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COMPARATIVE STUDY OF PHYSICO CHEMICAL PARAMETERS OF RAIN WATER IN URBAN, INDUSTRIAL AND RURAL AREAS OF DEHRADUN DISTRICT, UTTARAKHAND

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Abstract

Rain water is the purest form of naturally occurring water resource and can be best utilized for domestic purpose. Evaluation of physico chemical properties of rainwater is important for assessment of air pollution and its utility. The current study was conducted to compare the quality of rain water in urban, rural and industrial area to understand the problems of rainwater contamination due to various pollutants. Rainwater samples were collected from rural, urban and industrial areas between July 2021 to September 2021. The sampling sites included were rural areas udiyabagh (vikasnagar) and Charba, industrial area Selaqui and urban area Dehradun. Results for pH, EC, total hardness, calcium hardness, magnesium hardness, temperature, alkalinity, chloride content, DO, BOD, TDS, nitrate and phosphate content were reported in this study. Findings indicate that industrialization and urbanization have altered the physico chemical properties of rain water.

Key words: Rain water analysis, pH, BOD, hardness, Alkalinity, TDS, Electrical conductivity.

I. INTRODUCTION

Rain water analysis is an important tool in finding out the contaminants. It can reduce the contaminants in air as well as a source of contamination in soil, water and terrestrial vegetation (Flues *et al*., 2002). Vehicular emissions, anthropogenic emissions and agricultural emissions have resulted in deteriorating the rain water quality. Investigations in recent years have shown that large quantities of oxides of sulfur and nitrogen were released into the atmosphere resulting in acidic rainfall (Possanzini *et al*., 1988; Kulshrestha *et al*., 2003).

Various research groups have done evaluation of surface water, ground water and river water in India (Handa *et al*., 1982; Mahadevan *et al*., 1984; Mukhopadhyay *et al*, 1992; Rao *et al*., 1992, 1995; Agarwal & Singh, 2001; Khare *et al*., 2004; Naik *et al*., 2002). Study related to the analysis of physico chemical parameters of rain water was done by certain research groups (Olobaniyil and Efe, 2007, V A.K yadav and G.P Mishra, 1979). Little information is available on quality of rain water in Uttarakhand district in India (A.M.J.A Obaidy).

It was reported that rain water contains dissolved gases such as carbon dioxide, sulphur dioxide, nitrogen dioxide, ammonia, fine particulate materials or aerosols, etc from the atmosphere (Asthana. 2003).The composition of rainwater actually reveals the composition of the atmosphere through which it falls (Matos *et al*., 2014).

The present study is carried out to compare physico chemical parameters of rain water in urban rural and industrial areas of Dehradun district of Uttarakhand and to correlate it with atmospheric pollution. The observed values were compared with IS-10500:2012 (Drinking Water Specifications) to determine the quality of water and its suitability for domestic usage.

II.MATERIALS AND METHOD

2.1.Sample collection

Sampling of rain water was done in the monsoon season, July- September 2021. Manual sampling with a plastic container in compliance with established standard norms was done. The Samples were collected from Site I (Udiyabagh), Site II (Charba), Site III (Selaqui), and Site IV (Dehradun).

The samples collected were then transferred to high-density polyethylene 'Tarson' brand bottles pre-rinsed with deionized water. The bottles were suitably caped in order to avoid the oxidation of the constituents. Temperature, pH and dissolved oxygen were measured at the sampling sight while for remaining analysis the samples were transferred to the laboratory stored at room temperature and analyzed within a week of collection.

Analysis of the collected water samples was done with respect to the procedures given in the 'Standard Methods for the Examination of Water and Wastewater' 19th edition, APHA, AWWA. (Washington DC, 1992).The results obtained were mean of three readings.

2.2.Analysis Method

S.No	Parameter	Method	Equipment
1	Temperature	Laboratory method	Thermometer
2	pH	Electrometric	pH meter
3	Hardness	Complexometric titration	
4	Alkalinity	Titration with Sulphuric acid	
5	Conductivity	Electrometric	Conductometer
6	DO,BOD	Iodometric titration	DO meter
7	Nitrate, phosphate	UV, Vis Spectrophotometric absorbance	UV visible spectrophotometer
8	TDS	Electrometric	Conductometer
9	Chloride ions	Precipitation titration	

2.3. Analytical Techniques

2.3.1 Temperature- Temperature was measured using Celsius thermometer.

2.3.2 pH – was measured immediately after sample collection and after 3 days of collection. A pH meter (Electronics India) having readability of 0.01 was used for the measurement.

2.3.3Conductivity- Conductivity was measured by conductometer (Popular traders) using 0.01 M KCl solutions as standard reference.

2.3.4. Total hardness- Hardness of buffered water sample (pH 10 using ammonia buffer) was measured using complexometric titration using EDTA as standard and EBT as indicator. Indicator gives wine red color

with Ca and Mg ions. On titration with EDTA it will form Ca- EDTA and Mg-EDTA complex. On adding extra drop of EDTA, the complex with EBT will break to combine with free Ca and Mg ions. The end point will be from wine red to pale blue.

