groves has been already initiated. The overall rise in water bodies is attributed to climatic conditions of the area and improved watershed management programmes.

The present study was undertaken to detect changes in the coastal zone of Goa using remote sensing and digital image classification techniques. After mapping the coastal land-use and land-cover features of the study area for three different years, changes that took place over that region for a period of 13 years have been detected. There are significant changes in urban land, barren land, vegetation and mangrove covers. This exercise reveals that the coastal zone of Goa has undergone extensive development in the last decade. In such a situation, the change detection study will be of use to the decision makers.

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Seasonal evaluation of hydro-geochemical parameters using correlation and regression analysis

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Correlations and multiple linear regressions were used to develop models relating well water chemical quality parameters to a set of independent chemical variables in post- and pre-monsoon seasons in the upper Gunjanaeru River basin, Cuddapah district, Andhra Pradesh, South India. The correlation between the specific electrical conductance (SEC) and other parameters except potassium (K^+) is significantly positive, whereas Ca^{2+} + $Mg^{2+}/Na^+ + K^+$ is significantly negative for both post- and pre-monsoon seasons. In predicting SEC for both post- and pre-monsoon, the independent variables, viz. HCO_3^-, SO_4^{2-} and Cl^- in the model had a significant effect (from '*t*' test for partial regression coefficient at the 5% level of probability). The multiple R^2 values 0.982 and 0.997 indicate that 98.2 and 99.7% of variability in the observed SEC could be ascribed to the combined effect of Na^+, Cl^-, $Ca^{2+} + Mg^{2+}$, HCO_3^-, and SO_4^{2-} for post- and pre-monsoon seasons, respectively. Out of the 98.2% variability in SEC due to the combined effect of Na^+, $Ca^{2+} + Mg^{2+}$, HCO_3^-, SO_4^{2-} and Cl^-; 44.8% is due to HCO_3^-, 44.4% is due to Cl^-, 9% is due to SO_4^{2-} and 2% each is due to Na^+ and $Ca^{2+} + Mg^{2+}$ for post-monsoon season. Whereas in the pre-monsoon season, 99.7% variability in SEC is due to the combined effect of Na^+, $Ca^{2+} + Mg^{2+}$, HCO_3^-, SO_4^{2-} and Cl^-; 38.8% is due to Cl^-, 36.9% is due to HCO_3^-, 12% is due to Na^+, 7% is due to SO_4^{2-} and 3% is due to $Ca^{2+} + Mg^{2+}$. This shows that HCO_3^-, Cl^-, SO_4^{2-} and Cl^-, HCO_3^-, Na^+, SO_4^{2-} are the most significant independent variables in predicting SEC for post- and pre-monsoon seasons respectively.

Keywords: Correlation, groundwater quality, hydrogeochemistry, regression models.

MAN has demonstrated control of some of undesirable chemical constituents in water before it enters the ground. But once the water has entered the soil mantle, man's control over the chemical quality of the percolating water is significantly reduced[1]. The quality of well water should be better in an area where the soil and aquifer permeability is greater than in an area which is less permeable, assuming that the chemical constituents of the recharge water and evapo-transpiration effects in the two areas are similar. Multivariate analyses are especially useful because the relative importance of the combinations of chemical vari-

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ables can be evaluated. They are used as analytical tools to reduce and organize large hydro-geochemical datasets into groups with similar characteristics. Correlation and regression analysis is widely used in geochemistry; it is useful for interpreting commonly collected groundwater quality data and relating them to specific hydro-geological processes. The basic purpose of such an analysis to the study of the hydro-geochemistry of an aquifer is to find a set of factors, few in number, which can explain a large amount of the variance of the analytical data[2]. Anthropogenic activities and improper management of natural resources also led to unequal distribution of major and minor elements in nature[3]. Sreedevi[4] has studied the groundwater quality of Pageru River basin in Cuddapah district and the assessment of water samples using various methods proved that majority of the water samples are good either for drinking or for agriculture in post- and pre-monsoon seasons. Reddy and Prasad[5] have studied the groundwater quality of Tadipatri area, Anantapur district. Their results show that Mg, Na, Cl, HCO_3 and SO_4 are slightly in excess during the pre-monsoon period than the post-monsoon period.

