Water Quality Assessment of District Bagh (Tehsil Dhirkot)Azad Jammu & Kashmir Using Multivariate Statistical Methods

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Abstract— **The present study is conducted to identify the physical and chemical characteristics of District Bagh, Azad Jammu and Kashmir surface water. Fifteen locations were selected from study area to collect the water samples. The various physico-chemical parameters of water tested are pH, Temperature, Total dissolved solids (TDS), Sodium, Potassium, Sulphate, Nitrate, Calcium, Magnesium and Bicarbonates. The heavy metals including Cr, Cu, and Cl are also the part of our current research on the basis on the outcome of previous studies conducted in the urban areas of Azad Jammu and Kashmir. The final results concluded that bicarbonate was present in high concentration in all samples whereas the other parameters were in the compliance of prescribed World Health Organization standards. Furthermore, Cluster analysis and Principal Analysis were performed which shows similar results and effects of bicarbonates and hardness of water as major contributor of altering the concentration of other variables.**

Index Terms— **Azad Jammu and Kashmir, Cluster Analysis, Multivariate Statistical Analysis, Principal Component Analysis, Physico-Chemical Characteristics.**

I.   INTRODUCTION

Water is the most common and valuable asset and is the basic necessity of life. This is a vital source for life is deteriorating due to our irresponsible behavior. Water is naturally available in rivers, lakes, water spring and streams. [1]. The quality of water is deteriorating day by day due to both natural processes i.e. precipitation rate, soil erosion, weathering and anthropogenic influence viz Agriculture, urban & industrial activities [2], [3]. An estimated 14-30 thousand people, mostly young children and the elderly has been reported to die every day from water-related diseases [4]. Poor quality give rise to various health related issues such as Diarrhea, Typhoid, Hepatitis A & Cholera [5]. Around 32 parameters are investigated to determine the quality of both surface and groundwater sources [6]. Heavy metals present in water can cause serious health issues whereas some trace elements are essential for life but their high concentration in blood stream is harmful for our health.[7], [8]. Multivariate statistical techniques are used for analyzing data related to quality of surface water [9].

Azad Jammu & Kashmir (AJK) is liberated part of state of Jammu and Kashmir. The total area spans 13397 km3 of Which only 13% is designated for agriculture. It is situated 73-75 0E on longitude and 37-39 0N on latitude. There are 03 divisions of Azad Jammu and Kashmir namely: Muzaffarabad,

Poonch, and Mirpur. Poonch is the current study area made by the districts Bagh, Poonch, Haveli and Sudhnoti [10], [11]. People of AJK largely lives in scattered villages, relying on the natural springs, water wells and water streams (glacial water) for both drinking and household use [12]. Poor consumption is the casual factor of 80% diseases in Azad Jammu and Kashmir. Ground and surface water contains high amount of trace metals. Due to natural and human activities these water sources are getting polluted day by day [13].
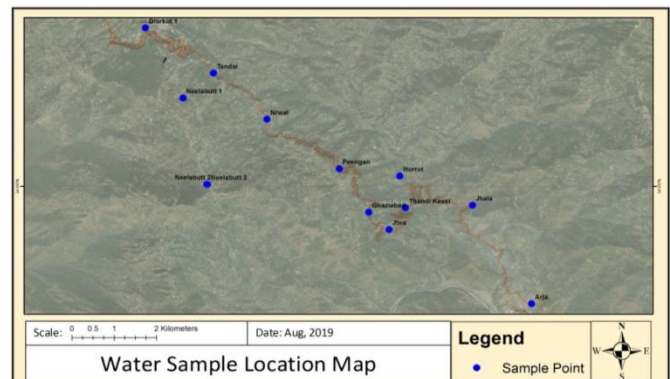

Fig. 1: Map of Sampling Sites of Tehsil Dhirkot (District Bagh, Azad Jammu & Kashmir)

The present study conducted to investigate the water quality of rural area of District Bagh. Tehsil Dhirkot was selected for the present study with following objectives:

- To identify the factors those are responsible to cause variation in water quality of the area. Further to check the trace metal concentration available to the residents of the selected sites.
- To analyze the quality of water in terms of uniformity and heterogeneity among collected samples Multivariate statistical analysis will be conducted.
- To analyze the concentration of heavy metals on the basis of the results of previous studies that reported the high concentration of lead, copper and chromium in water resources of urban areas of Azad Jammu and Kashmir [14], [15].

