REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

Monitoring And Analysis of Water Quality of Educational Institutes of Hamirpur

Megha[1], Abhinav Jamwal[2], Dr Vaishnav Kiran[3*]

[1]M.SC, Department of Environmental Sciences, Himachal Pradesh Technical University, Hamirpur, Himachal Pradesh, 177001, India
[2]Assistant Professor, Department of Environmental Sciences, Himachal Pradesh Technical University, Hamirpur, Himachal Pradesh, 177001, India
[3*]Assistant Professor, Department of Environmental Sciences, Himachal Pradesh Technical University, Hamirpur, Himachal Pradesh, 177001, India

***Corresponding Author**: Dr Vaishnav Kiran
*Assistant Professor, Department of Environmental Sciences, Himachal Pradesh Technical University, Hamirpur, Himachal Pradesh, 177001, India, *Vaishnav.rana5@gmail.com*

Abstract
This work is based on evaluation of physicochemical parameters, calculation of Water Quality Index (WQI) and Correlation to investigate the water quality of tap water of fifteen different educational institutes of Hamirpur city (Himachal Pradesh), India. The sampling was done every month from October, 2023 to March, 2024. The parameters like pH, Total Alkalinity (TA), Electrical Conductivity (EC), Total dissolved solids (TDS), Calcium Hardness (Ca-H), Magnesium Hardness (Mg-H), Total Hardness (TH), Sulphate (SO_4), Chloride (Cl), Dissolved oxygen (DO) and Biological oxygen demand (BOD) were investigated. The observed levels of these parameters were found as per BIS standards except DO and BOD which have been found slightly low and high, respectively as per CPCB. Subsequently the Water quality index was calculated from all the measured parameters. The Average value of WQI for these parameters was found to be 14.59±0.21, which indicates the excellent status of water. The correlation coefficient result shows that different physicochemical parameters have significant positive and negative relationship with each other and suggests that the water has an adequate mineral content, minimal organic contamination, and acceptable DO level.

Keywords: Physiochemical parameters, Water quality, Correlation, BOD.

Introduction

Water on Earth is present across various sources, with the majority found in oceans which contribute for about 97% of the planet's water resources. The remaining 3% is the freshwater with largest portion stored in glaciers and ice caps and modest amount as ground and surface water. This distribution of water is necessary for supporting ecosystems, agricultural, industrial and other human activities. It is also important to understand the distribution of water for sustainable water resource management and for clean and safe water supply to all living organisms. Availability of clean and safe drinking water is chief human requirement for hydration, cooking and overall hygiene. Evaluation of the physicochemical parameters of water plays a key role in evaluating the hydrochemistry of water and restoration of overall water quality [1-7, 16]. Researchers keep testing time to time the quality of water in their respective areas. For accomplishing this, water samples were collected from a variety of sources, including various villages, educational institutions, central and individual water supplies, ponds, dams, rivers, underground water and confluence points. The water quality was then assessed by determining the WQI and applying statistical techniques [4, 8-19, 26].