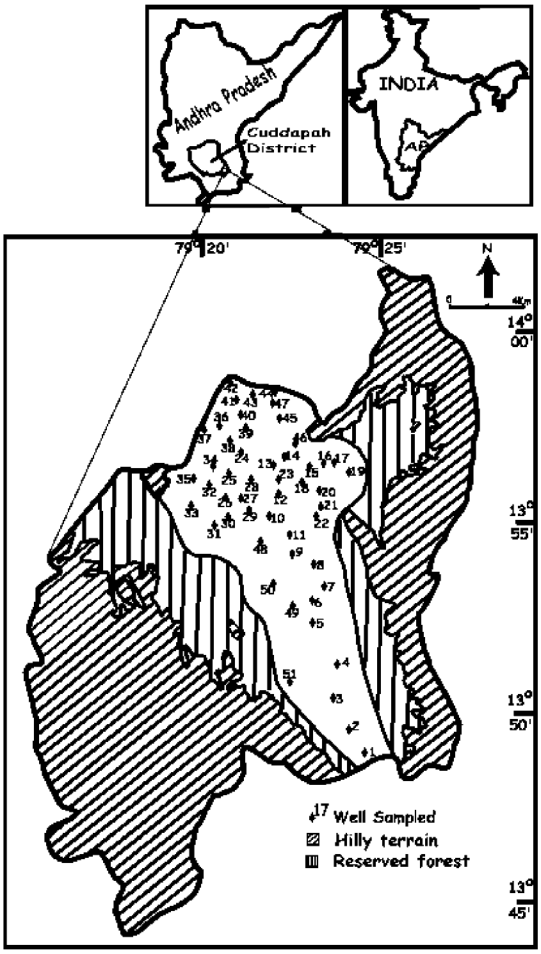

Figure 1. Location of water samples in Upper Gunjanaeru River basin.

In order to study the seasonal quality variations of the groundwater in the upper Gunjaneru river basin, Cuddapah district, Andhra Pradesh, South India, fifty-one samples during post-monsoon and forty six samples during pre-monsoon season were collected (N. Janardhana Raju, unpublished thesis) from dug wells in the vicinity of heavily cultivated agricultural land, dug wells in densely populated area and some abandoned wells (Figure 1) and analysed for various parameters to assess water quality of the river basin. The upper Gunjaneru river basin is located north lat. 13°43′45″–14°1′44″ and east long. 79°15′16″–79°27′38″. The climate of the river basin is hot and semi-arid with a drainage area of 390 km^2. Here an attempt has been made to evaluate the correlation and regression among selected well water quality parameters of the upper Gunajaeru River basin.

The major soil type in the study area is red loamy soil, which is of high agricultural value. The Nagari quarzites overlie these granitic rocks in the hilly regions of the area. The central and northeastern portions of the area are occupied by Pullampet shales which trend N15°–20°W and dip at 12–16° due NE (Figure 2). The shales are composed of clay with calcareous and argillaceous cementing material. The study area is covered with recent alluvial deposits, above shale formations, having thickness of 5–20 m consisting of boulders, pebbles, cobbles, pebbles and gravel with little silt and clay.

Gibbs[6] proposed a diagram to understand the relationship of the chemical components of waters from their respective aquifer lithologies. Viswanathaiah *et al.*[7] studied the

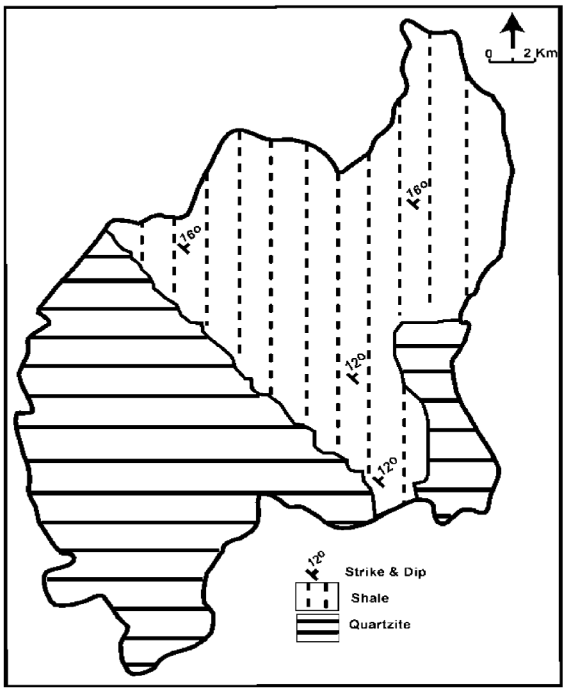

Figure 2. Geology of the Upper Gunjanaeru River basin.

