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Comparative Study between Open Well Water and Tube Well Water of Balasore Town by Correlation and Regression Method

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Abstract:

A systematic calculation of correlation coefficients among water quality constituents for ground water samples of Balasore town has been carried out. The regression equations have been developed and their utility has been discussed to predict the concentration of water quality constituents having significant correlations. Drinking water at almost all the sites is found to be polluted. People dependent on this water must be facing the health hazards of contaminated drinking water and water quality management is urgently required in the catchment area of study.

Key words: Drinking water, Ground water quality, Correlation coefficients, Regression analysis

1. Introduction

Water is one of the abundantly available substances in nature. Pollution of land, water and air through water generated as a result of increasing is a challenge of serious dimensions. The main purpose of water analysis is to evaluate methods of treatments of ground water with to reuse or dispose, ascertain quality of water. Correlation among water quality parameters in specific environmental condition have been shown to be useful [1]. Recently, there has been an increased public concern and interest in the quality of ground water due to ever increasing growth of population. The quality of ground water is usually characterized in terms of certain water quality constituents according to its physical, chemical and microbiological properties [2]. Since chemical characteristics of ground water are interlinked, regression equations have been widely developed and used to predict the concentration of other constituents[3].

2. Methodology

Water samples were collected from Budhabalanga river of Balasore. The water samples were collected in every months. The correlation coefficient (r) among 23 water quality parameters, such as Chloride, Nitrate, sulfate, sulfide, phosphate, Nickel, Lead, Chromium, Cobalt, Zinc, Manganese, Iron, Turbidity, pH, electrical conductivity, Total alkalinity, Total hardness, calcium, magnesium, TDS, Sodium, Potassium, DO. of different categories of waters samples were calculated. The sampling of water was carried out during the period of one year (December-2012 to November-2013). The water samples were collected by holding glass stoppered sterile bottle near its base in the hand and plugging it and transported in the laboratory in an ice-box to avoid unpredictable changes in physico-chemical characteristic after measuring temperature. Physico-chemical analysis for water were done following the standard methods by APHA[4].

2.1. Correlation coefficient and Linear Regression

Correlation coefficient ' r ' has been calculated between each pair of parameters by using experimental data [5]. Let X and Y be the two variables, then the correlation ' r ' between the variables X and Y is given by

$$r = \frac{\sum XY}{\sqrt{\sum X^2 \times \sum Y^2}}$$

Where,

$$X = X - \bar{X} \text{ And } X = \frac{\sum X}{n}$$

$$Y = Y - \bar{Y} \text{ And } Y = \frac{\sum Y}{n}$$

n = no. of samples.

If the values of correlation coefficient ' r ' between two variables X and Y are fairly large it implies that these two variables are highly correlated. In such cases it is feasible to try linear relation of the form :

$$Y = AX + B$$

To correlate X and Y, where A and B are the constants.

For high ' r ' values linear equation is found for two variables X and Y i.e. the concentration of certain parameters can be predicted when one is determined.

3. Result and Discussion

Four samples were taken from ground waters of Balasore town planning area. The correlation coefficient (r) among 23 water quality parameters, such as Chloride, Nitrate, sulfate, sulfide, phosphate, Nickel, Lead, Chromium, Cobalt, Zinc, Manganese, Iron, Turbidity, pH, electrical conductivity, Total alkalinity, Total hardness, calcium, magnesium, TDS, Sodium, Potassium, DO. of different categories of waters samples were calculated. The value of ' r ' in positive correlation was between 0 to 0.99 and for negative correlation 0 to 0.99.

- For open well water of eastern part of Balasore, there was some negative correlation between sulfide and total alkalinity ($r = -0.806$). There were some positive correlation between E.C. and TDS ($r = 0.994$), total alkalinity and potassium ($r = 0.884$), total hardness and calcium ($r = 0.952$).
- For open well water of eastern part of Balasore, there were some positive correlations between chloride and sodium ($r = 0.841$), lead and turbidity ($r = 0.834$), E.C. and TDS ($r = 0.989$), total hardness and calcium ($r = 0.990$).
- For tube well water of eastern part of Balasore, there were some positive correlations between chloride and total alkalinity ($r = 0.910$), sulfate and magnesium ($r = 0.835$), E.C. and TDS ($r = 0.985$), total hardness and calcium ($r = 0.828$).
- For tube well water of western part of Balasore, there were some positive correlations between sulfide and TDS ($r = 0.824$), E.C. and TDS ($r = 0.987$), total hardness and calcium ($r = 0.842$).