II.   MATERIALS AND METHODS

A.   Study Area

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As discussed earlier the current research was performed in Tehsil Dhirkot, District Bagh, Azad Jammu & Kashmir. District Bagh lies at 33.9794 0N and 73.7772 0E, where around 54.58% area covered by forest. It is about 10% of total land area of Azad Jammu & Kashmir [11].

Table I: Map Location of Water Collection of Tehsil Dhirkot

5.No	Location	Latitude	N°	Longitude	E°
1	Arja	33.973978	330 58'26.32152	73.658673	730 39'31.22388
2	Jhala	33.995793	33059'44.85408	73.646091	73038'45.92904
3	Jbra	33.990404	33059'25.45584	73.628309	73037'41,91096
4	Thandi Kassi	33.995191	33059'42.68724	73.631817	730 37'54.54048
5	Dhirkot 3 Kohalla Bagh	33.994219	3401'55.22268	73.623971	73034'9.57504
6	Dhirkot 2 Challa	33.9942219	340 1'55.18956	73.623971	73034'9.62076
7	Dhirkot 1	34.035034	3402'6.1224	73.576424	73034'35.1276
8	Ghaziabad	33.994229	33059'39.22548	73.623971	73037'2629524
9	Tandal	34.025013	340 1'30.04536	73.590917	73035'27.3012
10	Nrwal	34.014817	340 0'53.33976	73.602337	730 36'8.4132
11	Peengan	34.003862	3400'13.905	73.617699	730 37'3.71568
12	Neelabutt 1	34.019544	3401'10.35732	73.584432	73035`3.95592
13	Neelabutt 2	34.000427	3400'153792	73.589532	73035'22.31412
14	Neelabutt 3	34.000385	340 0'1.38564	73.589657	73035'22.76556
15	Horrot	34.002241	3400'8.06688	73.630605	730 37'50.17872

B. On-Site Sampling

Fifteen Samples were collected from natural spring sources of District Bagh (Table 1) from the selected sources wells and Nullahs. Samples were collected in a way that will not get contaminated during relocation. Samples were gathered in bottles prior soaked in 10% nitric acid for 24 hours and then washed with distilled water. Around 500 ml of each sample was collected and pH, temperature, color and odor was noted on-site during sampling process. 2 to 3 drops of nitric acid were then mixed in the samples so that chemical characteristics may be altered.

C. Laboratory Tests and Statistical Analysis

Chemical analyses of the samples were carried in the Laboratory using standard methods. Table 2 shows the methodology used for analysis of samples. Statistical analysis was carried out using "Minitab" version 11.12. Pearson Correlation Matrix was created for all samples to check the concentration of samples whether parameters affect each other or not. Cluster analysis and Principal Component

Analysiswere carried out to check the homogeneity and heterogeneity among the variables.

Table II: The Samples were Analyzed by using Standard Methods

S#	Parameters	Abbreviation	Analytical Methods	Units
01	Color	Co	APHA Pt-Co Scale	Pt
02	Odor	Odor	Sensory Method	No
03	pH	pH	ASTM 0-1293	No
04	Temperature	Temp	Mercury Thermometer	oC
05	Total Dissolved Solids	TDS	APHA 2540 Gravimetric Method	mg L-1
06	Chromium	Cr	1,5-Diphenylcarbazide	mg L-1
07	Copper	Cu	Biquinoline M	mg L-1
08	Sodium	Na+	ASTM D-3561	mg L-1
09	Potassium	K+	ASTM D-3561	mg L-1
10	Sulfate	SO2-4	Lovibond Barium Sulphate turbidity	mg L-1
11	Nitrate	NO3-	Lovibond Chromotropic acid	mg L-1
12	Chloride	Cl-	ASTM D-512	mg L-1
13	Magnesium	Mg2+	ASTM D-1126	mg L-1
14	Calcium	Ca2+	ASTM D-1126	mg L-1
15	Bicarbonate	HCO3	ASTM D-1126	mg L-1

