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Research Article



Principal Components Analysis (PCA) of Water Catchments in BUI Division North West Region of Cameroon: Implications on the Origin of Ions and Correlation

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ABSTRACT

Principal Component Analysis (PCA) helps in interpreting data and simplifies the complexity in high-dimensional or multivariate data while retaining trends and patterns. This is done by transforming the data into fewer dimensions that act as summaries of characteristics. The multivariate or high-dimensional data was prevalent in the physico- chemical analysis of samples from some water catchments in Bui division, North West Region of Cameroon. The water catchments were in Elak (ELA) Oku subdision, Mbiame (MBI) Mbven subdivision, Belem (BEL) Nkum subdivision, Nkar (NKA) Jakiri subdivision and YEH in Kumbo subdivision. This type of data presents several challenges that PCA mitigates. With the application of SPSS (Software Package for Social Sciences) it transformed the multivariables obtained in the physico-chemical analysis from the water catchments into a correlation matrix either Pearson's or Spearman's matrix. In this work I Pearson's correlation matrix was used. It reduced the data by geometrically projecting onto lower dimensions in correlation circles.

Pearson's correlation matrix for the water catchments between the variables had a medium or moderate correlation with most of the coefficient values between -/+ 0.39 and +/- 0.49. Nonetheless, some strong positive correlations existed between Mg²⁺ / pH, TDS / EC, HCO₃⁻ / T°C, and SiO₂ / Mg²⁺, while a strong negative correlation existed between, Mg²⁺ / T°C, and Mg²⁺ / NO₃⁻. Generally, a weak correlation was observed between most of the variables.

Eighty-seven variables were correlated from the catchments with 51 having a positive correlation, whereas 36 were negative. Positive correlation values indicated a common source with the ions evolving concomitantly by similar weathering processes or inputs from a common source. This concomitant correlation was expressed between Ca^{2+} and HCO_3^{-} within the catchments. The negative values revealed that the ions evolve in an antagonistic manner. Consequently, in the water catchments, 58.62 % of the variables had a positive correlation while. 42.48 % had a negative correlation with antagonistic behaviour.

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Introduction

Bui division of the North West Region of Cameroon has a population that gives development of water catchments a primordial importance in the communities. Rapid population growth and urbanization, has imposed more demand of water and consequently the catchments for their diverse uses. Furthermore, an interaction of physicochemical variables in water bodies forms the centrepiece of many hydrogeochemical studies with human activity posing a great risk [1,2]. Because of inadequate availability of surface water to meet human demands, water catchments are an option to supplement the ever-rising water needs hence their development should be taken as a serious problem in Bui division as elsewhere Cameroon.

Ground water Chemistry is gained as result of chemical interactions that recharge the system by factors such as; soil- water interactions,

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dissolution of primary minerals, rock- water interactions and anthropogenic sources [3,4]. The importance of ground water has initiated some detailed works on its geochemical evolution [5]. The evaluation and establishing a correlation between the variables and tracing their origins is indispensible for a sustainable management of water catchments.

This work had as objective; an evaluation and monitoring of the origin of the ions and other variables within water catchments in Bui division with establishment of a correlation between the analysed variables. Prior to this study, no recorded works were available for this evaluation, presenting a data vacuum intended to be filled with this work.

Location of the study zone

The study site, was shown in Fig.1. Situated between latitudes 06000' and 06030' North of the equator and longitudes 10000' and 11000' East of the Greenwich meridian. Bui has boundaries, with

Donga Mantung to the North, Ngohketunjia to the South, Boyo to the West, and Noun division to the East. Water points, time, date, rock types and samples collected were presented in Table 1.