Scatter plots were drawn for positive correlation and negative correlation (Fig. 1 to 6).

Table-1 to 9 showed maximum, minimum, range, median, standard deviation of different parameters. A simple regression equation $Y = AX + B$ for only strong correlation values between the pairs of parameters X and Y followed by regression coefficients A and B separately. After developing the regression equation different dependent parameters were calculated [7].

The regression equations developed by taking different water quality parameters as dependent variable and other parameters are independent variables. The higher ' r ' values indicate better performance of relationship and suitability in predicting the dependent variables[2].

4. Conclusion

At a few sites drinking water is moderately polluted and some areas highly contaminated. It is concluded that the linear regression equations developed between various water quality constituents and electrical conductivity can be successfully used for predicting the concentration of various parameters [6]. Similar approach can be tried for other regions of the country for predicting water quality.

5. References

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	Minimum	Maximum	Range	Mean	Median	Std. Deviation	Variance
Chloride	38.30	105.25	66.95	76.3537	84.0800	23.39778	30.64394
Nitrate	.101	7.782	7.681	3.25933	3.04150	2.972909	91.21227
Sulfate	9.60	42.40	32.80	22.2433	20.0600	10.20520	45.87988
Sulfide	.16	.25	.09	.2000	.2000	.02887	14.435
Phosphate	.002	.600	.598	.10400	.00800	.220487	212.0067
Fluoride	.241	.528	.287	.43000	.52100	.163716	38.07349
Nickel	.001	.002	.001	.00157	.00200	.000535	34.07643
Lead	.011	.250	.239	.07983	.06350	.062700	78.5419
Chromium	.000	.011	.011	.00200	.00000	.004427	221.35
Cobalt	.000	.018	.018	.00883	.01050	.007387	83.65798
Zinc	.000	.112	.112	.03133	.02350	.034618	110.4947
Manganese	.628	2.450	1.822	1.36167	1.08350	.584908	42.95519
Iron	.020	.375	.355	.17042	.13500	.122631	71.9581
Turbidity	2.00	8.00	6.00	4.5833	4.0000	1.84432	40.24
Ph	6.830	7.580	.750	7.08833	7.02000	.228546	3.224257
Ele. Conductivity	565	1420	855	855.83	825.00	231.122	27.0056
Total Alkalinity	23.060	88.210	65.150	58.68667	60.05000	16.886583	28.77414
Total Hardness	23.177	106.670	83.493	78.69092	86.25700	26.774661	34.0251
Calcium	14.429	85.320	70.891	63.15358	70.94900	24.061655	38.10022
Magnesium	7.620	35.964	28.344	15.78650	13.52000	8.309780	52.63852
TDS	367.25	923.00	555.75	553.1708	531.9250	154.89640	28.00155
Sodium	38.30	71.40	33.10	51.2000	51.6500	11.89721	23.23674
Potassium	6.20	43.00	36.80	19.7333	18.4000	9.79483	49.63605
DO	3.82	6.20	2.38	5.3742	5.5350	.72634	13.51531

Table 1: Statistical Data for water quality parameters of open well water of eastern part of Balasore (S_1)

	Minimum	Maximum	Range	Mean	Median	Std. Deviation	Variance
Chloride	28.90	130.17	101.27	72.3574	58.2840	31.18841	43.10328
Nitrate	.123	7.801	7.678	3.42200	2.80600	3.136230	91.64904
Sulfate	14.30	36.80	22.50	23.1208	23.3800	7.42840	32.12865
Sulfide	.14	.28	.14	.1962	.2000	.04689	23.89908
Fluoride	.239	.516	.277	.42033	.50600	.157119	37.37992
Nickel	.001	.002	.001	.00129	.00100	.000488	37.82946
Lead	.010	.104	.094	.05192	.04750	.031085	59.87096
Chromium	.000	.009	.009	.00192	.00100	.002678	139.479
Cobalt	.000	.016	.016	.00700	.00800	.005410	77.285
Zinc	.000	.132	.132	.04158	.03400	.041897	100.7624
Manganese	.033	2.010	1.977	.75400	1.03500	.641888	85.13103
Iron	.010	.390	.380	.15917	.13000	.115086	72.30383
Turbidity	2.00	7.50	5.50	4.6250	4.2500	1.70727	36.91395
pH	6.780	7.610	.830	7.19000	7.17500	.199909	2.780376
Ele. Conductivity	548	980	432	820.25	837.50	116.817	14.24163
Total Alkalinity	25.530	82.850	57.320	51.40000	49.27500	19.382900	37.70992
Total Hardness	30.902	143.856	112.954	88.11250	87.21000	31.985406	36.30065
Calcium	19.238	132.192	112.954	74.71583	73.74000	32.718028	43.78995
Magnesium	4.860	18.920	14.060	12.80467	12.46700	4.459041	34.82355
TDS	323.32	656.60	333.28	534.9725	555.0500	92.78036	17.34301
Sodium	28.90	70.60	41.70	50.6000	47.0000	14.19885	28.06097
Potassium	6.00	20.80	14.80	11.2667	10.8000	4.66658	41.41923
DO	4.01	6.24	2.23	5.4542	5.7350	.66105	12.12002