mechanism of controlling the chemistry of groundwater of Karnataka. The Gibbs diagram has three distinct fields, namely precipitation dominance, evaporation dominance and rock dominance areas. The Gibbs ratio I – Cl/(Cl + HCO_3) for anion and ratio II – Na + K/(Na + K + Ca) for cation of water samples were plotted separately against the respective values of total dissolved solids. Ratios I and II range from 0.15 to 0.71 and 0.14 to 0.91 for post-monsoon, and from 0.14 to 0.61 and 0.18 to 0.82 for pre-monsoon season respectively. The chemistry of groundwater samples indicates that 80% in post-monsoon and 86% in pre-monsoon, as per the ratio I, are from rock dominance and rest of the 20 and 14% are of precipitation dominance (Figure 3). According to ratio II, 83% in post-monsoon and 85% in pre-monsoon groundwater samples indicates rock dominance and rest of 17 and 15% are of precipitation dominance (Figure 4). Rock dominance of most of the samples during both seasons in ratios I and II is caused by the interaction between the chemistry of aquifer rocks and groundwater.

Parametric statistical methods were used to calculate the normal statistical parameters (arithmetic mean and standard deviation) for water quality parameters. The degree of association or the strength of a linear relationship between two variables was evaluated[8] by calculating the coefficient of correlation, *r*. Nightingale and Bianchi[9] have studied the correlation of selected well-water quality parameters with soil and aquifer hydrologic properties in the Fresno-Clovis, California. Correlations among the selected water quality parameters indicate that a good correlation exists between the specific electrical conductance (SEC), HCO_3^- and Cl^- parameters for shale aquifers[10]. Sivasankaran *et al.*[11] have discussed the distribution of major ions and their variation with seasons, inter-elemental correlation and the mean dominant cations and anions of groundwater of Pondicherry region are in the order of $HCO_3 > Cl > SO_4$ and $Na > Ca > Mg > K$ (meq/l) respectively. Regression equations for total dissolved solids (TDS) as a function of SEC, and for TDS as a function of SEC and SiO_2 were determined for the upper Gunjaneru

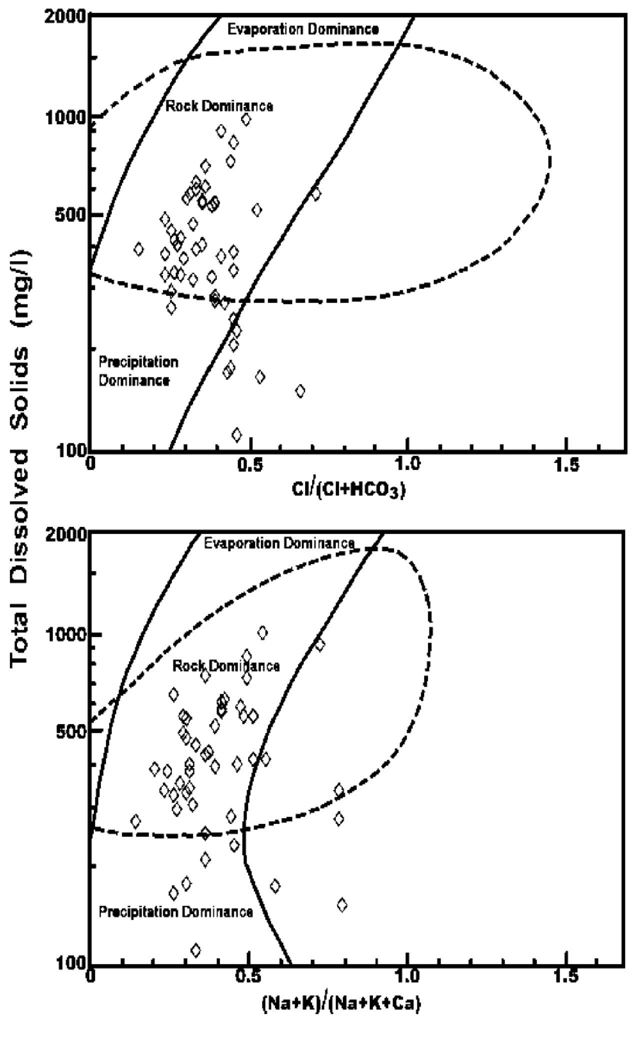

Figure 3. Mechanism controlling chemistry of groundwater during post-monsoon (after Gibbs[6]).