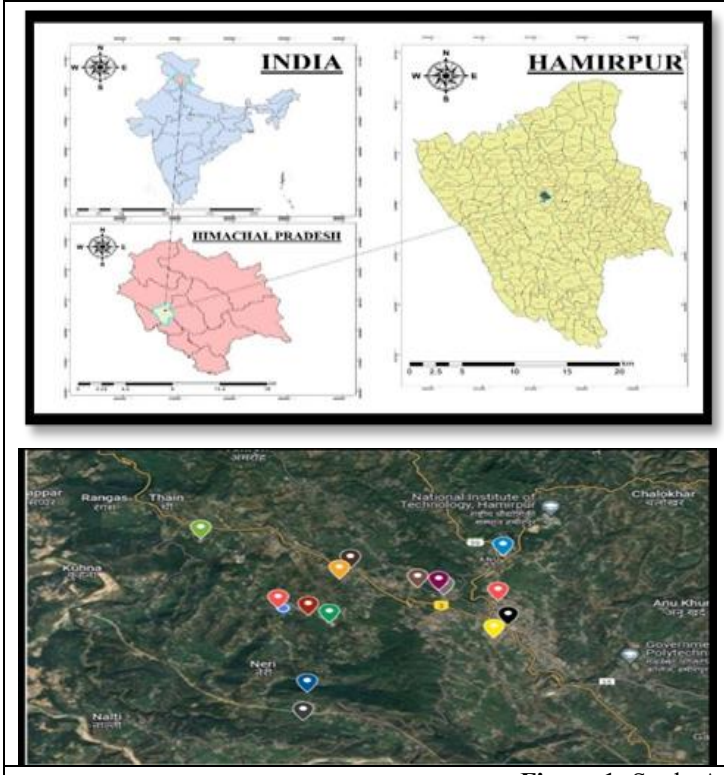
From the literature review it is revealed that in the present scenario drinking water is continuously becoming prone to contamination. The source of contamination may be human and animal litters, improper use of pesticides, fertilizers, municipal and industrial waste emissions [17, 21-27]. Therefore, it is need of hour to investigate physicochemical parameters of drinking water in own respective areas. In this study we have endeavoured to analyse physicochemical parameters of tap water samples from fifteen different educational institutions of Hamirpur city, Himachal Pradesh, India with the objective to ensure the safety and well-being of students, teachers and staff members. By investigating physicochemical parameters such as pH, TA, EC, TDS, Ca-H, Mg-H, TH, SO4, Cl, DO and BOD, the quality of water being consumed within these institutions has been examined. Therefore, in this work we have also attempted to measure the water quality index by utilizing results of physicochemical parameters. Statistical analysis has also been performed to calculate correlation coefficient of different physicochemical parameters of tap water samples [1-3, 7, 10]. This study not only highlights the significance of water quality management in educational settings but also underlines the requirement of regular monitoring and testing to uphold standards of hygiene and environmental sustainability.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

Method

Investigation area

This study was conducted at Hamirpur city, district Hamirpur, Himachal Pradesh, India. Geographically, co-ordinates of Hamirpur are 31.68°N 76.52°E and is located at an average elevation of 790 meters above sea level in the Lower West Central Outer Himalayas [30, 31]. The Arc GIS software was used to create the study area map represented in Figure 1.



S1-Himachal Pradesh Technical University
S2-Government Senior Secondary School Matani
S3-Government Primary School Matani
S4-Government Primary School Pacca Bhro
S5-Gurukul Public School Gopal Nagar
S6-Super Magnet Public School
S7-Gautam Group of Colleges
S8-Government Boys Senior Secondary School Hamirpur
S9-Institute of Hotel Management
S10-Government Middle School Khagal
S11-Parmarth School Krishna Nagar
S12-Netaji Subhash Chander Bose College Hamirpur
S13-Maa Janaki College of Nursing
S14-Govt Middle School Neri
S15-Silver Bells Public School

Figure 1: Study Area Map

Sampling

In the present study a total of thirty tap water bottles (two water bottles of 500ml capacity) from each fifteen selected educational institutes of Hamirpur city, Himachal Pradesh, India were collected through first week of every month throughout the period of October, 2023 to March, 2024 during 9.00 am to 10.00 am by adopting standard methods of sampling [29]. Grab Sampling method was used for sample collection. Water samples were collected in clean and dry High-density polyethylene bottles, avoiding contamination and followed by noting down of location, time, date, proper labeling and were preserved in refrigerator to analyze in the laboratory by using standard methods, within 24 hours of collection [26, 29].

