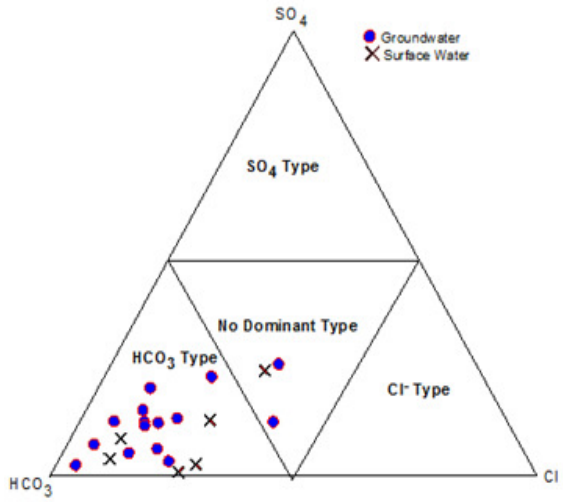

Figure-2: Piper diagram relating Ca, Mg, and (Na+K).

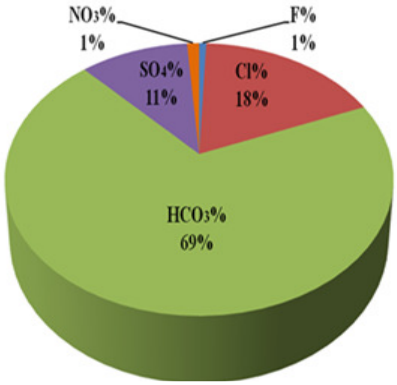

Figure-3: Contribution of cation towards total cationic charge (TZ-) balance.

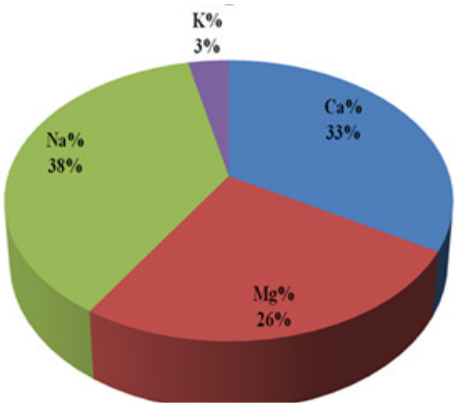

Figure-4: Contribution of anions towards total anionic charge (TZ-) balance.

The chloride concentration in the water samples varies between 8.90mg/l to 187.95mg/l and 15.27 mg/l to 74.45mg/l for ground and surface water respectively. On an average chloride contributes 18% of the total anionic balance and the concentration of sulphate in the ground water samples varies between 9.375mg/l to 113.2mg/l with an average concentration of 48.19mg/l while that of surface water has 2.39mg/l to 45.28 mg/l, with average concentration of 18.81mg/l. Sulphate is next to the bicarbonate and chloride in abundance among concentration contributing on an average 11% of total anion. Concentration of fluoride ranges of surface water is 0.91 to 2.036 mg/l having an average value of 1.081mg/l while for ground water, value lies between 0.32mg/l to 1.618 mg/l with average of 0.872 mg/l. Fluoride contributes 1% of the total anionic balance. Organic nitrogen (Nitrogen combined with carbon) is found in protein and other compound. The Concentration of nitrate in ground water ranges from 0.73 to 46.8 mg/l with an average value of 12.45mg/l while that of surface water has 0.75mg/l. Nitrate is contributing 1% of the total anionic balance (Figure-3). Nitrate concentration of two samples exceeded the desirable limit of drinking water i.e. 45mg/l, specified by BIS (IS: 10500).

In general water resources show the dominance of actions in order of Na>Ca>Mg>K (Figure-4). Analyzed sample of ground water the sodium concentration ranges from 29.31mg/l to 184.85mg/l with average value of 66.69mg/l while that of surface water has 17.56mg/l to 81.07mg/l with an average concentration of 42.90 mg/l. Sodium constitutes 38% of the total cationic balance (Figure-4). Potassium in analyzed samples is ranges from 0.71mg/l to 43.48mg/l with an average value of 6.85mg/l and that of surface water has value between 3.15mg/l to 11.59mg/l, with average of 8.20mg/l. Potassium is present in least quantity in the water samples of this area, contributing about 3% of the total cationic concentration**.** The most abundant cation in the river and ground water is calcium and its concentration in the ground water sample ranges from 22.35 mg/l to 85.9mg/l with an average value of 53.03 mg/l while the concentration of calcium in surface water is 6.69 to 45.41 mg/l with average concentration of 23.67 mg/l. Ca accounts for 33%