Figure 1: Position of study area: (a) The NWR (b) Bui in the NWR (c) Location of sites

Table 1: Water points, time, date, rock types and samples collected											
Water point	Time	Date	Rock type	Sample/Reference							
Elak (Water tank)	8.15 am	11-02-16	Trachyte	ELA ₁							
	8.30 am	31-05-16	Trachyte	ELA ₂							
	8.20 am	06-08-16	Trachyte	ELA ₃							
	8.45 am	18-11-16	Trachyte	ELA ₄							
Mbiame catchment	11.20 am	11-02-16	Basalt	MBI ₁							
	11.46 am	31-05-16	Basalt	MBI ₂							
	11.40 am	06-08-16	Basalt	MBI ₃							
	11.52 am	18-11-16	Basalt	MBI ₄							
Belem catchment	12.31 pm	11-02-16	Basalt	BEL ₁							
	12.50 pm	31-05-16	Basalt	BEL ₂							
	12.55 pm	06-08-16	Basalt	BEL ₃							
	13.02 pm	18-11-16	Basalt	BEL ₄							
Nkar (catchment)	14.03 pm	11-02-16	Basalt	NKA ₁							
	14.15 pm	31-05-16	Basalt	NKA ₂							
	14.25 pm	06-08-16	Basalt	NKA ₃							
	14.51 pm	18-11-16	Basalt	NKA4							
Yeh (catchment)	15.30 pm	11-02-16	Basalt	YEH ₁							
	15.45 pm	31-05-16	Basalt	YEH ₂							
	15.55 pm	06-08-16	Basalt	YEH ₃							
	16.00 pm	18-11-16	Basalt	YEH ₄							

Geologic context

Bui division is part of the Bamenda highlands, a northward extension of the Bambouto Mountain part of the continental Cameroon Volcanic Line (C.V.L). The dominant geologic formations of Bui are basalts and trachytes similar to those of the Bambouto Mountain. Revealed by Kumbo and the Bambouto Mountain are of same volcanic origin [6-9]. These observations strongly agree with the field realities that indicated trachytes, and basalts as the dominant rock types within the water catchments.

Materials and Methods

Materials

Sample bottles were cleaned and rinsed with the water sample from the collection site and finally filled to the brim to avoid any atmospheric oxidation. The samples were taken immediately to the Laboratory for physico-chemical analysis

Methods

The physico-chemical data was submitted to treatment in a Software Package (SPSS) to obtain Perason correlation matrix from which the Principal Components Analysis (PCA) was to be done.

The Principal Components Analysis (PCA)

A correlation between the analysed parameters from the Bui water catchments was done to find out the relation between the variables in a bid to establish the closeness or distance between these parameters in water. The correlation coefficient is one of the indices that evaluates the strength of a relation between many variables, [10,11]. A high positive correlation between elements generally indicated the possibility of a common source of origin. Pearson's correlation matrix between the variables and some physical parameters from the Bui water catchments and presented in Table 2. Pearson's correlation results were used in the construction of correlation circles that are projections on a 2-dimensional factorial plan as expressed in Fig.3 for the water catchments. In these projections, the variables closeness suggested their common source of origin.

Results

Tables 2 and 3 presented the physico-chemical results and Pearson's correlation matrix from Bui water catchments respectively.

Table 2 : Physico-chemical results of ground and surface water (n = 60) in Bui water catchments (February, May, August, November) in 2016; n = 40, and March/ September 2017; n = 20 (n = number of samples)