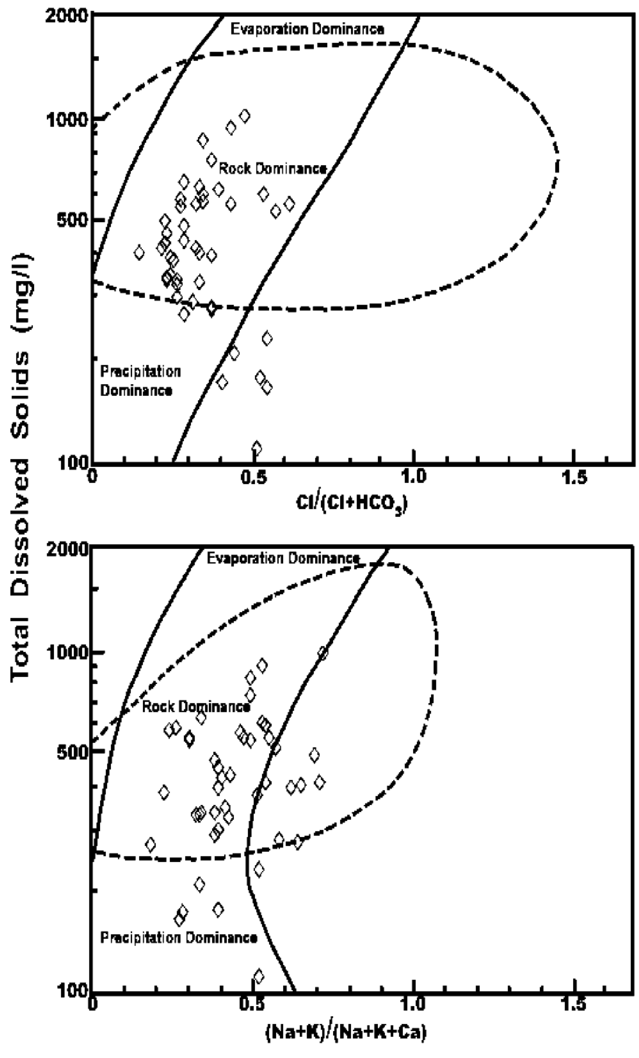

Figure 4. Mechanism controlling chemistry of groundwater during pre-monsoon (after Gibbs[6]).

Table 1. Range in concentration of groundwater chemical parameters of the study area and Indian Standards for drinking water

Parameter	Post-monsoon (N = 51) Range	Arithmetic mean	Standard deviation	Pre-monsoon (N = 46) Range	Arithmetic mean	Standard deviation	Indian Standard (IS 10500, 1991) Highest desirable	Maximum permissible
SEC	150–1850	751.63	391.79	140–1515	550.08	290.33	–	–
TDS	87–1126	441	228	95–1009	375	199	500	2000
Na^+	8–344	51.98	55.68	6–295	48.52	49.28	–	–
K^+	3–27	13.16	37.12	3–20	7.55	4.92	–	–
Ca^{2+}	8.4–130	63.73	28.67	8–95	47	17.81	75	200
Mg^{2+}	4.7–74	33.99	17.83	4–70	30.08	16.97	30	100
Cl^-	26–330	98.9	60.46	29–328	86.19	63.48	250	1000
SO_4^{2-}	5–130	40.73	28.15	2–75	12.56	14.29	200	400
HCO_3^-	52–730	294.76	146.49	42–670	271.89	122.53	–	–
Transformations								
$Na^+ + K^+$	11.1–348	65.15	70.24	10–299	56.07	49.22	–	–
$Ca^{2+} + Mg^{2+}$	10.6–191	97.73	42.26	16–159	77.08	32.37	–	–
$\frac{Ca^{2+} + Mg^{2+}}{Na^+ + K^+}$	0.22–4.72	2.22	1.31	0.28–4.52	1.86	1.02	–	–

SEC in μmho/cm and others in mg/l.

River basin[12]. When more than two variables were considered simultaneously, multiple linear regression analyses were used to evaluate their interdependency. The coefficient of determination (r^2 values or R^2 values for multiple regressions) is more readily interpretable than r as a measure of the degree of association, because r^2 or multiple R^2 is equal to the proportion of the total variability in the dependent variable that may be ascribed to the effect(s) of the independent or causative variable(s). Jayakumar and Siraz[13] examined the results of R-mode factor analysis performed on major ion data from a hydrogeochemical survey, during post- and pre-monsoon season, over the coastal Quaternary deltaic aquifer of the Cauvery basin, Tamil Nadu, India. Water quality assessment in Akpabuyo, southeastern Nigeria indicated that the waters are acidic and characterized by low sodium adsorption ratio. The waters are classified into four chemical facies[14], Ca–Cl, Na–Cl, Ca–SO_4 and Ca–HCO_3.