of the total cationic balance (Figure-5). Out of the 21 water samples, calcium concentration in 6 samples (29%) exceeded the desirable limit of BIS. The magnesium concentration ranges between 10.42mg/l and 37.5mg/l with an average of 53.05 mg/l while in surface water it is between 4.42mg/l to 15.15 with average concentration of 11.22mg/l. Mg constitutes about 26% of the total cationic charge balance. In 7 ground water samples, magnesium exceeded the desirable limit of 30 mg/l recommended by BIS (2012) for drinking water.

Heavy / Trace Metal Distribution: Heavy metal is has high density and is toxic at low concentrations. Table-4 shows the concentration of nine trace metals analyzed in the 21 sample collected from Asansol urban area of Bardhman district.

Table-4: Trace Metals Concentration in the Ground Water Samples, Unit: All units in ppb (µg/l).

S.No	Mn	Cu	Zn	Ni	As	Al	Se	Ba	Fe
GW-1	511.0	1.1	20.58	8.5	2.5	37.5	1.15	114.6	1150.9
GW-2	4.9	0.3	9.3	6.5	0.4	10.4	0.24	75.1	889.7
GW-3	1.8	4.7	84.2	6.7	1.1	67.1	0.9	123.8	870.0
GW-4	8.6	3.4	211.6	8.0	2.6	115.1	0.8	129.1	865.8
GW-5	1.2	1.13	13.8	5.0	0.6	11.9	0.2	65.8	618.5
GW-6	181.4	0.19	237.3	6.5	0.4	10.3	0.21	67.9	941.0
GW-7	0.6	0.8	2.2	5.4	0.9	11.2	0.49	97.5	652.5
GW-8	448.0	0.24	31.8	7.6	0.61	8.0	0.102	42.8	817.2
GW-9	0.9	0.56	5.8	5.4	1.1	13.4	0.14	26.7	614.5
GW-10	7.0	0.27	2759.9	5.0	0.4	9.9	0.36	210.7	590.7
GW-11	18.1	2.1	41.7	5.8	3.8	72.8	0.29	61.1	1095.9
GW-12	2.1	0.66	25.1	4.8	1.4	15.6	0.16	36.9	584.6
GW-13	0.58	0.59	3.9	3.7	0.3	19.5	0.18	72.7	356.9
GW-14	46.9	0.3	10.6	4.4	0.2	7.9	0.75	567.8	575.4
GW-15	0.5	0.6	17.4	5.1	0.3	18.9	BDL	37.5	564.9
SW-1	2.1	0.4	4.3	3.9	2.0	11.8	0.55	76.2	324.9
SW-2	1.2	1.22	7.8	4.2	1.0	14.2	0.17	106.4	386.2
SW-3	5.6	1.04	3.4	5.6	2.1	20.2	0.51	63.3	667.9
SW-4	3	2.2	2.35	3.8	0.9	12.6	0.18	120.8	361.1
SW-5	187.9	2.5	16.01	6.3	5.3	237.5	0.13	119.0	498.8
SW-6	0.8	0.4	39.2	3.6	1.0	14.5	0.1	114.6	210.3
Min.	0.53	0.19	2.25	3.6	0.25	7.9	0.1	26.7	210.3
Max.	511.0	4.7	2759.9	8.4	5.29	237.5	1.15	210.76	1150.9
Avg.	68.32	1.19	168.99	5.54	1.41	35.30	0.36	111.01	649.4

Iron (Fe), zinc (Zn), Barium (Ba) and Manganese (Mn) are the most abundant metals in the water resources of Asansol urban area of Bardhman District. The average concentration of Selenium, zinc, barium, Ni, arsenic, copper and aluminum in water resources of the Asansol is found to be 0.36µg/l, 168.99µg/l, 111.01µg/l, 5.54µg/l, 1.41µg/l, 1.19µg/l and 35.30µg/l respectively. Thus, it can be concluded that in the water of study area, except for Fe, Mn and Al, concentrations of the other analyzed heavy metals are present below the maximum permissible levels for drinking water by BIS (IS-10500, 2012) with a few exceptions. The presence of higher concentration of heavy metals is a cause of health hazards like hypertension, cancer and gastrointestinal disorder etc.