Catchn	ient ID	Alt (m)	Т	pН	EC	TDS	\mathbf{Na}^+	\mathbf{K}^{+}	Mg^{2+}	Ca ²⁺	Cl	HCO3	SiO_2	SO42-	NO ₃ -	$\mathbf{NH_4^+}$
			(°.c)		us/cm	•				m	<u>ا/ا</u>					
ELA	▲ELA1	2254	10.4	7.0	0.15	96.00	0.11	0.76	9.80	34.20	0.02	30.50	32.08	13.2	10.1	0.00
2016	ELA ₂	2254	15.5	6.9	0.13	83.00	0.09	0.73	9.70	33.50	0.01	30.30	31.29	13.5	10.9	0.00
	ELA3	2254	15.3	6.8	0.11	70.40	0.08	0.71	8.90	33.00	0.01	29.91	31.00	13.2	10.0	0.00
	ELA4	2254	15.0	6.9	0.14	89.60	0.10	0.75	8.95	33.45	0.02	30.00	31.06	13.1	11.8	0.00
2017	ELA1	2254	14.8	6.8	0.13	83.20	0.12	0.75	9.80	33.40	0.01	30.40	32.00	13.3	12.0	0.00
	ELA ₂	2254	15.4	6.7	0.10	64.00	0.08	0.70	8.89	33.00	0.01	29.90	31.00	13.5	11.0	0.00
MBI	MBI1	2111	19.9	6.7	0.19	121.6	0.13	0.69	8.70	31.60	0.02	33.70	31.82	13.0	12.5	0.00
2016	MBI ₂	2111	20.2	6.7	0.16	102.4	0.11	0.51	7.60	31.00	0.02	33.68	30.00	14.1	11.9	0.00
	MBI3	2111	20.0	6.6	0.14	89.60	0.08	0.53	8.00	30.00	0.01	33.21	31.02	13.9	10.9	0.00
	MBI4	2111	21.0	6.8	0.17	108.8	0.10	0.61	8.52	31.20	0.01	33.40	31.36	12.9	09.2	0.00
201' I	D = Identity	2111	19.8	6.6	0.18	115.2	0.12	0.68	8.60	31.50	0.01	33.67	33.70	13.3	10.4	0.00
		2111	20.0	6.7	0.14	89.60	0.08	0.52	7.90	29.90	0.01	33.20	31.00	13.7	10.8	0.00
BEL	▲ ^{BEL1}	2185	21.8	6.7	0.19	121.6	0.13	0.73	7.70	32.00	0.02	34.00	31.36	13.2	11.5	0.39
	BEL ₂	2185	21.7	6.6	0.17	108.8	0.12	0.71	7.62	30.90	0.01	33.80	30.36	13.8	11.0	0.37
2016	BEL ₃	2185	22.0	6.4	0.15	96.00	0.01	0.62	7.00	30.00	0.01	32.31	30.50	14.0	15.0	0.35
	BEL ₄	2185	22.5	6.7	0.17	108.8	0.11	0.69	7.64	31.00	0.01	33.00	30.91	13.6	15.6	0.34
2017	BEL1	2185	21.7	6.6	0.18	115.2	0.12	0.72	7.69	31.90	0.01	33.82	31.20	13.3	16.3	0.30
	BEL ₂	2185	21.9	6.7	0.15	96.00	0.01	0.61	7.00	30.01	0.01	32.30	30.00	13.5	14.0	0.32
NKA	NKA1	1746	20.0	7.0	0.31	198.4	0.12	0.68	9.53	30.90	0.02	32.52	31.39	14.0	11.5	0.03
2016	NKA ₂	1746	18.9	6.9	0.28	179.2	0.12	0.65	9.00	30.00	0.00	32.52	31.21	13.8	09.0	0.02
	NKA3	1746	19.8	6.8	0.20	128.0	0.08	0.45	8.76	30.00	0.00	31.20	31.00	13.4	08.0	0.02
	NKA4	1746	22.8	6.9	0.29	185.6	0.11	0.57	9.21	30.60	0.00	31.58	31.23	13.3	10.2	0.02
2017	NKA1	1746	18.8	6.8	0.27	123.1	0.11	0.65	9.50	30.80	0.01	32.50	31.20	13.0	09.4	0.02
	NKA2	1746	22.7	6.9	0.28	179.2	0.07	0.44	8.74	30.00	0.00	31.00	31.00	13.1	08.1	0.01
YEH	▲ YEH1	1895	21.0	7.1	0.30	192.0	0.14	0.13	9.21	40.20	0.02	33.60	31.82	14.0	10.0	0.00
2016	YEH2	1895	20.5	7.0	0.22	140.8	0.13	1.00	9.00	39.90	0.01	33.54	31.03	13.9	10.8	0.00
	YEH3	1895	20.6	6.7	0.20	128.0	0.11	0.08	8.52	37.82	0.01	31.50	31.00	13.2	10.1	0.00
	YEH4	1895	22.9	6.8	0.28	179.2	0.12	0.09	8.80	38.54	0.01	32.30	31.40	13.6	10.0	0.00
2017	YEH1	1895	20.4	6.7	0.21	134.4	0.10	0.07	8.50	37.80	0.01	31.40	31.00	13.7	10.7	0.00
	YEH2	1895	22.7	6.7	0.20	128.0	0.10	0.07	8.51	37.81	0.01	31.42	31.00	13.5	11.0	0.00

