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Trend Surface Modeling Of Fluid Geochemistry Of Peninsular And Extra-Peninsular Hot Springs Of India

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Abstract
The objective of performing a trend analysis is to identify a trend in the data by fitting polynomial functions to the dataset, selecting the best polynomial to use 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, and then using this trend surface for performing spatial interpolation, given the geographic coordinates of the location. While mapping, polynomial power was set at 3 or cubic, which gives a better recognizable pattern than the original raw data.

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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 coinciding 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 in entirety were considered for trend surface analysis or trend surface mapping. 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.

Fig. 1 Association of Geothermal Fields and Tectonic Settings

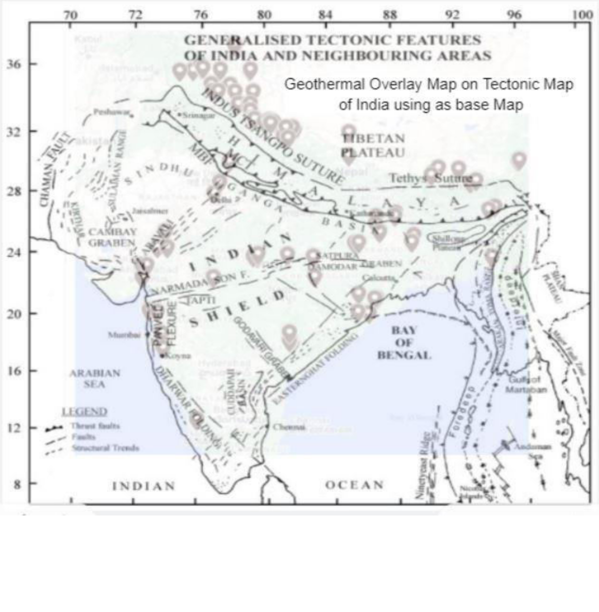


Table 1: The values of Y- and X- coordinates, HCO3 and Cl contents (in mg/L) at different localities

1	Location	Y	X	HCO3 mg/l	Cl mg/L
2	Agni kund	23.8833	87.3666	39	88
3	Suryakund	24.09	85.41	44	90
4	BakreshwarR	23.52	87.25	150	8
5	Attri	20.123	85.3045	65	257
6	Tarabalo	20.1505	85.181	95	143
7	Athmalik	20.443	84.301	105	250
8	Gopalpur	19.2647	84.862	610	100
9	Taptapani	19.2905	84.235	205	0
10	Tatta	23.4515	84.0212	120	105
11	Matang	23.492	84.294	240	20
12	Sitakund	25.22	86.36	0	0
13	Lachmikund	25.03	86.29	0	0
14	Rajgir	25.01	85.25	22	1
15	Tapoban	24.55	85.19	26.4	2
16	Surajkund	24.09	85.41	60	94
17	Takshing	28.2	93.15	435	18
18	Chetu	28.25	93.26	362	154
19	Naza	28.273	93.25	353	35
20	Tatwani	32.071	76.431	15	2
21	Manikaran	32.0278	77.3473	9170	133
22	Chuza	32.0345	78.37	490	855
23	Jeori	31.314	77.47	218	102
24	Napta	31.342	77.582	342	232
25	Karchham	31.3	78.105	303	200
26	Skiba	31.35	78.223	173	45
27	Jamnotri	31	78.23	276	170
28	Banas	30.572	78.25	145	30
29	Chaudaduni	30.5502	78.3336	15	2
30	Jhaya	30.5325	78.4012	248	72
31	Tunja	30.5325	78.433	272	10
32	Gaurikund	30.3905	79.0135	445	35
33	Badrinath	30.4445	79.293	112	1485
34	Ghorshila	30.4158	79.352	103	0
35	Kanakar	36.325	79.313	117	15
36	Juma	30.36	79.481	861	48
37	Tapoban	30.293	79.373	278	12
38	Ungiya	30.0527	80.5313	38	5
39	Devkuna	29.58	80.0856	953	86
40	Balati	30.0853	80.2023	734	12
41	Dobat	29.515	80.3384	439	41
42	Panamik	34.465	77.324	254	13
43	Pulthang	34.4525	77.333	363	17
44	Changlung	34.564	77.2825	1610	85
45	Gul	33.162	75.0345	259	11
46	Yurdu	33.431	75.443	233	58
47	Tatwain	33.303	75.523	32	3
48	Galhar	33.204	76.562	112	30
49	Puga	33.13	78.195	0	410
50	Chhumathang	33.22	78.21	0	7
51	Sunsani	32.421	76.0425	415	596
52	Gajkhad	32.0755	76.105	264	13
53	Baijnath	32.071	76.431	49	104
54	Sohnadh	28.15	77.04	154	1375
55	Sohna	28.15	77.04	188	140
56	Didwaka	26.353	76.193	315	130
57	Rindli	27	76.53	390	195
58	Parai	24.11	73.411	500	140
59	Parsad	24.13	73.424	290	50
60	Gogbasp	21.4053	72.1544	190	1347
61	Gogbatw	21.4053	72.1544	410	110
62	Dholera	22.15	72.12	150	2725
63	Cambaywell	22.14	72.41	1534	2428
64	Keedapad	23.2	73.56	183	71
65	Koknere	19.423	72.51	13	4800
66	Paduspada	19.4105	72.543	11	850
67	Akloli	19.293	73.05	14	1210
68	Vadavil	18.04	73.27	18	78
69	Keed	17.43	73.24	71	426
70	Toral	17.15	73.35	30	375
71	Tapibasin	21.4196	76.1666	63	265
72	Bugga	17.55	80.4315	364	30
73	Gundala	17.383	80.563	99	457
74	Manuguru	17.5545	80.4425	366	257
75	Pagdaru	17.56	80.43	171	50
76	Janampeta_s	18.06	80.4	128	166
77	Tatapani	23.6993	83.6842	177	67

