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Seasonal Analysis Of Physico-Chemical Parameters Of Ground Water Samples From Rural Areas Of Karkala Taluk, Karnataka State, India

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ABSTRACT

Ground water, especially bore well samples of three seasons from the parts of the western ghats rural areas of karkala taluk, karnataka state, were subjected to physico-chemical analysis and the EC, SAR and RSC values were calculated to decide the suitability of these water sources for irrigation purposes. The results showed that majority of these samples were 'good' and a few samples showed higher RSC values indicating the presence of excess amount of bicarbonate ions. Caution has to be practiced while using the waters with high bicarbonate content.

KEYWORDS

Karkala taluk;
Karnataka State;
Physico-chemical parameters;
RSC;
Salinity hazard;
SAR;
Seasonal analysis;
Ground water.

INTRODUCTION

Water is an essential component for the living beings. The health of an individual depends upon the use of wholesome water. Water is not a vital environmental factor to all the forms of life but it has also a great role to play in social and economic development of human population. Subsurface water is an important source of water supply throughout the world. The usage of ground water has been continuously increasing with time for irrigation, industrial activities and for domestic activities. The demand of ground water for various activities has lead to continuous degradation of ground water quantity and quality. Since then water pollution has become a serious problem as almost seventy per cent of India's surface water resources and a growing number of its ground water resources have been con-

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taminated by biological, organic and inorganic pollutants[10]

Water is the most important input required for plant growth in agriculture production. Bulk weight of all living organisms consists of 80 to 90% water. Water need for plant growth is met out of soil water storage in plant root zone. Under rain fed conditions, soil water storage is continuously replenished with natural rainfall; however, irrigation is essential in arid and semi arid climates to maintain soil water storage at an optimum level to get higher yield[7]. Agriculture is now considered to be the largest consumer of water, accounting for some 80 per cent of total water use. At present, about 15 percent of all cultivated lands are being irrigated.

All water sources used in irrigation contain impurities and dissolved salts irrespective of whether they are surface or underground water. However, quality of water has meaning only with respect to its particular use. Water, which can be considered good quality for household use, may not be ideal for irrigation. In agriculture, water quality is related to its effects on soils, crops and management necessary to compensate problems linked to water quality[7].

Even today the economy of rural areas of karkala taluk, Southwestern karnataka depends on agriculture. Assessment of quality of water throughout the year for better management of crop production is essential to improve the economy of the people. Based on water management options the farmers can opt for growth of crops other than rice, areca nut and coconut, which is presently cultivated on a large scale. With this in view, the study was undertaken to study the ground water quality especially that of bore wells which is one of the sources of water for irrigation in rural areas of karkala taluk.

MATERIALS AND METHODS

Study area

Karkala taluk is situated between $74^0 50'$E to $75^0 08'$E longitude and $13^0 07'$N to $13^0 33'$N latitude and covers an area of 1091km^2. Kundapura and udupi taluks on the north and western side, mangalore taluk on the southwest, belthangady taluk on the southeastern side, theerthahalli and shringeri taluks along the eastern side border the taluk(Figure 1). As per the 2001 Census of India, the taluk has a total population of 2,05,598 with male population of 96,755 and female population of 1,08,843 spread over 50 villages.

A part of the western ghats traverses along the eastern border of the taluk, which has local and limited ground water in compact formations with less inter-granular porosity and fractures. The aquifer yield is less than one liter per second. In the charnockites, gneiss and unclassified crystalline of Archaean age which is present in the taluk, groundwater is restricted to 60m depth in weathered residue and fractured zones down to 300m in disturbed area. The aquifers have secondary porosity with yield ranging from one liter to five liters per second to five to ten liters per second.

Sampling

One bore well sample each from fifteen villages of karkala taluk(Figure 2) was collected using the standard method available[1] during: (i) November-December, (ii) April-may, (iii) July-august, representing winter, summer and rainy seasons respectively in the study area.