	T°C	Ph	EC	TDS	Na ⁺	K^+	Mg ²⁺	Ca ²⁺	Cl-	HCO3 ⁻	SiO ₂	SO4 ²⁻	NO3 ⁻
T⁰C	1.00000 0		$\mu S/cm$	•									
pН	- 0.32454 7	1.00000 0											
EC	0.47707 9	0.48483 5	1.00000 0										
TDS	0.50502 2	0.49129 2	0.97180 6	1.00000 0									
Na ⁺	- 0.05207 5	0.41522 3	0.38738 5	0.38465 2	1.00000 0								
K+	- 0.39921 7	0.04614 2	- 0.35625 5	- 0.38368 9	0.00453 6	1.00000 0							
Mg ²⁺	- 0.57946 0	0.75275 7	0.30021 4	0.25485 1	0.46336 2	0.05840 8	1.00000 0						
Ca ²⁺	- 0.03156 8	0.35842 4	0. 19 350 7	0.22872 3	0.39580 1	- 0.47088 0	0.32044 5	1.00000 0					
Cl-	- 0.28054 3	0.10547 1	- 0.17845 4	- 0.17629 1	0.29638 5	0.10585 8	0.00370 3	0.24917 6	1.00000 0				
HCO3-	0.61685 5	- 0.26045 6	0.26207 3	0.26030 6	0.31110 6	0.05413 4	- 0.49980 5	- 0.11631 2	0.21363 9	1.00000 0			
SiO ₂	- 0.28405 3	0.21028 2	0.13448 6	0.13841 0	0.48499 9	0.08685 4	0.52338 8	0.16028 5	0.12621 4	0.03321 2	1.00000 0		
SO4 ²⁻	0.24086 3	- 0.04712 0	0.12736 1	0.19631 1	- 0.07545 4	- 0.13436 4	- 0.27371 7	0.12879 4	0.08933 6	0.29947 8	- 0.33629 6	1.00000 0	
NO3 ⁻	0.17035 0	- 0.49494 5	- 0.35722 2	- 0.32781 5	- 0.21099 5	0.26898 6	- 0.56452 7	- 0.14696 4	0.30704 8	0.25583 8	- 0.22828 0	0.19733 4	1.00000 0

Table 3: Pearson's correlation matrix between variables in the catchments

Most of the coefficient values lie between -/+ 0.39 and +/- 0.49 and it is said to exhibit a medium or moderate correlation. Nonetheless, some strong positive correlations exist between Mg²⁺ / pH, TDS / EC. HCO₃⁻ / ToC, and SiO₂ / Mg²⁺, while a strong negative correlation exists between, Mg²⁺ / NO₃⁻. Generally, a weak correlation was observed between most of the variables.

Discussion of Results

The Principal Components Analysis for Catchments

Pearson's correlation matrix between the variables had a medium or moderate correlation with most of the coefficient values between -/+ 0.39 and +/- 0.49. Nonetheless, some strong positive correlations indicated in bold existed between Mg2+ / pH, TDS / EC, HCO3-/ ToC, and SiO2/ Mg2+, while a strong negative correlation existed between, Mg2+/ ToC, and Mg2+/ NO3-. Generally, a weak correlation was observed between most of the variables.