Correlation and multiple linear regression were used for relating the given well-water chemical quality parameters to a set of independent chemical variables. The application has been broadened to study the relationship between two or more hydrologic variables and also investigate the dependence between successive values of a series of hydrologic data. Fifty-one groundwater samples during post-monsoon and forty-six groundwater samples during pre-monsoon, mostly from shale aquifers were collected and analysed for various parameters to assess the quality of water using standard methods[15,16]. The water quality parameters considered for correlation and regression analysis are Na^+, K^+, Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^-, SO_4^{2-}. SEC (μmho/cm) was used to estimate total salinity. The analytical results have been evaluated to ascertain the suitability of groundwater for human consumption, by comparing with specifications set by the Indian Standards[17]. The range of the ionic content of different parameters during post- and pre-monsoon seasons and the standard of drinking water set given by IS are shown in Table 1.

The content of TDS ranges from 87 to 1126 mg/l during post-monsoon season and 95 to 1009 mg/l during pre-monsoon season. According to ISI specifications, TDS content during post- and pre-monsoon seasons is within the maximum permissible limit. Hence, a comparison of the water quality parameters with Indian Standards[17] indicated that the quality of groundwater in the study area is good for drinking purpose during both seasons. Due to the presence of thick alluvial deposits the permeability of the soil is more; hence the overall quality of groundwater in the study area is good. In the multiple regression analysis for post- and pre-monsoon seasons, the arithmetic mean (x), standard deviation (S) for the cations and anions along with three transformations are considered (Table 1). The mean concentration of $Ca^{2+} + Mg^{2+}$ is about one and half times that of $Na^+ + K^+$ during post-monsoon, whereas during pre-monsoon it is one and one-fourth times. For the major anions, the order of concentration was HCO_3^-, Cl^- and SO_4^{2-} for both seasons. The mean SEC of 751 μmho/cm is equivalent to TDS of about 436 mg/l during post-monsoon, but during pre-monsoon the mean SEC of 550 μmho/cm is equivalent to TDS of about 357 mg/l.

The degree of linear association between any two of the water quality parameters, as measured by the simple correlation coefficient (r) is presented as a correlation matrix for both post- and pre-monsoon seasons. The correlation between SEC and other parameters except potassium (K^+) is significantly positive, whereas $Ca^{2+} + Mg^{2+}/Na^+ + K^+$ is significantly negative for both post-monsoon and pre-monsoon seasons. The r value between SEC and Cl^- was 0.906 (Table 2) and the coefficient of determination ($r^2 = 0.821$) indicated that 82.1% of the variability in

Table 2. Correlation matrix for water quality parameters of post-monsoon season ($N = 51$)

Parameter	Correlation coefficient, r									
	SEC	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	HCO_3^-	$Na^+ + K^+$	$Ca^{2+} + Mg^{2+}$
Na^+	0.816									
K^+	0.282	0.212								
Ca^{2+}	0.680	0.219	0.212							
Mg^{2+}	0.799	0.449	0.312	0.632						
Cl^-	0.906	0.734	0.316	0.658	0.661					
SO_4^{2-}	0.796	0.701	0.185	0.471	0.689	0.697				
HCO_3^-	0.905	0.727	0.191	0.650	0.829	0.681	0.685			
$Na^+ + K^+$	0.796	0.851	0.616	0.286	0.521	0.749	0.653	0.677		
$Ca^{2+} + Mg^{2+}$	0.798	0.338	0.275	0.945	0.851	0.725	0.610	0.791	0.414	
$\frac{Ca^{2+} + Mg^{2+}}{Na^+ + K^+}$	–0.323	–0.503	–0.211	0.199	–0.008	–0.377	–0.228	–0.125	–0.511	0.978

Table 3. Correlation matrix for water quality parameters during pre-monsoon season ($N = 46$)