Methodology

The tap water samples were examined in the laboratory for determining pH, TA EC, TDS, Ca-H, Mg-H, TH, SO_4, Cl, DO and BOD. The pH, EC and TDS were measured by using digital water analysis kit. Dissolved oxygen (DO) was determined by Winkler titrimetric method and to find out Biological Oxygen demand (BOD) five-day BOD test was performed by keeping the water samples in BOD incubator [5, 6, 7, 8, 11-14, 17]. Total Hardness, Calcium and magnesium harness was calculated by using complexometric titration method with Ethylene diamine tetra acetic acid (EDTA). Using phenolphthalein and methyl orange as indicators, the water samples were titrated against a standard sulfuric acid solution to estimate the total alkalinity. Amount of chlorine has been calculated by adding potassium dichromate in water sample and titrating it against standard silver nitrate solution. The concentration of sulfate in water has been calculated by Barium chloride method [5-10]. The analytical results were contrasted with the standard as recommended by Bureau of Indian Standards (BIS) 10500:2012 [32] and DO and BOD parameters compared with Central Pollution Control Board (CPCB) 2019 guidelines [33].

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

Data Analysis
By using Descriptive statistics Minimum, Maximum, Mean and Standard Deviation were calculated for physiochemical parameters. Water Quality Index (WQI) was examined by weighted arithmetic index method [10, 22, 28]. The Karl Pearson's Correlation analysis was employed to find out correlation between physicochemical parameters of examined water samples to ascertain their inter-relationship [1-3, 27].

Results and discussions
From the observation mentioned in Table 1 it has been found that the Mean pH value of six months study ranges from 6.9 – 7.2 with a minimum of 6.4 observed for sample six (S6) and maximum of 7.8 observed for samples S10 and S14 indicating that pH values are well within acceptable limit of BIS and water was not too acidic nor too alkaline and found perfect for drinking. Six months mean value of total alkalinity ranges between 69.67-93.83 mg/l which has been found within the acceptable limits of BIS, hence, these alkalinity levels are very good for contribution of alkalinity in water's buffering capacity [24 & 25]. The six months EC analysis mean value ranges from 142.03 – 164.82 µS/cm, however, there is no direct acceptable or permissible limit of EC has been specified and it is correlated with TDS. The observed mean value of TDS lies in the range of 101.67 -148.33 mg/l. The common approximate conversion factor for most natural waters = TDS (mg/L) ≈ EC (µS/cm) * (0.5 to 0.7) [34]. On applying conversion factor the estimated TDS range of tap water is found to be 71.02 -.115.37 mg/l, which is comparable with the observed TDS range 101.67 -148.33 mg/l. Hence, TDS level is not exceeding the acceptable limit as given by BIS shown in Table 1 indicating good palatability and adequate mineral content, which has been found excellent for drinking. Calcium and magnesium are necessary for maintaining bones mass density and other health requirements [26]. From the study it has been revealed that mean value of calcium and magnesium was found to be 74.17 – 109.33 mg/l and 26.00 – 45.50 mg/, respectively. This suggests that upper limits of calcium and magnesium was found above the acceptable limits but still within the permissible limits, hence indicating their contribution to slight hardness. The observed mean value of total hardness is found to be 112.67 – 144.67 mg/l, which has been within acceptable limits, suggesting that water is moderately soft to slightly hard and still palatable [18]. Mean values of sulphate ranges between 0.39 -1.37 mg/l, which are very low than that the acceptable limits and not prone to pose any health issue as high values of sulphate is the cause of laxative effect. Mean chloride values range between 60.00 – 80.67 mg/l and found below the acceptable limits, however water is well suitable for drinking because high chloride level can cause contamination or salty taste [35]. BIS primarily focuses on chemical and physical parameters of drinking water. The Central Pollution Control Board (CPCB) guidelines, which often align with BIS, state that for "Drinking Water Source without conventional treatment but after disinfection (Class A water)," should have DO 6 mg/l or more and BOD 3 or less mg/l [33]. The observed mean values of DO and BOD of water was found to be 5.15-5.35 and 3.34-3.80 mg/l indicating slightly low value of DO and slightly high value of BOD, which indicates the low organic content with adequate oxygen level [20]. However, these levels are for tap water and it's hard to make a definitive suitability statement based on DO and BOD levels.