Eighty-seven variables were correlated from the catchments with 51 having a positive correlation, whereas 36 were negative. Positive correlation values indicated a common source with the ions evolving concomitantly by similar weathering processes or inputs from a common source. This concomitant correlation was expressed between Ca2+ and HCO3- within the catchments. The negative values revealed that the ions evolve in an antagonistic manner. Consequently, in the water catchments, 58.62 % of the variables had a positive correlation while. 42.48 % had a negative correlation with antagonistic behaviour. pH and EC had a positive correlation indicating a constant and predominant source of mineralization within the catchments. Equally, all the pairs of exchangeable bases; Na+-Ca2+; Na+- Mg2+; Na+- K+, had positive correlations which indicated that; increasing or decreasing of the concentration of cations was probably a combination of anthropogenic inputs and other processes governed by chemical reactions. Table 4 gave the contribution the variables in determination of the principal factors. Tables 5 (a) and 5 (b), gave the variables and factors respectively that led to a determination of their percentage contribution in a correlation circle on to which the variables were projected. Fig.2 gave the proper values and total % variance for catchments. The projections were on a reduced space with two principal components; Fig. 3. In the catchments, contributions were from 13 factors. Consequently, projections were made in many reduced spaces each with its two components, and the circle with the highest percentage contribution from the factors was considered most significant; F1 + F2 = 51.93%, with F1 = 29.01% and F2 = 22.92% in Fig. 3 (a). All the others had lower percentages. From the corresponding graph ; Fig. 2, five factors that expressed 84.29 % of factors from catchments were used in the construction of the correlation circles, based on Kaiser's criteria [12]. A representation of the results in a reduced space for all the variables from the catchments revealed a low

dispersion and variability of the chemical composition of the water. As evident in the projection space in Fig.3, the low dispersal of the variables in space had no particular trend or pattern.

	Fact. 1	Fact. 2	Fact. 3	Fact. 4	Fact. 5	Fact. 6	Fact. 7	Fact. 8	Fact. 9	Fact.10	Fact.11	Fact.12	Fact.13	
T°C	0.004838	0.288209	0.004034	0.013764	0.027872	0.022635	0.001749	0.021095	0.029779	0.000321	0.015371	0.560294	0.010038	
рН	0.174374	0.011804	0.000004	0.003383	0.179344	0.061634	0.005172	0.002972	0.113891	0.417471	0.000149	0.006200	0.023602	
EC	0.129082	0.126994	0.005318	0.024958	0.018553	0.040095	0.013295	0.031924	0.008555	0.126201	0.036630	0.073506	0.364889	
TDS	0.125326	0.140867	0.003940	0.013236	0.021080	0.022949	0.031341	0.031823	0.001755	0.005843	0.118478	0.037157	0.446204	
Na ⁺	0.111970	0.000923	0.185797	0.013791	0.014618	0.008337	0.020493	0.226343	0.333284	0.016844	0.057001	0.000311	0.010291	
K+	0.018559	0.076996	0.053419	0.206064	0.215388	0.000218	0.014986	0.098468	0.092742	0.169551	0.051115	0.002358	0.000137	
Mg ²⁺	0.176676	0.084560	0.002230	0.000370	0.009647	0.003314	0.023962	0.000129	0.036008	0.049051	0.345750	0.193635	0.074668	
Ca ²⁺	0.068282	0.001524	0.024623	0.345799	0.060777	0.000013	0.037444	0.178610	0.186822	0.073201	0.000002	0.022338	0.000564	
Cl-	0.000003	0.009973	0.350750	0.079612	0.002855	0.104925	0.104236	0.243500	0.000002	0.048172	0.015733	0.040235	0.000004	
HCO ₃ ⁻	0.005604	0.147031	0.178150	0.079573	0.000994	0.029684	0.090155	0.005171	0.079478	0.015388	0.283533	0.042475	0.042764	
SiO_2	0.066396	0.029397	0.064419	0.089851	0.171046	0.143378	0.150857	0.144221	0.066914	0.021486	0.030197	0.002916	0.018921	
SO_42^-	0.004478	0.077165	0.013844	0.125053	0.273329	0.433222	0.021197	0.014258	0.009835	0.000093	0.004482	0.015431	0.007614	
NO ₃ -	0.114412	0.004557	0.113470	0.004545	0.004498	0.129597	0.485115	0.001487	0.040934	0.056379	0.041559	0.003143	0.000304	