Quality Assessment of Ground Water and surface water Resources: Assessment for Drinking and domestic Uses: For the assessment of water, hydro chemical parameter of the water samples is compared with the Indian standard for drinking water i.e. IS: 10500 (2012) (Table-5). Most of the water samples were found suitable for drinking and domestic uses with few exceptions as most of parameters were within the permissible limits.

Table-5: Range of chemical parameters in study area and of Indian Standard (IS: 10500). Unit: mg/l except heavy metals (µg/l), EC (µScm^{-}1) and pH.

Parameter	Range	IS:10500 (2012)		Percentage of samples exceeding the permissible limit
		Highest permissible	Max. desirable	
pH	6.91 - 8.06		6.5-8.5	NIL
EC (µScm^{-} 1)	246.50 - 1196.0	-	-	NIL
HCO_3	107.0 - 480.0			NIL
F^-	0.32 - 2.04	1.5	1	19%
Cl^-	8.90 - 187.95	1000	250	NIL
NO_3^-	0.74 - 46.78		45	9%
SO_4^{2-}	2.40 - 113.20	400	200	NIL
Na	17.50 - 184.85	-	-	NIL
Ca	7.56 - 85.90	200	75	9%
Mg	4.42 - 37.50	100	30	28%
K	0.71 - 43.48	-	-	NIL
TDS	242.82 - 976.47	2000	500	NIL
TH	56 - 306	600	200	52%
Heavy metals				
Mn	0.534 - 511.03	300	100	19.04%
Cu	0.19 - 4.7	1500	50	NIL
Zn	2.257 - 2759.94	15000	5000	NIL
Ni	3.63 - 8.48	N.R.	20	NIL
As	0.25 - 5.295	50	10	NIL
Al	7.932 - 237.548	200	30	23.80%
Se	125.9 - 1437.1	N.R.	10	NIL
Ba	26.7 - 210.76	N.R.	700	NIL
Fe	300.4 - 1644.2	N.R.	300	100%

Concentration of nitrate at some sites exceeded the permissible limit (45mg/l) due to which it is not recommended for drinking purposes. The Ca and Mg concentration also exceeded the desirable limit as given for drinking water by IS:10500. Concentration of Ca and Mg exceeds the desirable levels of 75mg/l and 30mg/l in about 9% and 28% of the water samples. TDS exceeds the desirable limit (500mg/l) in 52% of the samples; however it is well within the maximum permissible limit of 2000mg/l prescribed by BIS. Concentration of F- exceeds the drinking water maximum range of permissible limit (1.5mg/l) in 19% of the total analyzed water samples.

In case of heavy metals the concentration iron (300mg/l) exceeded the permissible limits in 100% of sample, while Aluminium and Manganese concentration exceeded in 23.80% and 19.05% of samples. According to the inhalation studies, chronic manganese intake is linked with neurological disorders; however, data of long-term exposure to elevated manganese levels through oral intake (food and water) and its effects on the human health are still limited[8].

Assessment for Irrigation Uses: The parameters such as Total Hardness (TH), sodium percentage (Na%) residual sodium Carbonate (RSC), Total Dissolve Solid (TDS), Sodium Absorption Ratio (SAR), permeability index (PI), and Magnesium Hazard (MH), which affects the water quality for irrigation purposes ware computed and results are presented in Table-6.

Alkali and Salinity Hazard: Electrical Conductivity (EC) and sodium concentration are the major parameter for the classification of irrigation water. The plant growth is indirectly affected by the salt present in water as it affects the soil structure, permeability and aeration. Thus, the total concentration of soluble salts can be used as a basis for the classification of irrigation water as low (EC=250µScm^{-1}), medium (250 to 750µScm^{-1}), high (750 to 2250µScm^{-1}) and very high (2250 to 5000µScm^{-1}). High salt and high sodium concentration in water leads to formation of saline soil and an alkaline soil respectively.

Table-6: Calculated Parameter for Assessment of Water Quality.