Table 2: Statistical Data for water quality parameters of open well water of western part of Balasore (S_2)

	Minimum	Maximum	Range	Mean	Median	Std. Deviation	Variance
Chloride	15.66	27.20	11.54	23.5008	25.0380	3.98700	16.96538
Nitrate	.081	2.362	2.281	.88333	1.04300	.740588	83.84047
Sulfate	.04	30.56	30.52	9.0667	7.1900	8.62293	95.1055
Sulfide	.12	.65	.53	.2778	.1800	.20185	72.66019
Fluoride	.424	.662	.238	.55833	.58900	.121928	21.83798
Nickel	.001	.003	.002	.00163	.00150	.000744	45.64417
Lead	.000	.102	.102	.04075	.03350	.035765	87.76687
Chromium	.000	.004	.004	.00217	.00200	.001467	67.603
Cobalt	.000	.064	.064	.02483	.01550	.024041	96.822
Zinc	.001	.041	.040	.01608	.01250	.011221	69.78234
Manganese	.018	.212	.194	.13200	.14750	.076300	57.80303
Iron	.045	.540	.495	.21042	.16750	.149840	71.20996
Turbidity	3.00	8.00	5.00	5.4833	5.4000	1.42499	25.98782
pH	6.860	7.400	.540	7.14000	7.19000	.173100	2.42437
Ele. Conductivity	256	560	304	435.75	440.00	89.262	20.48468
Total Alkalinity	28.800	72.320	43.520	54.61833	55.86000	13.632893	24.96029
Total Hardness	36.055	76.044	39.989	56.59417	55.12500	12.662804	22.37475
Calcium	22.445	60.350	37.905	42.33400	41.98500	9.977923	23.56953
Magnesium	8.420	35.964	27.544	14.22683	13.11000	7.132023	50.1308
TDS	143.36	344.72	201.36	254.6917	266.7000	59.23753	23.25852
Sodium	12.10	21.30	9.20	15.5125	14.3500	3.47969	22.43152
Potassium	.70	1.90	1.20	1.2767	1.3000	.31026	24.30172
DO	5.08	6.25	1.17	5.6708	5.7700	.36763	6.48286

Table 3: Statistical Data for water quality parameters of Tube-well water of eastern part of Balasore (S_3)

	Minimum	Maximum	Range	Mean	Median	Std. Deviation	Variance
Chloride	7.83	29.92	22.09	19.2292	17.7525	6.21288	32.30961
Nitrate	.060	6.752	6.692	1.78942	1.26750	2.135686	119.3507
Sulfate	.00	19.44	19.44	8.7725	8.5500	5.91867	67.46845
Sulfide	.14	.62	.48	.2838	.1800	.20894	73.62227
Fluoride	.421	.648	.227	.55667	.60100	.119818	21.52406
Nickel	.001	.002	.001	.00140	.00100	.000548	39.14286
Lead	.001	.101	.100	.03350	.02500	.032498	97.00896
Chromium	.000	.010	.010	.00225	.00200	.002633	117.023
Cobalt	.000	.052	.052	.02242	.01400	.021219	94.643
Zinc	.003	.056	.053	.02567	.02550	.015400	59.99221
Manganese	.011	.210	.199	.09217	.10600	.057859	62.77422
Iron	.042	.280	.238	.14083	.12000	.084029	59.66697
Turbidity	3.00	7.00	4.00	5.5583	6.0000	1.20413	21.66364
pH	6.850	7.430	.580	7.07917	7.10000	.176040	2.486732
Ele. Conductivity	270	540	270	400.17	395.00	90.725	22.67161
Total Alkalinity	24.032	62.450	38.418	45.09558	47.52000	11.825190	26.2225
Total Hardness	41.885	63.930	22.045	51.15500	48.43500	7.596417	14.8498
Calcium	22.445	48.920	26.475	37.90767	37.87000	6.979639	18.41221
Magnesium	8.750	19.440	10.690	13.49733	11.63500	4.366577	32.35141
TDS	153.90	351.00	197.10	237.5508	229.1000	66.87153	28.15041
Sodium	9.20	52.10	42.90	15.1500	12.0500	11.71390	77.31947
Potassium	.60	1.48	.88	1.1867	1.2000	.22293	18.78571
DO	4.15	6.12	1.97	5.1458	5.0300	.61156	11.88464