Table 4: Contribution of variables in the def

Table 4 (a): Contribution of factors and cumulated percentages

	Proper value	Total % variance	Cumulated Proper value	Cumulated %
1	3.771860	29.01431	3.77186	29.0143
2	2.979952	22.92271	6.75181	51.9370
3	1.791871	13.78362	8.54368	65.7206
4	1.373240	10.56339	9.91692	76.2840
5	1.041056	8.00812	10.95798	84.2922
6	0.579713	4.45933	11.53769	88.7515
7	0.504552	3.88117	12.04224	92.6326
8	0.439804	3.38311	12.48205	96.0158
9	0.261013	2.00779	12.74306	98.0236
10	0.109472	0.84209	12.85253	98.8656
11	0.072676	0.55904	12.92521	99.4247
12	0.063236	0.48643	12.98845	99.9111
13	0.011555	0.08888	13.00000	100.0000

Table 4 (b): Contribution of variables in definition of each factor

Variables	Fact. 1	Fact. 2	Fact. 3	Fact. 4	Fact. 5
T°C	0.004838	0.288209	0.004034	0.013764	0.027872
рН	0.174374	0.011804	0.000004	0.003383	0.179344
EC	0.129082	0.126994	0.005318	0.024958	0.018553
TDS	0.125326	0.140867	0.003940	0.013236	0.021080
Na ⁺	0.111970	0.000923	0.185797	0.013791	0.014618
K ⁺	0.018559	0.076996	0.053419	0.206064	0.215388
Mg^{2+}	0.176676	0.084560	0.002230	0.000370	0.009647
Ca ²⁺	0.068282	0.001524	0.024623	0.345799	0.060777
Cl-	0.000003	0.009973	0.350750	0.079612	0.002855
HCO ₃ -	0.005604	0.147031	0.178150	0.079573	0.000994
SiO ₂	0.066396	0.029397	0.064419	0.089851	0.171046
SO ₄ ²⁻	0.004478	0.077165	0.013844	0.125053	0.273329
NO ₃ -	0.114412	0.004557	0.113470	0.004545	0.004498



Figure 2: Proper values & Total % variance for catchments

Principal component analysis enabled us to see the five factors that permitted to express 84.3 % of the total variation of the data. Factors 1 and 2 predominantly expressed 51.93 % evaluation of the relation between variables. In the correlation circles for the catchments the bold values in Table 4 (b) represented the contribution of the variables in the definition of each factor, within an acceptable correlation value above 0.5 for the variables. Factor 1 had the variables Mg²⁺, pH, TDS, EC and Na⁺ strongly correlated, with positive values above 0.6 while Ca²⁺ and SiO₂ equally showed a correlation with value 0.5. The positive correlations revealed that in the catchments, the variables evolved concomitantly with each other. There was much interrelation between these variables that were interpreted with pH, as most of the water in the catchments was acidic responsible for the dominantly acidolysis reaction that leached ions such as Ca2+, Mg2+, Na+ into solution from the silicate minerals within the catchments. The presence of these ions in

