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Trend Analysis Of Fluid Geochemistry With Reference To HCO3 And Cl Contents Of Peninsular And Extra-Peninsular Hot Springs

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Abstract
The systematic variations of a variable or set of variables in time and space can be solved by using a least-squares technique that finds the line of best fit through a scatter graph of a set of data points visualising the relationship between the variables. Deterministic functions such as polynomials or a curved line can be employed to describe a trend in fluctuating data. The polynomial degree can be determined by the number of fluctuations in the data or by the number of hills or valleys that appear in the curve. The second order-order trend, for example, has only one hill, while the third order has one or two hills or valleys. The trend function in Excel is a statistical function that computes the predictive value of Y for a given array of values of X using the least squares method based on the given data series. The aim of the present study is to interprete the fluid geochemical data with reference to bivariate variables HCO3 and Cl with the technique of trend analysis to simplify and analyse the data so obvious yet not revealed by the lines and surfaces using a statistical curve fitting technique that accomplishes "best-fitting' a series of polynomials by the least-squares criterion of multiple regression. Looking at the trend and between-group and within-group differences, the HCO3 and Cl contents of fluid geochemistry show an inverse relationship between the bivariates of two distinct groups of geothermal springs.

Key words: *Trend analysis, least-squares technique, best-fit curve, polynomials, regression analysis, bivariates*

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I. INTRODUCTION

More recent studies furnish a geostatistical explanation of spatially dependent multivariate geothermal data representing two spatially distinctive regions of diverse geologic-tectonic settings: one from a 2400 km long arcuate belt of the tectonically active Extra-Peninsular Himalayan region and the other from Late-Precambrian or Proterozoic mobile belts in the Central Highland in an otherwise stable landmass or shield of Penininsular India (Amitabha Roy, 2023). Geothermal hot springs spread over these areas, conspicuously associating with the respective tectonic zones of different degrees of severity. In the present study, the two sets of data representing Peninsular and Extra-Peninsular India were thoroughly blended, which was then subjected to trend analysis using Excel's statistical trend function. From the previous knowledge of the geochemical characteristics of the hot springs in regions with diverse tectonic settings, two types of spring water—bicarbonate, or HCO3, and chloride, or Cl —were identified. Looking at the trend and between-group and within-group differences, the HCO3 and Cl contents of fluid geochemistry were considered for the present study.

Table 1: The values of Y- and X- coordinates, HCO3 and Cl contents (in mg/L) at different localities along with other computed values