Table 4: Statistical Data for water quality parameters of Tube-well water of western part of Balasore (S_4)

Zinc	Cobalt	Chromium	Lead	Nickel	Phosphate	Sulfide	Sulfate	Nitrate	Chloride	Chloride
-0.029	0.296	0.324	0.095	0.515	-0.465	-0.412	0.235	-0.036	1.000	1.000
0.012	-0.266	-0.459	-0.208	-0.010	0.302	0.089	-0.100	1.000		Nitrate
0.632	-0.269	0.010	-0.217	0.312	-0.111	-0.075	1.000			Sulfate
-0.389	0.143	-0.623	-0.540	-0.740	-0.138	1.000				Sulfide
-0.014	-0.466	-0.029	0.250	-0.256	1.000					Phosphate
0.482	-0.268	0.273	0.322	1.000						Nickel
-0.214	-0.194	0.605	1.000							Lead
-0.039	0.127	1.000								Chromium
-0.134	1.000									Cobalt
1.000										Zinc
										Manganese
										Iron
										Turbidity
										pH
										Ele. Cond
										Total Alkal.
										Total Hard
										Calcium
										Magnesium
										TDS
										Sodium
										Potassium
										DO

Potassium	Sodium	TDS	Magnesium	Calcium	Total Hard	Total Alkal.	Ele. Cond	pH	Turbidity	Iron	Manganese
0.743	0.699	0.422	0.347	0.167	0.274	0.673	0.445	-0.229	-0.242	0.059	0.302
-0.089	0.140	-0.065	-0.151	-0.559	-0.558	-0.004	-0.028	-0.240	0.183	-0.251	-0.457
-0.056	0.212	-0.114	0.299	-0.472	-0.325	-0.074	-0.075	-0.077	-0.004	-0.428	-0.404
-0.531	0.015	-0.045	-0.106	0.244	0.191	-0.806	-0.001	-0.252	-0.524	0.458	-0.081
-0.010	-0.319	-0.083	0.000	-0.433	-0.422	0.070	-0.065	-0.157	0.561	-0.371	-0.259
0.357	-0.045	-0.152	-0.062	-0.381	-0.352	0.562	-0.168	0.428	0.114	-0.280	-0.058
0.367	-0.375	-0.017	0.214	0.097	0.147	0.589	-0.067	0.264	0.124	-0.349	0.235
0.330	-0.030	0.134	0.216	0.255	0.298	0.495	0.071	-0.115	0.123	-0.443	0.587
-0.033	0.269	-0.008	0.103	0.752	0.721	-0.042	-0.016	-0.277	-0.526	0.396	0.378
-0.248	-0.197	-0.334	0.132	-0.539	-0.443	-0.039	-0.346	0.378	0.308	-0.483	-0.579
0.292	0.126	0.194	-0.134	0.562	0.472	0.237	0.170	-0.261	-0.359	0.212	1.000
0.094	0.252	0.178	-0.273	0.611	0.475	-0.208	0.209	-0.010	-0.383	1.000	
0.221	-0.036	0.245	0.051	-0.486	-0.440	0.326	0.212	0.211	1.000		
-0.032	-0.553	-0.060	0.094	-0.138	-0.091	0.093	-0.118	1.000			
0.715	0.628	0.994	0.603	0.223	0.389	0.395	1.000				
0.884	0.329	0.410	0.332	-0.044	0.062	1.000					
0.237	0.205	0.418	0.429	0.952	1.000						
0.113	0.138	0.251	0.133	1.000							
0.430	0.227	0.614	1.000								
0.706	0.578	1.000									
0.564	1.000										
1.000											