solution was responsible for the pronounced electrical conductivity as well as the TDS value in the water catchments. These variables indicated a common origin as they were grouped together as expressed in the correlation circles. The NO, on the contrary with a negative strong value of -0.7 has an opposing relation to the other variables with respect to factor 1. This indicated that the nitrate had a source in the water catchments different from the other variables. This was probably of anthropogenic origin such as ferlilizers from farming activities, faecal wastes disposal and urine from animal grazing within the vicinity of the water catchments. Factor 2 indicated a significant presence of T°C, with the HCO,, TDS and EC. Temperature was a variable that at all times conditions the dissolution of rock minerals affecting both TDS and EC. These trends were conspicuously expressed in Fig.3 a, b and c for the catchments with the greatest percentage contributions for the factor analysis. Factor 1 had identical correlation with factors 2, 3 and 4. Generally, the significance of Cl⁻ ion in water catchments could be from water treatment and had a correlation with HCO₂ in Fig. 3 (d) due to their acidic origins. HCO_3^{-1} is from bicarbonic acid. Ca^{2+} , Na⁺, and K⁺ evolved in a similar manner in the water catchments according to the climatic conditions involving temperature and rainfall to dissolve the dominantly plagioclase minerals. This trend was observed at ELA and NKA catchments. The evolution of pH was minimal and remained relatively constant as compared to its evolution with other variables in the water catchments. TDS, T°C and EC were interrelated and generally showed correlation in the water catchments, particularly as temperature determines the ions present in water that directly contribute to EC. The change in sulphate ions was not in function of any variable and it was one of the independent variables in the water catchments with its source mainly anthropogenic through application of sulphate fertilizer.



Figure 3: Correlation circle for catchments

The contribution between the variables of factors 1 and 2 in the water Catchments were presented in Table 5. The values in bold greater than or equal to 0.50 to contributed significantly in the PCA.

Variables	T°C	pН	EC	Na ⁺	\mathbf{K}^{+}	Mg ²⁺	Ca ²⁺	Cl	HCO ₃ -	NO ₃ -	SO4 2-	SiO ₂	
Factor 1	-0.15	0.80	0.70	0.60	-0.3	0.80	0.08	0.00	-0.15	-0.65	-0.15	-0.65	
Factor 2	0.90	0.40	0.60	-0.05	0.30	0.50	0.08	0.20	-0.65	-0.10	-0.50	-0.10	

Distribution of the variables in Bui water catchments on the loading axis in terms of their vectors (directions) are illustrated in Fig. 4. V_1 , V_2 , V_3 and V_5 included all variables with positive correlation and V4 negative. V6 had no bearing.



Figure 4: Loading graphic for water samples from Bui catchments

Nonetheless, all the different correlations materialized in the correlation circle for variables according to axis F1 and F2 also called principal components with variables dispersed into all vector directions, with both negative and positive correlation from all the water catchments. The projections of these variables were illustrated in correlation circles. The linear correlations suggested a common source for the variables, mainly from the weathering of silicate minerals. This assertion where the samples analysed plotted into encircled clusters indicated in Fig, 3 symbolized the same dominating mechanism responsible for their origins.

General Conclusion

It was observed that the greatest percentage contribution of the variables in the definition of the factors, were given in the correlation circles for factors 1 and 2 as opposed to other circles with lower percentage contribution. These factors; F1 and F2 consequently, were most important in the data analysis. In all the correlation circles, the positively correlated variables are grouped together and evolve concomitantly, while the negatively correlated variables are positioned on opposite sides of the plot origin in opposed quadrants and evolve in an antagonistic manner

Perspectives

Vulnerability on parameters inherent in water quality envisages another sampling and analysis to monitor evolution and suggest strategies to mitigate any disastrous outcome linked to water quality to the local authorities.

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Conflict of interest

In course of this work no conflict of interest was encountered. The authors had total collaboration with support of the Earth science department of the University of Dschang- Cameroon

Data Availability

The data from this work is available in the article and includes; physical, chemical and bacteriological analysis of the water samples as well as the mineralogy of the rock type in the studied sites

Reviewers

I readily accept reviewers proposed by the editorial board of this journal.

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