1	Location	Y	X	HCO3 mg/l	Cl mg/L	New HCO3	TREND (HCO3)	New Cl	TREND (Cl)
2	Agni kund	23.8833	87.3666	39	88	39	26.30802808	88	27.02928622
3	Suryakund	24.09	85.41	44	90	44	26.312141	90	27.02535254
4	BakreshwarR	23.52	87.25	150	8	150	26.39933495	8	27.18663363
5	Attri	20.123	85.3045	65	257	65	26.32941528	257	26.69688983
6	Tarabalo	20.1505	85.181	95	143	95	26.35409281	143	26.92110988
7	Athmalik	20.443	84.301	105	250	105	26.36231865	250	26.71065773
8	Gopalpur	19.2647	84.862	610	100	610	26.77772378	100	27.00568411
9	Taptapani	19.2905	84.235	205	0	205	26.4445771	0	27.20236837
10	Tatta	23.4515	84.0212	120	105	120	26.37465742	105	26.9958499
11	Matang	23.492	84.294	240	20	240	26.47336755	20	27.16303152
12	Sitakund	25.22	86.36	0	0	0	26.27594729	0	27.20236837
13	Lachmikund	25.03	86.29	0	0	0	26.27594729	0	27.20236837
14	Rajgir	25.01	85.25	22	1	22	26.29404415	1	27.20040153
15	Tapoban	24.55	85.19	26.4	2	26.4	26.29766352	2	27.19843468
16	Surajkund	24.09	85.41	60	94	60	26.32530236	94	27.01748517
17	Takshing	28.2	93.15	435	18	435	26.63377151	18	27.1669652
18	Chetu	28.25	93.26	362	154	362	26.57372285	154	26.89947462
19	Naza	28.273	93.25	353	35	353	26.56631959	35	27.13352888
20	Tatwani	32.071	76.431	15	2	15	26.28828606	2	27.19843468
21	Manikaran	32.0278	77.3473	9170	133	9170	33.81904638	133	26.94077831
22	Chuza	32.0345	78.37	490	855	490	26.67901365	855	25.52071799
23	Jeori	31.314	77.47	218	102	218	26.45527069	102	27.00175043
24	Napta	31.342	77.582	342	232	342	26.55727116	232	26.7460609
25	Karchham	31.3	78.105	303	200	303	26.52519037	200	26.80899986
26	Skiba	31.35	78.223	173	45	173	26.41825439	45	27.11386045
27	Jamnotri	31	78.23	276	170	276	26.50298059	170	26.86800513
28	Banas	30.572	78.25	145	30	145	26.39522203	30	27.14336309
29	Chaudaduni	30.5502	78.3336	15	2	15	26.28828606	2	27.19843468
30	Jhaya	30.5325	78.4012	248	72	248	26.47994823	72	27.0607557
31	Tunja	30.5325	78.433	272	10	272	26.49969025	10	27.18269994
32	Gaurikund	30.3905	79.0135	445	35	445	26.64199736	35	27.13352888
33	Badrinath	30.4445	79.293	112	1485	112	26.36807674	1485	24.28160718
34	Ghorshila	30.4158	79.352	103	0	103	26.36067349	0	27.20236837
35	Kanakar	36.325	79.313	117	15	117	26.37218967	15	27.17286573
36	Juma	30.36	79.481	861	48	861	26.98419247	48	27.10795993
37	Tapoban	30.293	79.373	278	12	278	26.50462576	12	27.17876626
38	Ungiya	30.0527	80.5313	38	5	38	26.3072055	5	27.19253415
39	Devkuna	29.58	80.0856	953	86	953	27.05987024	86	27.03321991
40	Balati	30.0853	80.2023	734	12	734	26.87972425	12	27.17876626
41	Dobat	29.515	80.3384	439	41	439	26.63706185	41	27.12172782
42	Panamik	34.465	77.324	254	13	254	26.48488373	13	27.17679941
43	Pulthang	34.4525	77.333	363	17	363	26.57454543	17	27.16893204
44	Changlung	34.564	77.2825	1610	85	1610	27.6003082	85	27.03518675
45	Gul	33.162	75.0345	259	11	259	26.48899665	11	27.1807331
46	Yurdu	33.431	75.443	233	58	233	26.46760946	58	27.0882915
47	Tatwain	33.303	75.523	32	3	32	26.30226999	3	27.19646784
48	Galhar	33.204	76.562	112	30	112	26.36807674	30	27.14336309
49	Puga	33.13	78.195	0	410	0	26.27594729	410	26.39596292
50	Chhumathang	33.22	78.21	0	7	0	26.27594729	7	27.18860047
51	Sunsani	32.421	76.0425	415	596	415	26.61731982	596	26.03013021
52	Gajkhad	32.0755	76.105	264	13	264	26.49310958	13	27.17679941
53	Baijnath	32.071	76.431	49	104	49	26.31625393	104	26.99781674
54	Sohnadh	28.15	77.04	154	1375	154	26.40262529	1375	24.49795986
55	Sohna	28.15	77.04	188	140	188	26.43059316	140	26.92701041
56	Didwaka	26.353	76.193	315	130	315	26.53506138	130	26.94667884
57	Rindli	27	76.53	390	195	390	26.59675521	195	26.81883407
58	Parai	24.11	73.411	500	140	500	26.6872395	140	26.92701041
59	Parsad	24.13	73.424	290	50	290	26.51449677	50	27.10402624
60	Gogbasp	21.4053	72.1544	190	1347	190	26.43223833	1347	24.55303145
61	Gogbatw	21.4053	72.1544	410	110	410	26.6132069	110	26.98601569
62	Dholera	22.15	72.12	150	2725	150	26.39933495	2725	21.84272242
63	Cambaywell	22.14	72.41	1534	2428	1534	27.53779178	2428	22.42687466
64	Keedapad	23.2	73.56	183	71	183	26.42648024	71	27.06272255
65	Koknere	19.423	72.51	13	4800	13	26.28664089	4800	17.76152413
66	Paduspada	19.4105	72.543	11	850	11	26.28499572	850	25.5305522
67	Akloli	19.293	73.05	14	1210	14	26.28746347	1210	24.82248888
68	Vadavil	18.04	73.27	18	78	18	26.29075381	78	27.04895465
69	Keed	17.43	73.24	71	426	71	26.33435078	426	26.36449344
70	Toral	17.15	73.35	30	375	30	26.30062482	375	26.46480241
71	Tapibasin	21.4196	76.1666	63	265	63	26.32777011	265	26.68115509
72	Bugga	17.55	80.4315	364	30	364	26.57536802	30	27.14336309
73	Gundala	17.383	80.563	99	457	99	26.35738315	457	26.30352132
74	Manuguru	17.5545	80.4425	366	257	366	26.57701319	257	26.69688983
75	Pagdaru	17.56	80.43	171	50	171	26.41660923	50	27.10402624
76	Janampeta_s	18.06	80.4	128	166	128	26.3812381	166	26.8758725
77	Tatapani	23.6993	83.6842	177	67	177	26.42154473	67	27.07058992

II. Methodology of Calculating Trendline

Equation for Trend Line

The Trend Function finds the line that best fits data by using the least squares method. A trend line signifies a polynomial relationship. The equation for this relationship is as follows:

$$y = mx^n + b$$

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} x_i \ (\text{the average of } x)$$

$$\bar{Y} = \frac{1}{n}\sum_{i=1}^{n} y_i \ (\text{the average of } y)$$

$$m = \frac{\sum_{i=1}^{n}(x_i - \bar{X})(y_i - \bar{Y})}{\sum_{i=1}^{n}(x_i - \bar{X})^2}$$

Where:

- *y is* the dependent variable to be calculated.
- *x is* the independent variable used to calculate *y*.
- b: the intercept (which indicates where the line intersects the y-axis and is equal to the value of y when x is 0).
- m: the slope (which indicates the steepness of the line).
- n- is the degree or power of polynomials.