DO	0.106	-0.631	0.280	0.063	-0.247	0.077	0.304	0.230	0.047	0.063	-0.022	0.099	-0.290	0.310	0.153	-0.064	0.538	0.407	0.534	0.175	-0.214	0.074	1.000
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Table 5: Correlation coefficient 'r' among various parameters of Open-well water of Eastern part of Balasore

Zinc	Cobalt	Chromium	Lead	Nickel	Sulfide	Sulfate	Nitrate	Chloride	Chloride
-0.426	-0.098	0.238	-0.567	-0.148	0.253	0.262	0.195	1.000	Chloride
0.085	-0.547	-0.430	0.228	0.171	0.348	-0.256	1.000		Nitrate
0.241	-0.097	-0.204	-0.090	-0.195	0.039	1.000			Sulfate
-0.427	-0.498	-0.363	-0.068	-0.231	1.000				Sulfide
0.561	-0.379	0.304	0.123	1.000					Nickel
0.207	-0.486	-0.333	1.000						Lead
-0.297	0.151	1.000							Chromium
-0.093	1.000								Cobalt
1.000									Zinc
									Manganese
									Iron
									Turbidity
									pH
									Ele. Cond
									Total Alkal.
									Total Hard
									Calcium
									Magnesium
									TDS
									Sodium
									Potassium
									DO

Potassium	Sodium	TDS	Magnesium	Calcium	Total Hard	Total Alkal.	Ele. Cond	pH	Turbidity	Iron	Manganese
0.342	0.841	0.210	-0.193	0.150	0.111	-0.032	0.250	-0.311	-0.524	0.253	0.375
-0.463	0.176	0.299	-0.256	0.053	0.036	-0.446	0.305	0.258	0.206	-0.220	-0.321
0.115	0.346	-0.274	-0.152	-0.499	-0.553	-0.244	-0.215	-0.294	-0.304	0.073	-0.409
0.283	0.419	0.488	-0.073	-0.112	-0.109	-0.677	0.486	-0.353	-0.107	0.331	0.128
-0.269	-0.338	-0.243	0.372	-0.337	-0.259	0.198	-0.273	0.513	0.521	-0.652	0.141
-0.560	-0.386	0.056	-0.165	-0.228	-0.239	-0.097	0.035	0.356	0.834	-0.078	-0.492
0.377	-0.140	0.136	0.236	0.048	0.076	0.685	0.101	-0.119	-0.107	-0.236	0.746
0.188	-0.037	-0.376	0.038	0.481	0.472	0.337	-0.353	-0.104	-0.512	0.108	0.128
-0.403	-0.463	-0.614	0.309	-0.480	-0.435	-0.032	-0.615	0.546	0.355	-0.557	-0.609
0.490	0.172	0.354	0.123	0.298	0.330	0.453	0.321	-0.248	-0.226	0.214	1.000
0.217	0.478	0.274	-0.330	0.432	0.382	-0.062	0.301	-0.456	-0.316	1.000	
-0.487	-0.492	0.001	0.129	-0.370	-0.327	0.072	-0.045	0.577	1.000		
-0.259	-0.369	-0.371	0.036	-0.232	-0.190	0.279	-0.463	1.000			
-0.144	0.099	0.989	-0.500	0.014	-0.051	0.020	1.000				
-0.004	-0.367	0.076	-0.158	0.018	0.005	1.000					
0.083	0.261	-0.080	0.068	0.990	1.000						
0.033	0.306	-0.022	-0.061	1.000							
0.426	-0.251	-0.484	1.000								
-0.091	0.033	1.000									
0.271	1.000										
1.000											

DO	-0.273	-0.653	0.402	-0.397	-0.186	0.099	0.345	0.154	0.047	-0.023	0.067	-0.106	-0.111	-0.068	0.511	-0.350	-0.313	-0.136	-0.029	-0.403	0.207	1.000
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Table 6: Correlation coefficient ‘r’ among various parameters of Open-well water of Western part of Balasore