The WQI in the 0-25 range is if excellent grade [22 & 28]. Our observed WQI from six months analysis ranges in between 14.09-14.91 as shown in Table 2. The results demonstrate the excellent quality of water over six months period and making it suitable for drinking. This is a positive indicator for public health and water management in the region. Table 3 shows the correlation matrix for various water quality parameters, which are collected over a six-month study of tap water. Each cell shows the correlation coefficient (R-value) between two parameters. An R-value close to +1 indicates a strong positive correlation, close to -1 indicates a strong negative correlation, and close to 0 indicates a weak or no correlation [2, 20, 29]. The very strong positive correlation between EC and TDS strongly validates the data as these two parameters are excellent indicators of the overall mineral content and purity of the tap water. A strong positive correlation suggests consistent water source or treatment where the ionic composition remains relatively stable.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: Revised: Accepted:

Table 1: Descriptive analysis data

		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
p H	Minimum	6.5	6.7	6.5	6.6	6.5	6.4	6.5	6.8	6.7	6.5	6.6	6.6	6.5	6.8	6.6
	Maximum	7.2	7.4	7.2	7.3	7.7	7.5	7.6	7.7	7.4	7.8	7.6	7.5	7.4	7.8	7.4
	Std Dev	0.23	0.29	0.28	0.25	0.46	0.41	0.42	0.35	0.32	0.46	0.39	0.36	0.30	0.38	0.30
BIS IS 10500:2012				Acceptable limit: 6.5-8.5							Permissible limit: ---					
Total Alkalinity (mg/l)	Minimum	55	61	54	50	57	56	45	56	56	67	56	67	68	59	56
	Maximum	120	120	124	128	98	120	100	154	120	125	124	129	111	122	123
	Std Dev	24.81	22.68	24.40	29.54	16.91	24.70	22.56	35.54	25.24	20.13	27.79	22.69	16.54	28.36	31.61
BIS IS 10500:2012				Acceptable limit: 200 mg/l							Permissible limit: 600 mg/l					
EC (µs/cm)	Minimum	136.4	132	132	134	132	135	134.5	136.8	139.5	134	135.6	132	136	143	137
	Maximum	150	156	160	176.6	168	179	178.9	179.8	180	179	178	180	179	179.9	180
	Std Dev	5.13	8.57	10.93	16.34	14.42	17.02	19.84	20.59	16.30	16.90	16.07	23.06	20.99	14.72	20.30
BIS IS 10500:2012				Acceptable limit: ----							Permissible limit: ----					
TDS (mg/l)	Minimum	79	81	78	78	88	100	83	88	69	71	86	58	79	78	56
	Maximum	145	146	141	150	150	160	183	176	178	147	156	178	199	185	199
	Std Dev	23.75	25.02	24.77	27.24	24.94	21.12	45.62	38.05	44.82	26.78	28.82	53.37	54.33	43.14	59.96
BIS IS 10500:2012				Acceptable limit: 500 mg/l							Permissible limit: 2000 mg/l					
Calcium Hardness (mg/l)	Minimum	56.00	66.00	46.00	34.00	65.00	41.00	76.00	82.00	70.00	68.00	87.00	75.00	84.00	62.00	57.00
	Maximum	85.00	102.00	116.00	150.00	133.00	127.00	133.00	112.00	135.00	139.00	122.00	136.00	133.00	124.00	91.00
	Std Dev	10.91	16.19	32.07	39.04	25.52	29.90	19.39	10.11	21.98	26.01	12.91	26.03	18.96	25.18	13.77
BIS IS 10500:2012				Acceptable limit: 75 mg/l							Permissible limit: 200 mg/l					