The samples have been tested for pH, electrical conductivity(EC), total dissolved solids(TDS), total

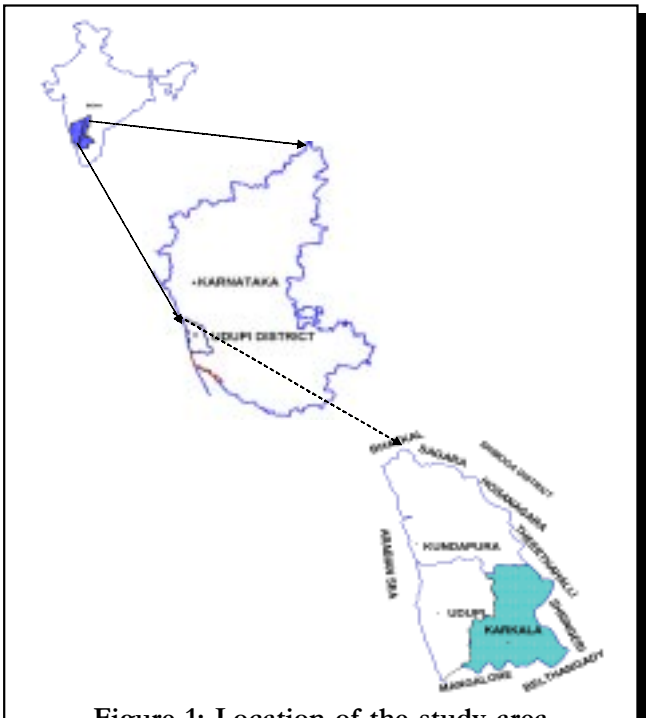

Figure 1: Location of the study area.

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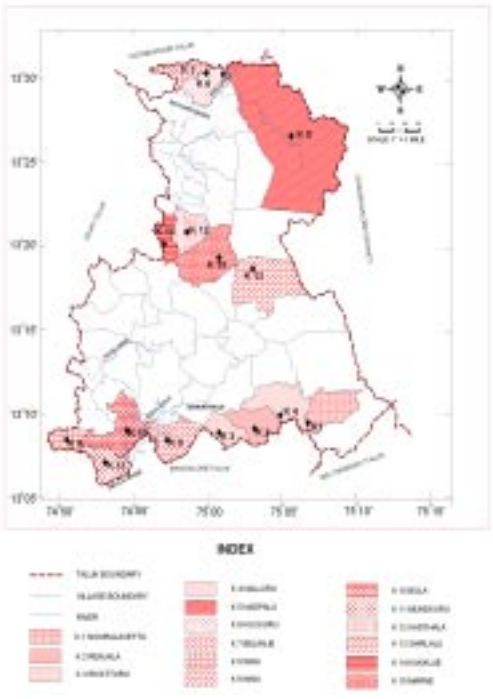

Figure 2: Sampling locations within the study area

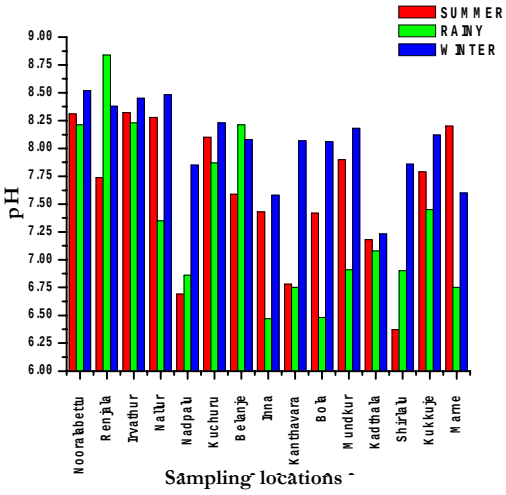

Figure 3: Seasonal variation of pH in the bore well waters in the sampling locations.

hardness(TH), acidity, sodium(Na), potassium(K), calcium(Ca), magnesium(Mg), carbonate(CO_3), bicarbonate(HCO_3), chloride(Cl), sulphate(SO_4)[1] and nitrate (NO_3)[8].