Parameter	Correlation coefficient, r									
	SEC	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	HCO_3^-	$Na^+ + K^+$	$Ca^{2+} + Mg^{2+}$
Na^+	0.868									
K^+	0.045	0.063								
Ca^{2+}	0.712	0.351	–0.004							
Mg^{2+}	0.781	0.413	0.115	0.732						
Cl^-	0.879	0.686	0.057	0.655	0.776					
SO_4^{2-}	0.731	0.706	0.065	0.448	0.443	0.539				
HCO_3^-	0.891	0.785	0.014	0.676	0.707	0.594	0.633			
$Na^+ + K^+$	0.873	0.995	0.037	0.351	0.425	0.693	0.714	0.787		
$Ca^{2+}+Mg^{2+}$	0.801	0.410	0.058	0.934	0.927	0.767	0.479	0.742	0.416	
$\frac{Ca^{2+}+Mg^{2+}}{Na^++K^+}$	–0.298	–0.533	–0.272	0.173	0.022	–0.218	–0.215	–0.258	–0.551	0.106

SEC could be ascribed to the variable Cl^- concentration in the water. Similarly, 81.9 and 66.5% of the variability in SEC could be due to the variables HCO_3^- and Na^+ respectively, during post-monsoon season.

During pre-monsoon season, the r value between SEC and HCO_3^- was 0.891 (Table 3) and the coefficient of determination ($r^2 = 0.794$) indicated that 79.4% of the variability in SEC could be ascribed to the variable (HCO_3^-) concentration in the water. Similarly, 77.2, 76.2, 75.3 and 64.1% of the variability in SEC could be due to the variables Cl^-, $Na^+ + K^+$, Na^+ and $Ca^{2+} + Mg^{2+}$ respectively, during pre-monsoon season.

Multiple linear regression was used to develop models relating a given well-water chemical quality parameter to a set of independent chemical variables. The most significant multiple linear regression models for predicting SEC, Ca^{2+}+ Mg^{2+}, $Na^+ + K^+$, HCO_3^-, Cl^- and SO_4^{2-} from various combinations of known concentrations of other chemical constituents in the water are shown in Tables 4 and 5 for post- and pre-monsoon season respectively.

In predicting SEC for the post-monsoon season, the independent variables, viz. HCO_3^-, SO_4^{2-} and Cl^-, in the model had a significant effect (from 't' test for the partial regression coefficient at 5% level of probability). The multiple R^2 value (0.982) indicated that 98.2% of the variability in the observed SEC could be ascribed to the combined effect of Na^+, $Ca^{2+} + Mg^{2+}$, HCO_3^-, SO_4^{2-} and Cl^-. Whereas in predicting SEC for pre-monsoon season the independent variables, viz. SO_4^{2-}, Cl^- in the model had a significant effect. The multiple R^2 value (0.997) indicated that 99.7% of the variability in the observed SEC could be ascribed to the combined effect of Na^+, Ca^{2+} + Mg^{2+}, HCO_3^-, SO_4^{2-} and Cl^-.

Of the 98.2% variability in SEC due to the combined effect of Na^+, $Ca^{2+} + Mg^{2+}$, HCO_3^-, SO_4^{2-} and Cl^-; 44.8% is due to HCO_3^-, 44.4% is due to Cl^-, 9% is due to SO_4^{2-} and 2% each is due to Na^+ and $Ca^{2+} + Mg^{2+}$ for post-monsoon season. This shows that HCO_3^-, Cl^- and SO_4^{2-} are the most significant independent chemical variables in predicting SEC (Table 6). The other two variables are insignificant for post-monsoon. Similarly, 96.1% of the variability in observed HCO_3^- could be ascribed to the combined effect of Na^+, Mg^{2+}, SO_4^{2-}, Cl^-, $Ca^{2+} + Mg^{2+}/Na^+ + K^+$ and SEC, whereas in the case of Cl^-, 92.9% of the variability could be ascribed to the combined effect of K^+, $Ca^{2+} + Mg^{2+}/Na^+ + K^+$, HCO_3^- and SEC. All the variables included in the model for predicting HCO_3^- are significant, whereas $Ca^{2+} + Mg^{2+}/Na^+ + K^+$, HCO_3^- and SEC had significant effect in predicting Cl^- for post-monsoon season.