Magnesium Hardness (mg/l)	Minimum	30.00	20.00	21.00	28.00	21.00	32.00	23.00	22.00	28.00	21.00	22.00	20.00	22.00	21.00	26.00
	Maximum	56.00	38.00	34.00	45.00	35.00	56.00	45.00	45.00	50.00	36.00	45.00	46.00	50.00	53.00	56.00
	Std Dev	9.89	7.03	6.11	6.44	6.63	8.46	8.38	7.64	7.58	5.85	8.43	8.76	10.21	11.57	10.84
BIS IS 10500:2012				Acceptable limit: 30 mg/l							Permissible limit: 100 mg/l					
Total Hardness (mg/l)	Minimum	111.00	100.00	75.00	79.00	90.00	80.00	121.00	111.00	120.00	100.00	123.00	111.00	122.00	100.00	100.00
	Maximum	125.00	125.00	150.00	178.00	156.00	167.00	161.00	145.00	167.00	160.00	167.00	172.00	178.00	151.00	123.00
	Std Dev	5.47	10.91	30.66	33.08	24.16	28.47	15.80	11.54	16.78	21.44	17.58	23.86	19.92	20.05	8.50
BIS IS 10500:2012				Acceptable limit: 200 mg/l							Permissible limit: 600 mg/l					
Sulphate (mg/l)	Minimum	0.30	0.03	0.04	0.28	0.01	0.12	0.11	0.14	0.05	0.17	0.21	0.04	0.06	0.10	0.13
	Maximum	1.61	1.68	1.21	2.21	1.11	1.51	1.35	2.10	1.08	2.10	1.68	1.56	1.92	2.64	4.59
	Std Dev	0.61	0.65	0.52	0.83	0.47	0.47	0.51	0.76	0.38	0.81	0.56	0.66	0.76	1.00	1.74
BIS IS 10500:2012				Acceptable limit: 200 mg/l							Permissible limit: 400 mg/l					
Chloride (mg/l)	Minimum	22.00	47.00	56.00	51.00	45.00	48.00	62.00	59.00	58.00	53.00	67.00	59.00	68.00	34.00	45.00
	Maximum	89.00	90.00	89.00	89.00	89.00	89.00	95.00	91.00	90.00	97.00	89.00	87.00	98.00	89.00	90.00
	Std Dev	22.42	16.72	14.01	15.14	16.61	19.87	12.96	12.44	13.75	18.06	9.22	11.66	12.46	21.37	16.49
BIS IS 10500:2012				Acceptable limit: 200 mg/l							Permissible limit: 400 mg/l					
DO (mg/l)	Minimum	4.40	4.40	4.40	4.40	4.60	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.70	4.40
	Maximum	6.00	5.90	5.90	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
	Std Dev	0.64	0.55	0.58	0.62	0.60	0.66	0.68	0.66	0.67	0.66	0.61	0.66	0.66	0.56	0.66
BIS IS 10500:2012				Acceptable limit: ----							Permissible limit: ----					
BOD (mg/l)	Minimum	1.20	1.20	1.20	1.20	1.20	1.20	2.28	1.20	2.40	1.20	1.20	1.20	1.20	2.40	1.20
	Maximum	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80
	Std Dev	1.40	1.59	1.50	1.40	1.40	1.52	1.21	1.52	1.18	1.48	1.50	1.52	1.52	1.00	1.52
BIS IS 10500:2012				Acceptable limit: ----							Permissible limit: ----					

Very strong correlation between Ca-H with TH and weak correlation of Mg-H with TH indicating the major contribution of Ca in total hardness of water. Strong correlation between Cl and Ca-H is a significant finding and suggests that a major source of Calcium in the tap water is associated with chloride, possibly from dissolved calcium chloride. A very weak correlation between DO and BOD indicates that tap water likely has low organic pollution, as indicated by generally low BOD values and sufficient dissolved oxygen. For any unexpectedly weak or strong correlations (Mg-H vs. TH, or the negative correlation of pH with Mg-H and SO4) may be due to many reasons like geological influences, anthropogenic factors and any treatment processes.