S.No.	Sample code	%Na	SAR	RSC	PI	MH
1	G1	47.0	2.96	1.31	70.4	28
2	G2	24.2	1.08	0.09	54.7	50
3	G3	43.2	2.53	2.06	70.3	49
4	G4	62.8	5.17	1.57	82.1	37
5	G5	37.5	1.37	0.91	79.3	30
6	G6	25.5	1.18	0.09	56.0	48
7	G7	35.5	1.37	1.68	76.3	29
8	G8	31.3	1.50	0.40	60.3	47
9	G9	42.8	1.95	1.80	75.6	40
10	G10	36.6	1.69	1.39	70.4	61
11	G11	34.8	1.78	-2.27	55.0	31
12	G12	36.9	1.53	-0.04	69.3	43
13	G13	47.5	1.11	1.35	83.7	58
14	G14	33.0	1.48	2.53	70.6	60
15	G15	36.4	1.52	1.21	74.8	43
16	S1	49.5	1.75	0.84	89.4	53
17	S2	48.8	1.95	1.19	85.8	34
18	S3	30.4	1.03	1.12	75.6	28
19	S4	41.7	1.42	1.01	86.7	43
20	S5	70.2	3.91	3.40	112.0	77
21	S6	45.5	1.02	0.64	111.0	33
Min.		24.2	1.02	-2.27	54.7	28
Max.		70	5.17	3.40	112	77.8
Avg.		41.57	1.85	1.09	78.11	44.42

Irrigation waters is categorized on the basis of Sodium Absorption Ratio (SAR) in four. The SAR between 0-10, 10-18, 18-26 and >26 falls under excellent, good, fair and poor category. The calculated value of Sodium Absorption Ratio (SAR) ranges from 1.02 to 5.17 in water samples. Wilcox diagram of analyzed data, shows that most of the water samples fall in the category C2S1 and in C3S1 which indicates medium to high salinity and low alkali water, which can be used for irrigation in most soil and crops (Figure-5). Sample collected from Water resources of Asansol Urban area, salinity fall in the field of C3S1 (high salinity and low alkali) and C2S1 (medium salinity and low alkali). Medium level of sodium in water presents an appreciable sodium hazard in fine textured soils having high cation exchange capacity. High salinity and high alkali water is not suitable for irrigation uses in most of the cases.

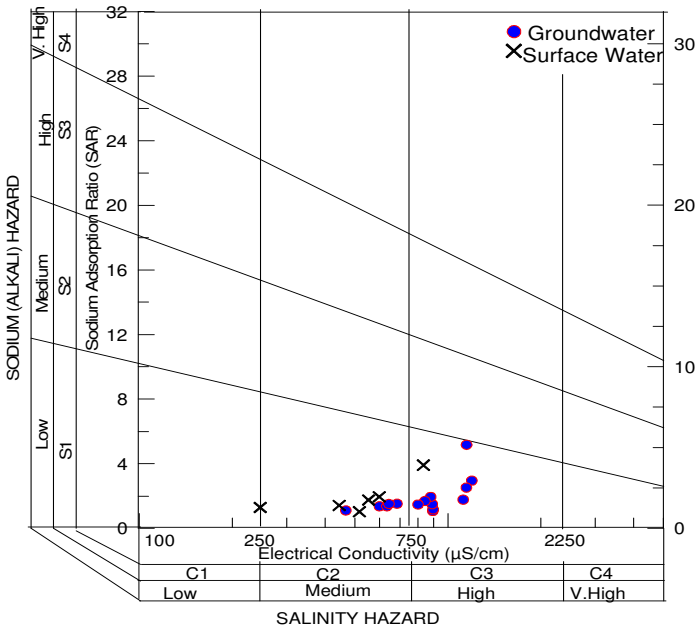

Figure-5: Wilcox diagram for classification of irrigation water.

Electrical conductivity (EC) and Sodium percentage (Na %): The Na% varies from 24% to 70% (average 42%) in the water samples of urban area of Asansol. As per the Indian standard maximum 60% of sodium is recommended for irrigation water. Few samples of the water from Asansol have exceeded permissible level, which may not be used for irrigation means (Figure-6).

Residual Sodium Carbonate (RSC), Magnesium Hardness (MH) and Permeability Index (PI): Increased adsorption of sodium on soil occurs due to the high value of RSC in water. RSC value greater than 5 meq/l is considered harmful to the growth of plants while value above 2.5meq/l is not suitable for irrigation purpose. In most of analyzed water samples, RSC are found towards lower side (< 2.5 meq/l) making in suitable water for irrigation uses while the samples no. GW-14 and SW- 20 exceeds the average RSC value above 2.5meq/l, so the waters is not suitable for irrigation purpose.