Hardness in terms of $CaCO_3$ (mg) = A x B x mol.wt. of $CaCO_3$ x 1000/vol. of sample
Where A = Volume in ml of EDTA used

B = concentration of EDTA

For calculating the concentration of Ca and Mg ions, two titrimetric methods were used. One method will indicate the concentration of calcium ions and the second method measures the total hardness. The magnesium ions concentration was calculated by taking difference between total hardness and calcium hardness.

Calcium- Buffered water sample (pH 12-13 with sodium hydroxide buffer) was used for the determination of calcium hardness. At a pH of 12.0, magnesium precipitates out and thus do not interfere in the titration. Eriochrome Black T indicator was added to the solution and EDTA was then added as a titrant. Disodium EDTA combines with the free calcium ions to produce an EDTA – calcium complex.

Calculation

Ca ions in terms of $CaCO_3$ = A x B x mol.wt. of $CaCO_3$ x 1000/vol. of sample
Where
A = ml of EDTA consumed
B = EDTA concentration
Mol.wt. of $CaCO_3$ =100
Calcium as Ca (mg/l) = 0.4 x Ca as $CaCO_3$ (mg/l)

Magnesium will be calculated by finding the difference between total hardness and Calcium as $CaCO_3$.
Mg hardness = Total hardness – Calcium hardness x 0.243

2.3.5. Alkalinity was determined by acid–base titration method.
25 ml of the sample was taken in a 250.0 ml conical flask and titrated with standard 0.1N sulphuric acid using phenolphthalein and methyl orange indicators. Phenolphthalein alkalinity indicates the presence of total hydroxide and half of the carbonate present in the sample. Methyl orange indicator was used to determine total alkalinity.
Total alkalinity (mg/l) $CaCO_3$ = A x B x 50,000/volume of sample
Where A = Volume of acid used in ml with methyl orange as indicator
B = Normality of standard acid solution
Carbonate as CO_3 = Phenolphthalein alkalinity (as mg $CaCO_3$) x 1.2
Bicarbonate as HCO_3 (mg/l) = (Total alkalinity - 2 x phenolphthalein alkalinity) x 1.22

2.3.6. Chloride was determined by Argentometric method.
25 ml of water sample was taken in conical flask. In it few drops of 5% Potassium chromate solution was added as an indicator and titrated with standard 0.01N AgNO3 solution. End point is from white precipitate to reddish brown.
Cl^- = (A-B) x N x 35450/vol. of sample
Where A = volume of $AgNO_3$ consumed for sample
B = volume of $AgNO_3$ consumed for blank
N = normality of $AgNO_3$

2.3.7. Nitrate was determined by UV Visible spectrophotometer model *EI* 2371 using potassium nitrate standard solutions.
A graph of absorbance against concentration is drawn as Calibration curve.

2.3.8. Phosphate was determined by UV Visible spectrophotometer model *EI* 2371 with standard Potassium dihydrogen phosphate solution.

2.3.9. Total Dissolved Solids were calculated indirectly from electrical conductivity values in µS.
Total dissolved solids = 0.64 x EC (µS/cm)

2.3.10. Dissolved Oxygen was determined by Wrinklers method and verified by DO meter

2.3.11. Biochemical Oxygen Demand (BOD): BOD was also determined by above method but after incubation for five days at 20^0C. BOD was then calculated on the basis of oxygen depleted when compared to DO before incubation.

III. Results and Discussion

Table 1

S.No	Parameters	Indian Standard for drinking water *max*	Rain Water			
			Site-I	Site-II	Site-III	Site-IV
1	Temperature		17.42±0.15	18.46±0.18	23.41±0.04	21.32±0.24
2	pH measured immediately	6.5-9.5	6.25±0.07	6.00±0.04	5.18±0.024	5.47±0.07
3	pH measured after 3days		6.78±0.07	6.57±0.04	6.14±0.024	6.07±0.07
4	Conductivity µ.S/cm		20.01±0.01	30.12±0.02	50.34±0.01	80.03±0.02
5	Total hardness mg/l	200	2.56±0.04	1.29±0.01	7.62±0.04	5.41±0.03
6	Calcium hardness mg/l	75	2.04±0.01	1.21±0.01	4.64±0.02	3.92±0.01
7	Magnesium Hardness mg/l	30	0.12±0.01	0.11±0.01	1.72±0.01	0.98±0.01
8	Alkalinity mg/l	200	1.62±0.01	1.96±0.08	3.23±0.02	3.12±0.04
9	Chloride mg/l	250	0.98±0.006	1.07±0.012	3.58±0.001	3.52±0.009
10	Nitrate mg/l	45	ND	0.08±0.005	1.21±0.01	1.37±0.01
11	Phosphate mg/l	0.3	ND	ND	0.06±0.02	0.04±0.01
12	TDS mg/l	500	12.84±1.01	19.27±1.00	32.21±1.06	51.21±1.20
13	DO mg/l	6	4.32±0.01	6.60±0.01	3.71±0.01	3.13±0.01
14	BOD mg/l	2	1.12±0.05	1.00±0.01	3.02±0.01	2.96±0.46

Results are mean ± standard deviation

3.1. Temperature- Elevated temperature of water accelerates chemical reactions, thus reducing the solubility of gases, changes taste and odour and further promotes metabolic activity of organisms (Usha rani *et al*., 2010; Kumari *et al*., 2013). The temperature of the water sample collected was found to be in the range of 17.42 to 23.41°C during sampling. The temperature in site III may be due to high air temperature.