Table 2: Water Quality status of analysed samples

Sample	WQI Value	Sample	WQI Value
S1	14.82	S9	14.81
S2	14.41	S10	14.54
S3	14.09	S11	14.56
S4	14.68	S12	14.44
S5	14.34	S13	14.77
S6	14.91	S14	14.75
S7	14.60	S15	14.44
S8	14.62	-	-

S1-S15 are Water Samples of fifteen Educational Institutes as shown in Figure 1

Table 3: Correlation Matrix of Water Quality Parameters

	p H	TA	EC	TDS	Ca-H	Mg-H	TH	SO4	Cl	DO	BOD
p H	1										
TA	0.239178	1									
EC	0.477734	0.320758	1								
TDS	0.466375	0.347577	0.917075	1							
Ca-H	0.377154	0.170494	0.441221	0.26866	1						
Mg-H	-0.26538	-0.19998	0.147549	0.104057	-0.22865	1					
TH	0.242059	0.071397	0.507687	0.315464	0.880833	0.259426	1				
SO4	-0.34288	0.236712	-0.20282	-0.27869	-0.17051	0.243273	-0.05256	1			
Cl	0.390433	-0.0615	0.151697	0.072769	0.76283	-0.18249	0.668399	-0.12435	1		
DO	0.242195	0.03659	0.619523	0.545979	0.332935	0.102733	0.378399	-0.16837	-0.10377	1	
BOD	0.43545	0.116438	0.562533	0.53976	0.130245	-0.09303	0.083366	-0.39653	-0.03007	0.115637	1

EC- Electrical Conductivity, TH-Total Hardness, Ca-H - Calcium Hardness, Mg-H - Magnesium Hardness, TA-Total Alkalinity, TDS-Total Dissolved Solids, SO4 -Sulphate, Cl-Chlorine, DO-Dissolved Oxygen, BOD-Biological Oxygen Demand

Conclusions

Study of six months physiochemical parameter analysis of tap water samples of fifteen educational institutes of Hamirpur city, Himachal Pradesh revealed that pH, TA, EC, TDS, SO_4, Cl levels were excellent and Calcium, Magnesium and total hardness levels are acceptable. These results and measured values are within permissible limits set by the BIS. As per CPCB, DO and BOD results indicates the low organic pollution in tap water. Water quality status was also found to be Excellent. Correlation data revealed that different physicochemical parameters have significant positive and negative relationship with each other and points toward the presence of significant mineral content in water and low organic pollution with sufficient DO in tap water.

Funding: This work was supported by ongoing Institutional funding. No additional grants to carry out this research work was received.