Zinc	Cobalt	Chromium	Lead	Nickel	Sulfide	Sulfate	Nitrate	Chloride	Chloride
-0.613	-0.070	0.366	-0.236	0.331	0.331	0.347	0.398	1.000	Chloride
-0.528	0.583	0.225	0.018	0.247	-0.524	0.182	1.000		Nitrate
-0.228	-0.337	-0.086	-0.608	0.476	0.151	1.000			Sulfate
0.032	-0.489	0.226	-0.500	0.253	1.000				Sulfide
-0.237	-0.022	-0.073	-0.351	1.000					Nickel
0.151	0.332	-0.252	1.000						Lead
-0.393	0.264	1.000							Chromium
-0.401	1.000								Cobalt
1.000									Zinc
									Manganese
									Iron
									Turbidity
									pH
									Ele. Cond
									Total Alkal.
									Total Hard
									Calcium
									Magnesium
									TDS
									Sodium
									Potassium
									DO

Potassium	Sodium	TDS	Magnesium	Calcium	Total Hard	Total Alkal.	Ele. Cond	pH	Turbidity	Iron	Manganese
0.190	0.459	0.318	0.339	0.260	0.395	0.910	0.281	0.172	0.215	-0.535	0.274
-0.367	-0.411	0.339	0.199	-0.045	0.074	0.293	0.235	0.698	0.332	-0.443	-0.447
0.078	-0.015	0.395	0.835	0.072	0.520	0.594	0.326	0.016	0.550	-0.373	0.227
0.653	0.649	0.243	-0.020	0.308	0.229	0.279	0.286	-0.730	-0.101	-0.235	0.358
-0.102	-0.041	0.489	0.588	0.247	0.533	0.345	0.410	0.042	0.353	-0.372	0.245
-0.387	-0.066	-0.404	-0.365	-0.195	-0.346	-0.332	-0.381	0.401	0.019	0.100	-0.074
-0.133	0.032	-0.214	-0.170	0.358	0.193	0.216	-0.234	-0.036	-0.225	-0.257	-0.366
-0.548	-0.519	0.058	-0.243	0.447	0.217	-0.327	-0.012	0.537	-0.193	-0.273	-0.472
0.205	-0.175	-0.429	-0.110	-0.372	-0.357	-0.438	-0.422	-0.085	0.065	0.553	-0.151
0.311	0.669	0.123	0.376	0.068	0.267	0.296	0.166	-0.300	-0.222	0.193	1.000
-0.060	0.015	-0.622	-0.086	-0.394	-0.360	-0.463	-0.583	-0.029	-0.434	1.000	
-0.229	-0.123	0.122	0.506	-0.257	0.084	0.420	0.060	0.307	1.000		
-0.577	-0.500	-0.202	0.330	0.003	0.189	0.159	-0.323	1.000			
0.502	0.105	0.985	-0.008	0.082	0.051	0.219	1.000				
0.180	0.350	0.254	0.546	0.137	0.414	1.000					
-0.225	-0.084	0.138	0.618	0.828	1.000						
-0.137	-0.095	0.119	0.071	1.000							
-0.184	-0.017	0.098	1.000								
0.448	0.029	1.000									
0.496	1.000										
1.000											

DO	-0.224	0.116	0.163	-0.654	-0.226	0.086	-0.425	0.185	-0.106	0.215	0.362	-0.196	0.402	-0.076	-0.096	0.158	0.021	0.267	-0.063	-0.370	-0.286	1.000
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Table 7: Correlation coefficient 'r' among various parameters of Tube-well water of Eastern part of Balasore

	Zinc	Cobalt	Chromium	Lead	Nickel	Sulfide	Sulfate	Nitrate	Chloride	Chloride	Chloride	Nitrate	Sulfate	Sulfide	Nickel	Lead	Chromium	Cobalt	Zinc	Manganese	Iron	Turbidity	pH	Ele. Cond	Total Alkal.	Total Hard	Calcium	Magnesium	TDS	Sodium	Potassium	DO
	-0.374	0.679	0.537	0.157	0.025	-0.154	-0.045	0.685	1.000																							
	-0.651	0.649	0.565	-0.053	0.212	-0.255	0.267	1.000																								
	-0.383	-0.180	-0.162	-0.606	0.385	0.238	1.000																									
	0.093	-0.504	-0.171	-0.471	-0.157	1.000																										
	-0.377	0.092	0.359	0.048	1.000																											
	0.256	0.314	0.210	1.000																												
	-0.410	0.502	1.000																													
	-0.499	1.000																														
	1.000																															