This equation for the line of best fit is also used in the linear regression analysis.

TREND function

The TREND function returns values along a linear trend. It fits a straight line (using the method of least squares) to the array's known_y's and known_x's. TREND returns the y-values along that line for the array of new_x's that we specify.

The syntax of the TREND function is as follows:

TREND (known_y's, [known_x's], [new_x's], [const])

Where:
Known_y's (required): a set of the dependent y-values that is already known.
Known_x's (HCO3/Cl)): one or more sets of the independent x-values.

- If only one x variable is used, known_y's and known_x's can be ranges of any shape but equal dimension.
- If several x variables are used, known_y must be a vector (one column or one row).
- If omitted, known_x's is assumed to be the array of serial numbers 1, 2, 3,...

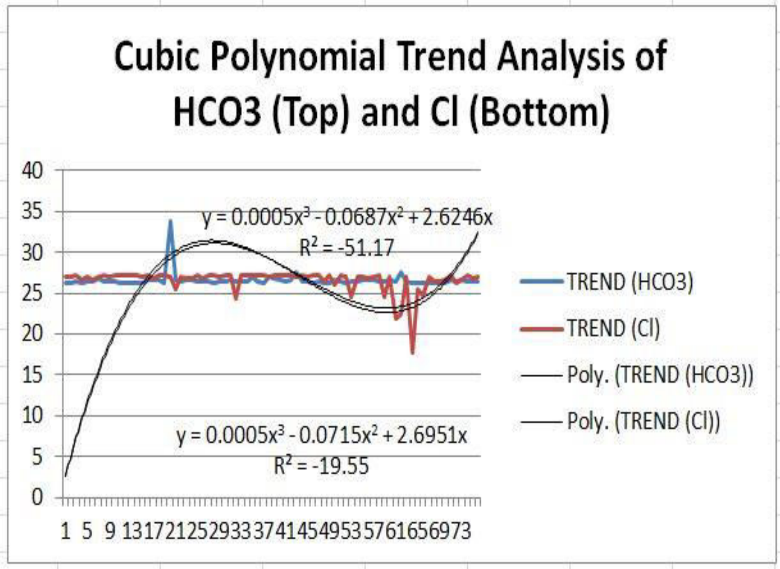
New_x's (New HCO3/New CL): one or more sets of new x-values for which we want to calculate the trend.

- It must have the same number of columns or rows as known_x.
- If omitted, it is assumed to be equal to known_x's.

Presenting the results and visualizing the results in a graph

Fig.1: Locations of Hot Springs on Google Map (Table 1)

Fig. 2: Bivariate Polynomial Trend Analysis based on computed values of variables HCO3 and Cl (Table 1)



Interpreting the results

One of the significant benefits of trend analysis is that one can compare the performance of varying variables on trend-based charts. The visualisation designs mentioned above are amazingly easy to interpret. Besides, we can use these charts to create compelling data stories. In the present study, multivariate polynomial regression is used to model complex relationships with multiple variables. Deterministic functions such as polynomials or a curved line has been employed to describe a trend in fluctuating data. The polynomial degree can be determined by the number of fluctuations in the data or by the number of hills or valleys that appear in the curve. In the present study, cubic or third-degree polynomials are chosen, which give a better recognisable pattern than the original raw data. Looking at the trend and between-group and within-group differences, the HCO3 and Cl contents of fluid geochemistry show an inverse relationship between the bivariates of two distinct groups of geothermal springs.

References Cited

[1]. Amitabha Roy, 2023Multivariate Geostatistical Modeling of Fluid Geochemistry in Peninsular and Extra-Peninsular India. J. Appl. Geol. & Geophys (ISOR-JAGG, V.11, Issue 2, Ser. I, pp. 11-22

[2]. Amitabha Roy, 2023. Regression Analysis of Multivariate Fluid Geochemical Data representing two distinct systems operative at the geothermal fields of Extra-Peninsular and Peninsular India J. Appl. Geol. & Geophys (ISOR-JAGG), V.11, Issue 2,Ser. I, pp. 01-10.

[3]. Amitabha Roy, 2023. A Comparative Statistical Study of Geochemistry of GeothermalFfields of Peninsular and Extra Peninsular India. J. Appl. Geol. & Geophys (ISOR-JAGG), V. 11, Issue I, Ser. II, pp. 32-44.

[4]. Amitabha Roy, 2023. Graphical Signature Recognition of Fluid Geochemistry of Hot Springs in Peninsular and Extra- Peninsular India. v.11 Issue 2, Ser.II, pp. 01-05