Compliance with Ethical Standards: not applicable

Conflict of Interest: have no conflict of interest

References

1. Kothari, V., Vij, S., Sharma, S.K., and Gupta, N., Correlation of various water quality parameters and water quality index of district of Uttaranchal, *Environmental and Sustainable Indicator*, 2020, vol. 9, pp. 2665-9727. http://doi.org/10.1016/j.indic.2020.100093
2. Dwivedi, K.N., and Lakhera, A., A review of various methods of correlation analysis on water quality parameters, *International Journal of Research Publication and Review*, 2022, vol. 3, pp. 1613-1616.
3. Shukla, S.K., and Sharma, R.K., The correlation and regression analysis of physicochemical water quality parameters of Wainganga River water in central India, *Journal of Indian Association for Environmental Management,* 2023, vol. 43, pp.11-17.
4. Akcaya, I. and Ozbaya, O., Assessment of Ecological and Potential Health Risk Caused by Nitrate Pollution of the Berdan and Goksu River Basins, Turkey, *Journal of Water Chemistry and Technology,* 2024, vol. 46, pp. 645–651. http://doi.org/10.3103/S1063455X24060018
5. Rahman, A., Jahanara, I., and Jolly, Y.N., Assessment of physicochemical properties of water and their seasonal variation in an urban river in Bangladesh, *Water Science and Engineering*, 2021, vol. 14, pp.139-148. https://doi.org/10.1016/j.wse.2021.06.006
6. Bilewu, C.F., Ayanda, O.I., and Ajayi, O.T., Assessment of physicochemical parameters in selected water bodies in Oyo and Lagos states, *IOP Conf Series Earth and Environmental Science*, *The Electrochemical Society,* 2022, vol. 1054, pp. 1-8. https://doi.org/10.1088/1755-1315/1054/1/012045
7. Meher, P.K., Sharma, P., Gautam, Y.P., A Kumar and K P Mishra. Evaluation of water quality of ganges river using water quality index tool, *Environment Asia*, 2015, vol. 8, pp. 124-132, https://doi.org/10.14456/ea.2015.15
8. Kale, V.S., Consequences of temperature, pH, Turbidity and DO water quality Parameters, *International Advanced Research Journal in science, Engineering and Technology,* 2016, vol. 3, pp. 2393-8021. https://doi.org/10.17148/IARJSET.2016.3834