III. RESULTS AND DISCUSSIONS

The present study was aimed to investigate water quality level of Tehsil Dhirkot, District Bagh Azad Jammu and Kashmir. Various physical and chemical analytical techniques and methods were applied to determine the concentration of selected parameters. Table 3 shows the results of samples which were analyzed during the study. The obtained results were compared the WHO guidelines for drinking water. Results of all parameters i.e. TDS (Total Dissolved Solids), magnesium, calcium, sodium, chromium, chloride, and sulphate is within the acceptable limits of WHO, 1993 guidelines except of bicarbonates [16]. Furthermore, the values of the sample collected from Arja and Choray have shown dissimilarities in TDS and total hardness results as compare to other locations.

A. The Pearson correlation matrix of selected parameters

The Person correlation matrix was developed to identify the interdependency of the parameters. The relationships between the parameters were given in the Table 4. No noteworthy relationship of temperature was found with other parameters. Whereas, pH shows the negative relationship and TDS, sulphates, and chlorides show the positive correlation. pH shows no significant correlation with other parameters. Sodium, potassium, total hardness and bicarbonates demonstrate the negative correlation with TDS and negative correlation with sulphates, Sodium showed significant correlations with Potassium, Chloride and Bicarbonates. Sulphates, also expressed the correlation with Chloride. Total Hardness showed a strong correlation with Bicarbonates. The discussion explains that high correlation was observed among the parameters of sodium, potassium, bicarbonates and TDS. It

shows that if concentration of these parameters is disturbed then we can expect alter in concentration of other parameters.

Table III: The Laboratory Results of Collected Samples

Sample	Location	Sources		Odor	Temp	pH	TDS (mg/l)	Cu (mg/l)	Na (mg/l)	K (mg/l)	Cr (mg/l)	SO₄²- (mg/l)	NO3- (mg/l)	Cl (mg/l)	Mg (mg/l)	Ca (mg/l)	HCO3- (mg/l)
Sample 01	Neela Butt	Storage Body (Tanki)	<5	Non-Objectionable	16	7.22	605	< 0.05	8	1.00	ND	4.4	< 1	14.27	9.14	131.06	436.35
Sample 02	Dhirkot	Water Spring	9	Non-Objectionable	20	7.25	480	< 0.05	5	1.00	ND	8.8	< 1	14.27	9.32	108.86	334.22
Sample 03	Dhirkot	Water Spring	6	Non-Objectionable	20	7.52	515	< 0.05	10	1.00	ND	5.4	< 1	21.38	12.81	103.63	357.43
Sample 04	Tandal	Water Spring	<5	Non-Objectionable	18	7.35	445	< 0.05	7	1.00	ND	7.1	< 1	14.25	10.31	92.58	311.01
Sample 05	Chory	Water Spring	<5	Non-Objectionable	18	7.07	570	< 0.05	12	2.00	ND	8.4	< 1	28.5	14.63	110.49	389.92
Sample 06	Chory	Water Spring	6	Non-Objectionable	18	7.61	498	< 0.05	11	1.00	ND	8.1	< 1	24.94	10.97	101.44	338.87
Sample 07	Nrwal	Water Spring	<5	Non-Objectionable	20	7.01	495	< 0.05	7	0.00	ND	5.9	< 1	14.25	14.63	98.44	352.79
Sample 08	Peenga	Water Spring	<5	Non-Objectionable	18	7.52	470	< 0.05	8	1.00	ND	6.4	< 1	17.81	6.4	102.98	329.94
Sample 09	Ghaziabad	Well	7	Non-Objectionable	17	7.43	480	< 0.05	8	1.00	ND	6.6	< 1	14.25	23.77	80.77	343.51
Sample 10	Jbra	Nullah	6	Non-Objectionable	18	7.11	510	< 0.05	4	0.00	ND	3.8	< 1	7.13	22.86	89.92	379.93
Sample 11	Thandi Kasi	Water Spring	<5	Non-Objectionable	16	7.38	450	< 0.05	9	1.00	ND	7.3	< 1	21.38	21.94	72.29	315.66
Sample 12	Jhala	Water Spring	6	Non-Objectionable	18	7.32	455	< 0.05	9	1.00	ND	7.5	< 1	21.38	18.29	82.32	366.72
Sample 13	Jhala	Water Spring	<5	Non-Objectionable	18	7.48	530	< 0.05	7	1.00	ND	6.8	< 1	17.81	20.12	100.58	376.12
Sample 14	Arja	Water Spring	6	Non-Objectionable	21	7.01	620	< 0.05	13	2.00	ND	9.3	< 1	28.5	25.6	107.35	431.71
Sample 15	Arja	Water Spring	8	Non-Objectionable	21	7.34	615	< 0.05	13	2.00	ND	9.6	< 1	28.5	23.77	109.3	427.06
WHO Permissible Limit			<TCU	No guidline	No guidline	6.5-8.5	<1000 mg/l	2 mg/l	200mg/l	1-2mg/l	0.05mg/l	250mg/l	50mg/l	<250mg/l	50mg/l	200mg/l	250mg/l