Potassium	Sodium	TDS	Magnesium	Calcium	Total Hard	Total Alkal.	Ele. Cond	pH	Turbidity	Iron	Manganese
-0.550	-0.086	-0.189	-0.017	0.472	0.434	0.315	-0.165	0.562	-0.100	-0.137	-0.481
-0.581	-0.080	-0.004	-0.270	0.288	0.120	0.063	0.076	0.186	0.294	-0.552	-0.567
0.061	0.544	0.262	0.212	-0.220	-0.053	0.418	0.302	-0.038	0.608	-0.589	0.037
0.311	-0.149	0.824	0.502	0.255	0.541	0.428	0.764	-0.462	-0.215	-0.239	0.400
-0.621	0.481	-0.170	-0.031	-0.310	-0.276	-0.244	-0.191	-0.348	0.485	-0.307	0.083
-0.347	-0.323	-0.447	-0.463	-0.012	-0.297	-0.298	-0.472	0.189	0.155	0.312	-0.248
-0.728	-0.331	-0.158	-0.387	0.395	0.157	-0.309	-0.134	-0.184	0.009	-0.143	-0.319
-0.490	-0.287	-0.171	-0.548	0.521	0.201	-0.129	-0.124	0.416	-0.122	-0.087	-0.464
0.626	0.158	-0.087	0.128	-0.440	-0.336	-0.199	-0.109	0.099	-0.225	0.480	0.206
0.195	0.179	0.169	0.612	-0.156	0.195	-0.041	0.055	-0.471	-0.169	0.166	1.000
0.173	-0.041	-0.446	0.017	0.129	0.133	-0.437	-0.453	0.187	-0.403	1.000	
-0.283	0.332	-0.185	-0.147	-0.412	-0.476	0.059	-0.146	-0.070	1.000		
0.113	0.203	-0.464	-0.057	0.018	-0.020	0.380	-0.415	1.000			
0.369	-0.304	0.987	0.000	0.368	0.389	0.226	1.000				
0.150	0.047	0.265	0.459	0.095	0.322	1.000					
-0.128	-0.372	0.422	0.350	0.842	1.000						
-0.226	-0.692	0.355	-0.200	1.000							
0.116	0.439	0.088	1.000								
0.352	-0.313	1.000									
0.087	1.000										
1.000											

DO	-0.043	-0.183	-0.077	-0.282	0.112	-0.004	-0.077	0.414	-0.313	-0.118	0.282	-0.301	0.187	-0.067	-0.110	0.116	0.303	-0.372	-0.079	-0.064	0.016	1.000
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Table 8: Correlation coefficient 'r' among various parameters of Tube-well water of Western part of Balasore

Category of water sample	X	Y	A	B	r	Regression equation Y=AX+B
Open well water of eastern part of Balasore	E.C.	TDS	0.666	-16.807	0.994	TDS=0.666 (EC) – 16.807
	Total alkalinity	Potassium	0.5129	-10.37	0.884	Potassium = 0.5129 (Total alkalinity) – 10.37
	Total hardness	Calcium	0.8554	-4.1621	0.952	Calcium = 0.855 (Total hardness) – 4.1621
Open well water of western part of Balasore	Chloride	Sodium	0.388	21.61	0.841	Sodium = 0.386 (chloride) + 21.61
	Lead	Turbidity	45.83	22457	0.834	Turbidity = 45.83 (Lead) + 2.2457
	EC	TDS	0.785	-109.1	0.989	TDS = 0.785 (EC) – 109.14
Tube well water of eastern part of Balasore	Total hardness	Calcium	1.0127	-14.519	0.990	Calcium = 1.0127 (Total hardness) – 14.519
	Chloride	Total alkalinity	3.111	-18.511	0.910	Total alkalinity = 3.111 (Chloride) – 18.511
	Sulfate	Magnesium	0.691	7.9616	0.835	Magnesium = 0.691 (sulfate) + 7.9616
	EC	TDS	0.6539	-30.261	0.985	0.6539 (EC) – 30.261
Tube well water of Western part of Balasore	Total hardness	Calcium	0.6524	5.414	0.828	Calcium = 0.6524 (Total hardness) + 5.414
	Sulfide	TDS	302.2	157.72	0.824	TDS = 302.21 (Sulfide) + 157.72