II. TREND SURFACE ANALYSIS

Mathematical consideration

A trend surface model is a particular case of a bivariate regression model with two independent variables, the coordinates X and Y, and a dependent variable, the thematic variable Z, to be modelled. In other words, the principle of a trend surface model is a regression function that estimates the variable value Z_i at any location based on the Xi and Yi coordinates of this location. The general function is:

$$Z_i = f(Y_i, X_i)$$

Where:

z_i = variable value at location i

Y_i, X_i = geographic coordinate values at location i

f = regression function

One can select a linear regression function (first order) or, if the spatial distribution is more complex, a polynomial function (2nd, 3rd,..., or nth order). The modelled surface will correspond to a flat, oriented plane or a curved surface with an increasing number of polynomial order.

The trend surface analysis technique is applied to separate the raw data into two components: the regional or background trend (regression) and the local anomalous values or residuals (deviations). It is in reality a mathematical curve fitting technique that accomplishes "best-fitting' a series of polynomial surfaces by the least squares criterion of multiple regression and determines a value about which the variance is a minimum. The goodness-of-fit of the appropriateness of trend surface curves to the data can be tested by the analysis of variance. A progressive higher-order trend surface fit to the data can be represented by the polynomial equation of arbitrary degree n:

$$Y_i = \sum_{r=0}^{n} a^r X_i^r$$

Where Y_i represents the calculated value in the i-th observation, a^r (r = 0,1,2,...n) indicates arbitrary complex coefficients, and X_i indicates the independent variable in the i-th observation. The 'best' is obtained when the sums of squares of differences between the observed values (y_i) for a particular application (in the present study, Cl and HCO3 elemental values) and the corresponding calculated values (Y_i) are as small as possible. That is

$$\sum_{i=1}^{n} d_i^2 = \sum_{i=1}^{n} (Y_i - y_i)^2 = \text{minimum}$$

The differences (d_i) are called residuals. Moreover, in the case of two-dimensional trend surface mapping, (Z_i) is defined as a function of the independent variables, such as mutually perpendicular geographic coordinates X_i (the easting) and Y_i (the northing). The trend is therefore a linear function of the geographic coordinates of a set of observations, minimizing squared deviations from the trend.