Table IV: PC loadings of ten variables from first three components taken from Eigen analysis > 1

Variables	PC1	PC2	PC3
Temperature	0.234	0.061	0.081
pH	-0.123	-0.409	-0.409
TDS (mg/l)	0.393	0.347	-0.009
Na (mg/l)	0.415	-0.249	-0.091
K (mg/l)	0.4	-0.17	-0.069
SO₄²- (mg/l)	0.294	-0.367	-0.006
Cl (mg/l)	0.4	-0.317	-0.111
Mg (mg/l)	0.162	-0.091	0.735
Ca (mg/l)	0.222	0.443	-0.498
HCO3- (mg/l)	0.349	0.401	0.108

The similarities between the samples were shown in Fig 2. The variables of C1(Neela butt)-C2(Dhirkot)-C3(Dhirkot)-C4(Tandal)-C5(Choray)-C6(Choray)-C7(Nrwal) and C13(Jhala) showed a similarity due to the short distance among the sample collection points and same collection sources. The samples were collected from Dhirkot, Tundal, Choray, Narwal and Jhala. The Sites of Dhirkot, Tundal and Choray located at UC Dhirkot while remaining located at UC Mkahyla and one sample from UC Mallot.

The reasons for resemblance were the same latitude, the short distance among the sites & the same type of sample collection sources i.e. Water Spring.

The Variables of C9 (Ghaziabad)-C11(Thandi Kassi)-C14 (Arja)-C15(Arja)-C10(Jabra) and C12(Jhala) showed a similarity. The sites of Ghaziabad, Jabra and Thandi Kassi were located at UC Makhyala and the water feed of all sites observed the same. The remaining sites located at UC Mallot. The latitude of all sites was observed similar. The characteristics of the three groups derived from agglomerative cluster analysis are presented in the sequel Table 5. PC1 explained that the factor TDS was influenced by the variables of Na, K, Cl and HCO3. A dissolved solid (TDS) shows the trace amount of organic matter and inorganic salts present in water. The major components are calcium, magnesium, sodium and potassium cations, carbonate, hydrogen carbonate, chloride, sulfate and nitrate anions (WHO, 1996). As a result, the factor TDS can be easily influenced by the variables salts and Bicarbonates. PC2 explained that the factor pH was influenced by the variables Ca, HCO3- & TDS. Water constitutes different types of dissolved minerals that can be caused by water hardness. The most common mineral in water is calcium, however, other minerals can also be present Water hardness is closely related to pH. These natural agents can alter water pH as well. Table: 04 Characteristics derived from Ward's clustering of the water quality variables of the samples

collected from Dhirkot Azad Jammu & Kashmir. Water constitutes different types of dissolved minerals that can be caused by water hardness. The most common mineral in water is calcium; however, other minerals can also be present Water hardness is closely related to pH. These natural agents can alter water pH as well. In Northern areas rocks contained high minerals, carbonates and bicarbonates are mixed with water. A correlation result demonstrates that there is a relationship between pH, TDS, total hardness and sulfate which shows confirmation after PCA [17]. PC3 also explained that the factor pH was influenced by total hardness.