3.2. pH –. The data in table 1 shows that the mean pH of the collected rain water samples ranged from 5.18-6.25 (average). The lowest pH (5.18) was the water sample of Selaqui collected in the month of July while the highest pH (6.25) was shown by the sample collected from Udiyabagh vikasnagar in the month of September. Lower pH value in the industrial area can be accounted to presence of higher level of CO_2 in the atmosphere. The pH value below 5.60 accounts for acid rain (Mishra *et al*, 2012).

The high pH indicates neutralization of acids by carbonates, mineral dust or by ammonium. Rainwater pH was found to be distinctly alkaline by certain research groups working in Indian cities like Agra (pH 7.01-7.05) (Saxena *et al*., 1991; Kumar *et al*., 2002), Lucknow (pH 6.5-8.7) (Singh *et al.*, 2007), and Varanasi (pH 6.3-7.9) (Pandey and Singh, 2011).The values of pH in rainwater samples of few sites were slightly below the permissible limits of drinking water. However it was observed that when same water sample was analyzed for pH after 3 days it was found to be almost neutral.

3.3. Electrical Conductivity- Electrical conductivity indicates the purity of water in terms of nature and concentration of ions in water at room temperature. The electrical conductivity of the collected water sample ranged between 20.01-80.03 µS/cm. Higher electrical conductivity may be attributed to higher ionisable solids. (Rao *et.al* 2013). A low level of electrical conductivity in rain water indicates atmosphere is not very highly scavenged by ions containing aerosols.

3.4. Total hardness- In the present study the mean total hardness was in the range 1.29-7.62 mg/l. The lowest value of total hardness 1.29 mg/lit recorded at Site II and highest, 7.62 mg/lit at Site IV. Highest value might be due to settlement of anions and cations.

Calcium- Ca^{+2} in rain water can neutralize the acidity. The concentration of Ca^{+2} ranges from 1.12 mg/l in site II to 4.64 mg/l in site III.
Magnesium Mg^{+2} ions in rain water can neutralize the acidity. The concentration of Mg^{+2} ranges from 0.11 mg/l in site II to 1.72 mg/l in site III.
The concentration of calcium and magnesium ions can be due to dust in the atmosphere from the land surface.
3.5. Chloride is one of the major inorganic anion in water. In present study the values of chloride varied between 0.98 mg/l to 3.58 mg/l which is considered to be safe for consumable purpose. Cl^- ions in rain water may be due to emissions from industries, vehicles and also marine aerosols. (Khan and Sarwar, 2014).

3.6. Nitrate- the concentration of nitrate was not detected in site I while it was 1.37mg/l in site IV which can be attributed to the automobile exhaust, fossil fuels and biomass burning. (Ceron *et al*., 2008)
3.7. Phosphate content in rain water was not detected in two sites while it was 0.04 and 0.02 mg/l in remaining two sites which could be attributed to collecting sites near the tree shed and the dust storm and particulate matter that, generally remain in the atmosphere until they are scavenged by precipitation, through dissolution, by falling rain droplets. (Baron and Denning., 1993).
3.8. Total Dissolved Solids - It indicates the chemical constituents of water. The maximum permissible limit of TDS for drinking water is 500 mg/lit. TDS values ranged from 12.84-51.21 mg/l. The high value reported in the site IV could be due to suspended particulate matter in the atmosphere which can be dust or even pollutants like nitrogen and sulphur oxide. High level of dissolved solid is not preferred for consumable purpose. (Jain *et.al* 2004)

3.9. Dissolved Oxygen Dissolved oxygen is necessary to many forms of aquatic life. The amount of dissolved oxygen needed varies from creature to creature. Assessment of dissolved oxygen (DO) is a attributing factor in all pollution related ecological studies (Vijayan, V.S. (1991) . The dissolved oxygen in rain water samples ranged between 6.60 mg/l in site II to 3.13 mg/l in site IV. The presence of dissolved oxygen in rain water may be attributed to its contact with the atmosphere.
3.10. Biochemical Oxygen Demand (BOD): The value of BOD in rain water samples ranged between 1.00 mg/l in site II to 3.02 mg/l in site III.

IV. CONCLUSION

The study of physicochemical parameters of rain water is important to find out the extent of contamination. The studies revealed that rapid industrialization and urbanization has resulted in variation in the physicochemical parameters of rain water. The air pollution in the industrial and urban area has contributed to the contamination in the rain water. Regular monitoring and assessment of physico chemical parameters of rain water and surface water is thus essential for sustainable water management and to keep check on the pollution related issues.

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