Of the 99.7% variability in SEC for pre-monsoon due to the combined effect of Na^+, $Ca^{2+} + Mg^{2+}$, HCO_3^-, SO_4^{2-} and Cl^-, 38.8% is due to Cl^-, 36.9% is due to HCO_3^-, 12%

Table 4. Multiple linear regression model for selected water quality parameters using chemical data as independent variables for post-monsoon season ($N = 51$)

Water quality dependent variable (multiple R^2 value)	Constant model	Significant (5% level) regression coefficient for independent variables (standard error of regression coefficient)					Standard error for regression model (**AOV, F-statistics)
SEC = (0.982)	–2.39	+0.18 Na	–0.25 Ca + Mg	+1.32 HCO_3	+1.57 SO_4	+3.17 Cl	54.90
		(1.06)	(1.47)	(0.38)*	(0.59)*	(0.73)*	(500.25)
Ca + Mg = (0.711)	25.37	+0.08 K	+0.13 SO_4	+0.55 Cl	+0.29 HCO_3	–0.10 SEC	23.96
		(0.09)	(0.21)	(0.22)*	(0.09)*	(0.06)	(22.11)
Na + K = (0.770)	–7.81	–0.28 Mg	–1.07 Ca + Mg	–0.02 HCO_3	+0.23 SEC		35.11
		(0.61)	(0.24)*	(0.08)	(0.03)*		(38.53)
HCO_3 = (0.961)	–6.14	–0.61 Na	+2.11 Mg	–1.14 SO_4	–1.57 Cl	+13.81 (Ca + Mg)/(Na + K)	30.88
		(0.18)*	(0.55)*	(0.27)*	(0.18)*	(4.13)*	(180.18)
Cl = (0.929)	–0.79	+0.03 K	+2.75 (Ca + Mg)/(Na + K)	–0.33 HCO_3	+0.25 SEC		16.72
		(0.06)	(2.11)	(0.04)*	(0.02)*		(152.06)
SO_4 = (0.663)	–5.72	+0.13 Na	+3.50 (Ca + Mg)/(Na + K)	–0.06 HCO_3	+0.06 SEC		17.03
		(0.08)	(2.44)	(0.04)*	(0.02)		(22.63)

SEC in µmho/cm, others in mg/l; **AOV, Analysis of variance for regression equation.
*Partial regression coefficients significant at 0.05 probability level.

Table 5. Multiple linear regression model for selected water quality parameters using chemical data as independent variables for pre-monsoon season ($N = 46$)

Water quality dependent variable (multiple R^2 value)	Constant model	Significant (5% level) regression coefficient for independent variables (standard error of regression coefficient)					Standard error for regression model (**AOV, F-statistics)
SEC = (0.997)	9.95	+0.85 Na	+0.38 Ca + Mg	+0.98 HCO_3	+2.16 SO_4	+2.02 Cl	14.86
		(0.38)*	(0.57)	(0.14)*	(0.28)*	(0.23)*	(3424.75)
Ca + Mg = (0.862)	14.59	+0.19 K	+1.33 SO_4	+1.59 Cl	+0.81 HCO_3	–0.57 SEC	12.74
		(0.38)	(0.32)*	(0.21)*	(0.11)*	(0.09)*	(50.02)
Na + K = (0.994)	1.85	–0.37 Mg	–1.06 Ca + Mg	–0.10 SO_4	+0.05 HCO_3	+0.24 SEC	3.80
		(0.09)*	(0.05)*	(0.06)	(0.01)*	(0.01)*	(1497.69)
HCO_3 = (0.991)	4.12	–0.03 Na	+1.24 Mg	–1.85 SO_4	–1.94 Cl	+0.78 (Ca + Mg)/(Na + K)	11.83
		(0.15)*	(0.32)*	(0.19)*	(0.06)*	(2.21)	(798.24)
Cl = (0.951)	1.73	+0.11 K	+3.68 (Ca + Mg)/(Na+K)	–0.47 HCO_3	+0.37 SEC		14.65
		(0.46)	(2.32)	(0.04)*	(0.02)*		(200.94)
SO_4 = (0.568)	–6.67	+0.12 Na	+1.83 (Ca + Mg)/(Na + K)	-0.01 HCO_3	+0.02 SEC		9.83
		(0.07)	(1.81)	(0.02)	(0.01)		(22.63)

SEC in µmho/cm, others in mg/l; **AOV, Analysis of variance for regression equation.
*Partial regression coefficients significant at 0.05 probability level.