Table V: Correlation Matrix among all Parameters

	Temp	pH	TDS (mg/l)	Na	K	SO₄²⁻	Cl	Mg	Ca
pH	-0.273								
TDS (mg/l)	**0.361**	**-0.402**							
Na (mg/l)	0.314	0.025	**0.559**						
K (mg/l)	0.137	0.028	**0.583**	**0.894**					
SO₄²⁻ (mg/l)	**0.468**	-0.008	0.198	0.618	**0.567**				
Cl (mg/l)	**0.352**	0.054	0.463	**0.952**	**0.846**	**0.747**			
Mg (mg/l)	0.151	-0.267	0.279	0.251	0.294	0.194	0.207		
Ca (mg/l)	0.272	-0.208	**0.722**	0.22	0.226	0.026	0.177	**-0.438**	
HCO3- (mg/l)	0.28	**-0.466**	**0.938**	0.443	0.487	0.068	0.34	0.359	**0.623**
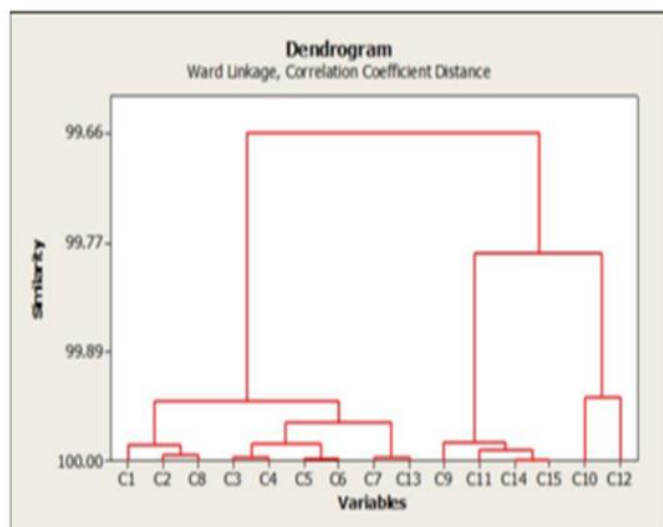
Fig. 2: Dendrogram resulting from Ward's clustering of the location referred in the present study.

The current study shows the comprehensive investigation of different water sources (well, nullahs, water storage bodies) of District Bagh Azad Jammu and Kashmir. The results of all analyzed Parameters were found satisfactory except the result of Bicarbonate. The concentrations of Bicarbonates of all samples were found above the WHO suggested limits. The highest concentration of bicarbonates is found is due to the formation of rocks, which contains carbonates and bicarbonates, which also increases alkalinity of water which passes by these rocks. There is a specific relationship between Sodium, Potassium, Bicarbonates, and TDS which was shown through Cluster analysis. The result indicated that these variables are responsible for concentration alteration of variables which shows the poor quality of water. All the physicochemical parameters from the present study are in accordance with the limits of WHO (1993) except bicarbonate that was found higher in all samples. Our parameters findings also match with the study from Gilgit and Hunza Rivers [17]. Alkaline water has a bitter taste or different from normal tap water. The bicarbonate water makes skin dry and causes kidney & skin issues [18]–[19]. The results shown that physical and chemical parameters are within the limits of WHO guidelines of drinking water, due to high concentration of bicarbonates water is of Bicarbonate type.

IV.   CONCLUSION AND RECOMMENDATIONS

The water quality assessment results from different Union councils of Tehsil Dhirkot, District Bagh Azad Jammu and Kashmir demonstrates that all selected parameters i.e. Temperature, pH, turbidity, total dissolved solids, calcium, sodium, magnesium, copper, sulphate except Bicarbonate were within the suggested limits of WHO. The unsatisfactory result of bicarbonates was evident in all samples. This is manifested from the geological condition of the area. In light of this study, it is recommended to modify water purification and disinfection techniques, such as boiling, use of direct sunlight at the domestic level & Membrane filtration Technique. The water resources which are found to be unprotected is due to presence of poor sanitation and other unhygienic conditions. However, attention

needs towards contaminated water resources are suggested so that forthcoming threat in terms of water contamination and other health related concerns could be minimized similar detailed studies suggested for all Tehsils of District Bagh so that reliable data could be available for researchers and other concerned departments.

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