Magnesium hazards (MH) > 50 is not suitable for irrigation purposes. In the water sample only 6 samples has the MH value > 50 and fall in unsuitable zone.

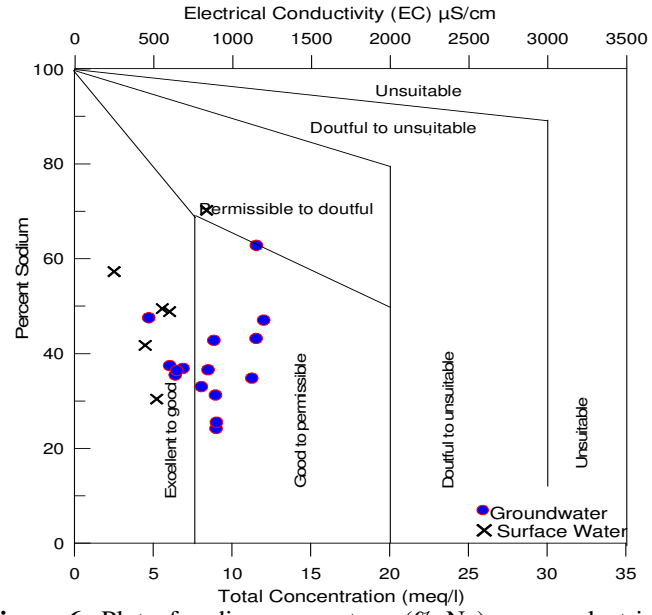

Figure-6: Plot of sodium percentage (% Na) versus electrical conductivity (EC).

Doneen[9] classification of irrigation water is based on the permeability index (PI). 11 samples of Asansol area, falls in class-I (52%) showing that the water is suitable for irrigation purpose with 75% or more of maximum permeability. However, 47% water samples fall under class II with maximum permeability ranging from 50- 75%. None of the sample was in the unsuitable category for irrigation with maximum permeability less than 50%. According to the Doneen's chart, water is classified as class - I, class - II where class - II represent waters which are suitable for irrigation with 50–75% or more of maximum permeability. Class - II waters are not suitable with 25% of maximum permeability. Most of the samples fall under class – II, showing that maximum permeability is more than 75% giving an indication of suitability for the irrigation purposes. Carbonate causes dissolution of organic matter in the soil bicarbonate due to which it is considered detrimental to the physical properties of soils. As a result, the excess of sodium in water, in the form of sodium carbonate occurs which is usually denoted by RSC.

Conclusion

Twenty-one water samples were collected from the Asansol urban areas of Bardhman District and analyzed for water quality parameters to assess the quality of ground water for domestic and irrigation uses. Samples were analyzed for pH, EC, cations,

anions and trace metal. The analytical data was evaluated by the chemical characteristics of the water resources of the Asansol urban areas and its suitability for drinking and irrigation uses. For the suitability of the groundwater for drinking purpose, its quality was compared with the prescribed drinking water standards of BIS (IS: 10500). Most of the water samples are found to be suitable for drinking and domestic uses with few exceptions. Violation of IS-10500 drinking water standards in respect of total hardness, F^-, NO_3^-, Ca, Mg, Mn, Al, and Fe have been evident in water of the study region. The parameter like percent sodium (%Na), residual sodium carbonate (RSC), sodium adsorption ratio (SAR), permeability index (PI), and magnesium hazard (MH) which affects the water quality for irrigation purposes were evaluated. The assessment of water samples for irrigation purposes showed that the water resource ranges from good to permissible quality. However, high value of salinity, Magnesium Hazard (MH) and Permeability Index (PI) at certain sites restrict its suitability for agriculture uses and requires suitable management of soil and water in the study area. Crop yields and soil physical conditions are affected by the poor quality of the irrigation water[10]. There is a requirement of detailed hydro-geochemical investigation and water management plan for the development of the water resources of the area which in turn will result in better plant growth as well as human health. The problem of groundwater depletion and pollution has emerged in many parts of world including India, so there is a need of sustainable management of groundwater resource. Rain water harvesting seems to be environmentally compatible emerging water resource management technique. Considering the local condition of the area, the suitable methods of artificial recharge to groundwater storage can be considered.

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