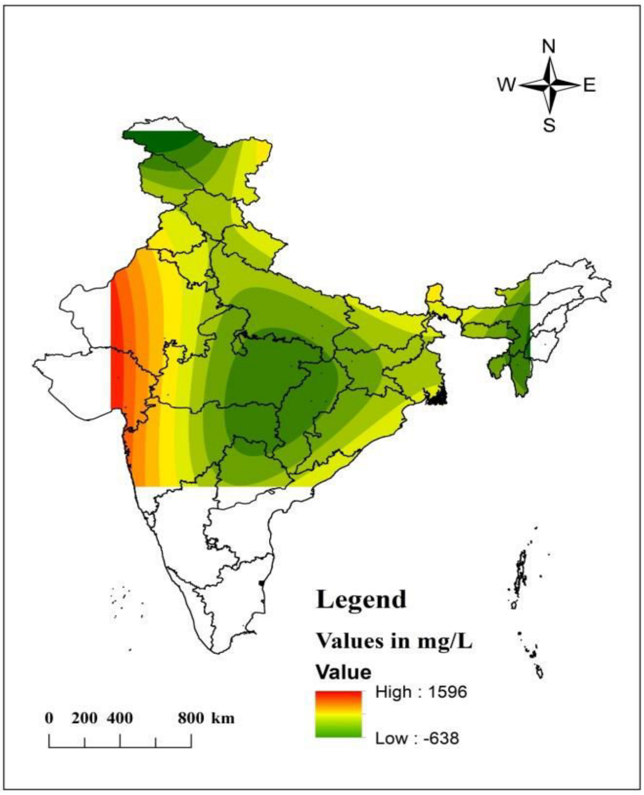
III. GIS MAPPING PROCEDURES

The principle of trend surface modelling is illustrated with a very obvious and observable spatial distribution of fluid geochemical variables, chloride (Cl), and bicarbonate (HCO3). The trend surface mapping of raw data was performed with the help of a GIS mapping tool at the Geography Division of the University of Calcutta at Ballygunge Science College, Kolkata. A Geographic Information System (GIS) is a computer assisted system that analyses and displays geographically referenced information. It uses data that is attached to a unique location. While mapping with the aid of GIS tool, polynomial power was set at 3 or cubic, which gives a better recognizable pattern than the original raw data..

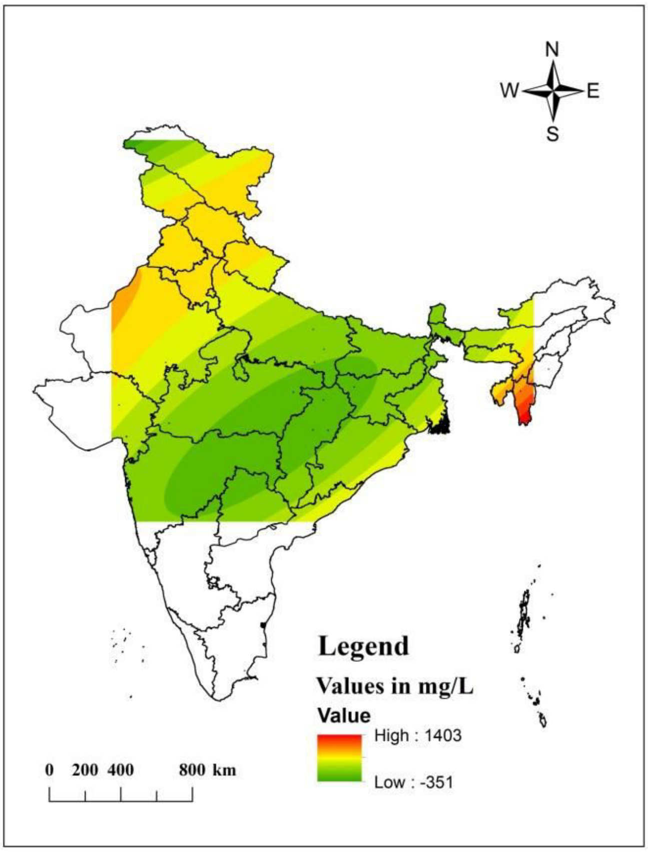
IV. RESULTS AND VISUALIZATION OF TREND SURFACE MAPS

The following figures illustrate the spatial distribution of bivariate fluid geochemical values within a study area as well as different trend surfaces modeling.

Cubic Polynomial Trend Surface of Cl



Cubic Polynomial Trend Surface of HCO3



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References cited

[1]. Amitabha Roy, 2023. Multivariate 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. Trend Analysis of Fluid Geochemistry With Reference To HCO3 And Cl Contents of Peninsular And Extra-Peninsular Hot Springs. J. Appl. Geol. & Geophys (ISOR-JAGG), V.11, Issue 3, Ser. I, pp. 21-24

[5]. Amitabha Roy, 2023. Graphical Signature Recognition of Fluid Geochemistry of Hot Springs in Peninsular and Extra-Peninsular India. J. Appl. Geol. & Geophys (ISOR-JAGG), V.11, Issue 2, Ser. II pp. 01-05

[6] A.Roy, 1983. A.Roy, 1983. Computer assisted trend surface mapping – An aid to geochemical Exploration in the Sargipalli Lead-Zinc Mine area, Sundergarh District, Orissa (India). J.Geol.Soc.Ind., V.24, pp. 421-425