is due to Na^+, 7% is due to SO_4^{2-} and 3% is due to $Ca^{2+} + Mg^{2+}$. This shows that Cl^-, HCO_3^-, Na^+ and SO_4^{2-} are the most significant independent chemical variables in predicting SEC for pre-monsoon season (Table 7). The other variable is insignificant. Similarly, during pre-monsoon for HCO_3^-, 99.5% of variability could be ascribed to the combined effect of Na^+, Mg^{2+}, SO_4^{2-}, Cl^-, SEC and $Ca^{2+} + Mg^{2+}/Na^+ + K^+$, whereas in $Na^+ + K^+$, 99.3% of the variability could be ascribed to the combined effect of Mg^{2+}, HCO_3^-, SO_4^{2-}, SEC and $Ca^{2+} + Mg^{2+}$. In the case of Cl^-, 95.1% of the variability could be ascribed to the combined effect of K^+, HCO_3^-, SEC and $Ca^{2+} + Mg^{2+}/Na^+ + K^+$. All the variables except $Ca^{2+} + Mg^{2+}$ and Na^+ included in the model for predicting HCO_3^- are significant, whereas HCO_3^-, SEC and $Ca^{2+} + Mg^{2+}$ had significant effect in predicting $Na^+ + K^+$; HCO_3^- and SEC had significant effect in predicting Cl^- for pre-monsoon season.

The well-water quality parameters of upper Gunjanaeru River basin indicated that inorganic chemical quality of water is excellent. The correlation between SEC and other parameters except potassium (K^+) is significantly positive for both seasons. The multiple R^2 values 0.982 and 0.997 indicate that 98.2 and 99.7% of variability in the observed SEC could be ascribed to the combined effect of Na^+, $Ca^{2+} + Mg^{2+}$, HCO_3^-, SO_4^{2-} and Cl^- for post- and pre-monsoon respectively. Out of the 98.2% variability in SEC due to the combined effect of Na^+, $Ca^{2+} + Mg^{2+}$, HCO_3^-, SO_4^{2-} and Cl^- for post-monsoon and 99.7% variability in SEC is due to the combined effect of Na^+, $Ca^{2+} + Mg^{2+}$, HCO_3^-, SO_4^{2-} and Cl^- for pre-monsoon season. All the variables included in the regression model for predicting HCO_3^- are significant in both the seasons. $Ca^{2+} + Mg^{2+}/Na^+ + K^+$, HCO_3^- and SEC had significant effect in predicting Cl^- for post-monsoon season, and HCO_3^- and SEC had

Table 6. Individual contributions of various independent chemical variables in prediction of chemical quality parameters during post-monsoon ($N = 51$)

Dependent variable	Independent variable									
	Na	K	Mg	HCO_3	SO_4	Cl	SEC	Ca + Mg	$\frac{Ca + Mg}{Na + K}$	Total variability (R^2)
SEC	0.02112	–	–	0.44828	0.09009	0.44430	–	–0.02149	–	0.9823
HCO_3	0.16892	–	0.21258	–	–0.14941	–0.44173	1.18678	–	–0.01541	0.9609
Cl	–	0.00537	–	1.49873	–	–	–0.02241	–	–0.55222	0.9297
SO_4	0.18116	–	–	–0.22315	–	–	0.74214	–	–0.03710	0.6631
Ca + Mg	–	0.02144	–	0.81049	0.05455	0.57342	–0.74893	–	–	0.7107
Na + K	–	–	0.03715	–0.02371	–	–	1.02448	–0.26783	–	0.7701

Table 7. Individual contributions of various independent chemical variables in prediction of chemical quality parameters during pre-monsoon ($N = 46$)

Dependent variable	Independent variable									
	Na	K	Mg	HCO_3	SO_4	Cl	SEC	Ca + Mg	$\frac{Ca + Mg}{Na + K}$	Total variability (R^2)
SEC	0.1266	–	–	0.3692	0.0780	0.3889	–	0.0344	–	0.9971
HCO_3	–0.0111	–	0.1217	–	–0.1371	–0.5999	1.6196	–0.0016	–	0.9951
Cl	–	0.0005	–	–0.5490	–	–	1.5124	–	–0.0129	0.9510
SO_4	0.3076	–	–	–0.0768	–	–	0.3656	–	–0.0281	0.5683
Ca + Mg	–	0.0017	–	2.2821	0.2828	2.3929	–4.0989	–	–	0.8606
Na + K	–	–	–0.0553	0.1128	–0.0215	–	1.2499	-0.2921	–	0.9938

significant effect in predicting Cl^- for pre-monsoon season. From the regression analysis, it is concluded that a good correlation (shale aquifers) exists between SEC, HCO_3^- and Cl^- either individually or in combination with other ions for the upper Gunjanaeru River basin.

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