Table 9: Least square fitting for linear relation Y = AX+B (X and Y = Parameters, A and B = regression coefficient, r = correlation coefficient)

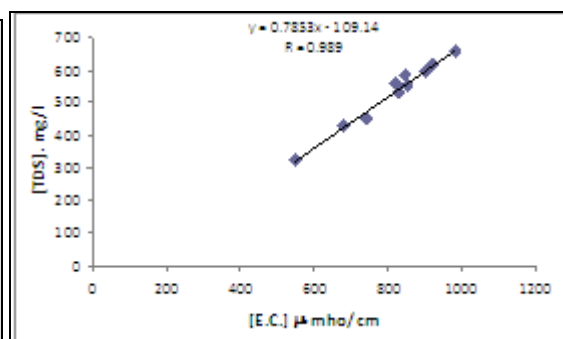
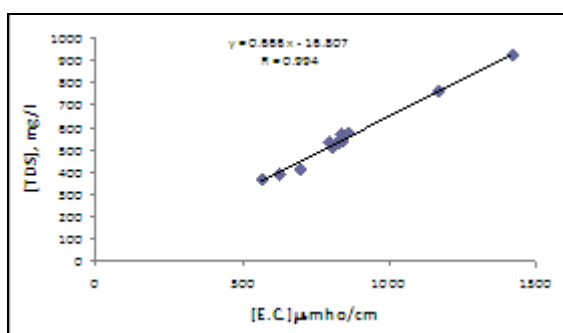


Fig. 1: Linear plot between observed E.C. and TDS of open-well water of western part of Balasore

Fig. 2: Linear plot between observed E.C. and TDS values of open-well water of eastern part of Balasore

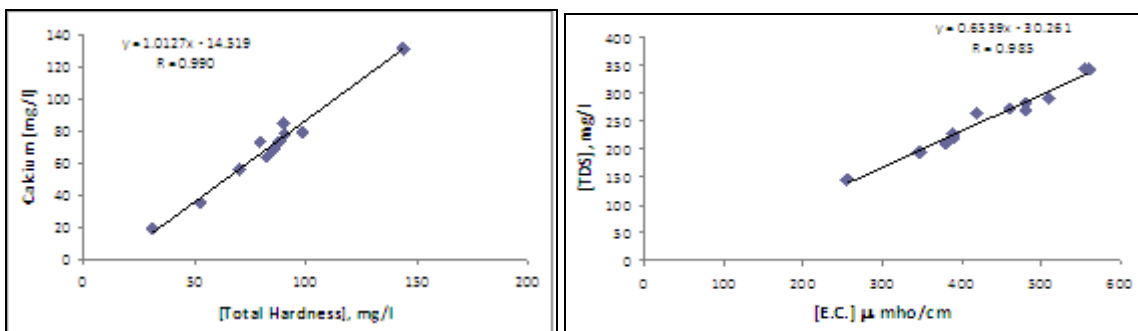


Fig. 3: Linear plot between observed Total Hardness values of open-well water of western part of Balasore

Fig. 4: Linear plot between observed Chloride and Total and Calcium Alkalinity values of Tube-well water of eastern part of Balasore

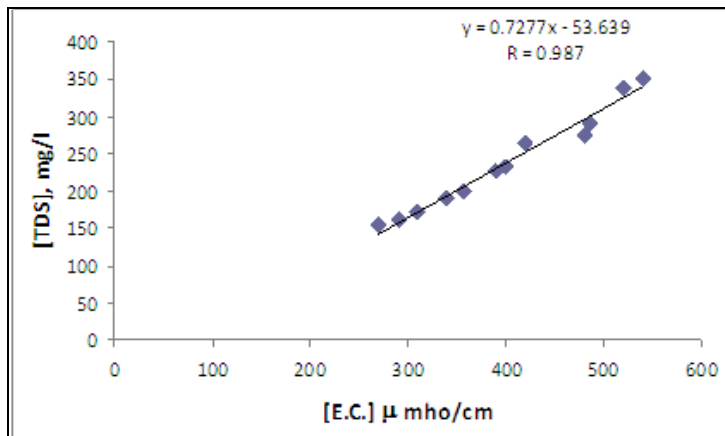


Fig. 5: Linear plot between observed E.C. and TDS values of Tube-well water of western part of Balasore