9. Fetrat, S., and Islam, S., Investigation of the physicochemical parameters of drinking water in Herat province and its comparison with World Health Organization standards, Discover Water, 2024, vol. 4, 112. https://doi.org/10. 1007/ s43832- 024-00169-8
10. Qureshimatva, U.M., Maurya, R.R., Garnit, S.B., Patel, R.D., and Solanki, H.A., Determination of physic-chemical parameters and water quality index (WQI) of Chandlodia lake, Ahmedabad, Gujarat, India, *Environmental and Analytical Toxicology*, 2015, vol. 5, pp. 1-6. https://doi.org/ 10.4172/2161-0525.1000288
11. Yadav, S.D., Mishra, K., Chaudhary N.K., and Mishra, P., Assessing physicochemical parameters of potable water in Dhankuta, Municipality of Nepal, *Science Journal of Analytical Chemistry*, 2015, vol. 3, pp. 17-21. https://doi.org/10.11648/j.sjac.20150302.11
12. Abdullahi, A.B., Siregar, A.R., Pakiding, W., and Mahyuddin, The analysis of BOD (Biological Oxygen Demand) and COD (Chemical oxygen Demand) contents in the water of around laying chicken farms, *IOP Conf. Series. Earth and Environmental Science,* 2021, vol. 788, pp. 1-6.
13. Ahmed, B.O., Evaluation of drinking water quality from water coolers in Makkah, Saudi Arabia, *Environmental Health Insights*, 2023, vol. 17, pp. 1-5. https://doi.org/10.1177/11786302231163676
14. Bhutiani, R., and Khanna, D.R., DO-BOD modelling of river Ganga from Devprayag to Roorkee, India using BMKB model, *Pollution*, 2016, vol. 2, pp. 25-34. https://doi.org/10.7508/pj.2016.01.003
15. Borah, K., Sharma, P., Bhuyan, B., and Sharma, H., A case study on ground water quality of western Darrang district, Assam with special reference to some parameters and mapping using geospatial techniques, *Pollution Research*, 2018, vol. 37, pp. 744-749.
16. Das, H., and Borah, K., Iron excess in drinking water of Darrang district of Assam and some adjoining areas, Defence Research Laboratory, *Journal of Environmental and Analytical Toxicology*, 1983, vol. 33, pp. 31-37.
17. Kulishenkoa, O. Yu., Klymenkoa, N. A. and Nevinnaa, L.V., Effect of Solar Activity Cycles on the Dnipro Water Quality Parameters, *Journal of Water Chemistry and Technology*, 2024, vol. 46, pp. 652–665. https://doi.org/10.3103/S1063455X24060079
18. Chobotara, V.V., Kopilevicha, V.A., and Kravchenkoa, O.O., Analysis of Natural Water Quality in the Dniester River Basin for Economic Utilization, *Journal of Water Chemistry and Technology*, 2024, vol. 46, pp. 636–644. https://doi.org/10.3103/S1063455X24060031
19. Jouanneau S., Recoules, L., Durand, M.J., Boukabache, A., Picot, V., Primault, Y., and Thouand, G., Methods for assessing biochemical oxygen demand (BOD): Review, *Water Research*, 49: 62-82, 2014. https://doi.org/10.1016/j.watres.2013.10.066
20. Sahu, M., Shrivastava, A., Jhariya, D.C., Diwan, S., Subhadarsini, J., Evaluation of correlation of physicochemical parameters and major ions present in groundwater of Raipur using discretization, *Measurement: Sensors*, 2024, vol. 34, pp. 1-14. https://doi.org/10.1016/j.measen.2024.101278
21. Mascher, F., Reinthaler, F., Schuhmann, G., Enayat, U., Sixl W., and Klambauer, B., Microbiological and chemical analysis of drinking water in Southern India (with special consideration of Aeromonas species), *Geogr Med Suppl*, 1989, vol. 3, pp. 135-140. https://doi.org/10.5455/vetworld.2013.300-306
22. Murali, K., Kumar, R.S., and Elangovan, R., Assessment of ground water quality in Coimbatore South Taluk, Coimbatore district, India, *Nature Environment and Pollution Technology,* 2011, vol. 10, pp. 521-524.
23. Rehaili, A. E., and Misbahuddin, M., Levels of trace metals in Riyadh Drinking water at the consumer taps, *Journal of King Saud University Engineering Sciences*, 1995, vol. 7, pp. 1-22.
24. Sharma, A., and Aggarwal, R. K., Water quality assessment of Schools in Solan district of Himachal Pradesh, *World Environ*, 2020, vol. 15, pp. 253-259. http://dx.doi.org/10.12944/CWE.15.2.13
25. Swarnakar, A.K., and Chaubey, S., Testing and analysis of pond water in Raipur city, Chattisgarh, *International Journal of Science and Research*. 2016, vol. 5, pp. 1962-1965. http://dx.doi.org/10.21275/23197064
26. Okabekwa, V.C., Arinze, R.U., Tabugbo, B.I., Okafor, V.N., Assessment of physicochemical properties of water from Eleme river, south-south Nigeria, *J. Chem. Soc. Nigeria*, 2024, vol. 49, pp. 013 – 022. http://dx.doi.org/10.46602/jcsn.v49i1.947
27. Dwivedi, K.N., Lakhera, A., Correlation Analysis of River Narmada by Karl-Pearson Method and Weighted Arithmetic Water Quality Index, *International Research Journal of Modernization in Engineering Technology and Science*, 2022, vol. 4, pp. 2729-2736.
28. Brown, R.M., Mccleil, N.J., Deiniger, R.A., and Connor, M.F., Water quality index-crossing the physical barrier, *Res Jerusalem*, 1972, vol. 6, pp. 787–797.
29. Guidelines on Water Quality monitoring (WQMA 2017).
30. Balokhra, J.M., The wonder Land Himachal Pradesh, 2016.
31. Vats, G., Geography of Himachal Pradesh, 2020.
32. Indian Standard Drinking Water-Specification 10500:2012, Bureau of Indian Standards
33. CPCB, Ministry of Environment, Forest and Climate change, Government of India, October 2019.
34. Kovacova V., Estimation a conversion factor between Electrical conductivity and Total Dissolved Solids in Zinty ostrov Surface water, Journal of Polish Engineering Water, 2023, pp 1-10, http://doi.org/10.29227/IM-2024-01-30
35. Masters, G. M., ELA W.P., Introduction to Environmental Engineering and Science, 2013