Criteria of suitability of water for irrigation

The results obtained from the analyses were used to compute sodium adsorption ratio and residual sodium carbonate(RSC) for each season. The salinity hazard(C) was calculated based on EC value at 25^{0}C expressed as μmohs/cm.

Sodium hazard is expressed as sodium adsorption ratio(SAR). The SAR is calculated from the ratio of sodium to calcium and magnesium.

$$SAR=\frac{Na^+}{\sqrt{Ca^{2+}+Mg^{2+}/2}}$$

The effect of bicarbonate together with carbonate is evaluated through an index called 'residual sodium carbonate'(RSC) The RSC is an indication of the excess amount of anions namely carbonate and bicarbonate over cations namely calcium and magnesium[2] that is calculated using the formula $RSC=(HCO^-_3 + CO^{--}_3)-(Ca^{2+} + Mg^{2+})$.

RESULTS AND DISCUSSION

pH

pH of bore well water ranges between 6.37 and 8.84, and it is generally alkaline in nature due to the dissolved carbonate and bicarbonates. In the present study the pH of the water varies seasonally(Figure 3). In most of the cases, during rainy season the pH of the water reduces from alkaline to neutral condition due to dilution by rainwater infiltration. In a few cases the pH of the water has increased due to the dissolution of carbonate and bicarbonate present in the soil and bedrock. pH values of all the samples except one remain within the tolerance limit prescribed by the pollution control board of India[1,6] given in TABLE 1.

TDS

The natural water never occurs in the form of 'pure water' but always have a variable quantity of dissolved inorganic salts. The commonly occurring natural salts are comprised mostly of cation like sodium, potassium, calcium and magnesium associated with anions like chloride, sulphate, bicarbonate and carbonates. The composition of solids present in a natural body of water mainly depends upon the nature of bedrocks and the soil developed from it. The physico-chemical factor, which governs the chemistry of the salt in water, may also influence the salt composition.

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TABLE 1: Water quality for irrigation

Sl. No	Characteristic	Tolerance limit[6]	Usual range in irrigation water[1]
1	pH value	6.0-8.5	6.0- 8.5
2	EC at 25^{0}C, max	2250×10^{-6} mhos	0-3 dS/ m
3	Sodium adsorption ratio, max	26	0-15
4	Total dissolved solids, (mg/L), max	2100	0-2000
5.	Chloride(mg/L)	600	0-106.38
6.	Carbonate(mg/L)	-	0-3.0
7	Bicarbonate(mg/L)	-	0-620
8	Sulphates(asSO_4),(mg/L), max	1000	0-960.6
9	Nitrate-nitrogen(mg/L)	-	0-10
10	Sodium(mg/L)	-	0-920
11	Calcium(mg/L)	-	0-40
12.	Magnesium(mg/L)	-	0-60
13.	Potassium(mg/L)	-	0-2

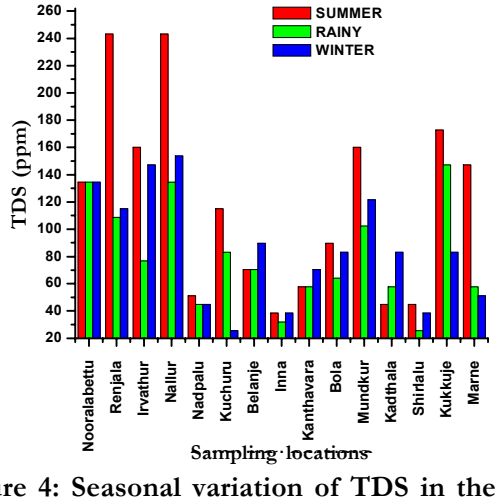

Figure 4: Seasonal variation of TDS in the bore well waters in the sampling locations.

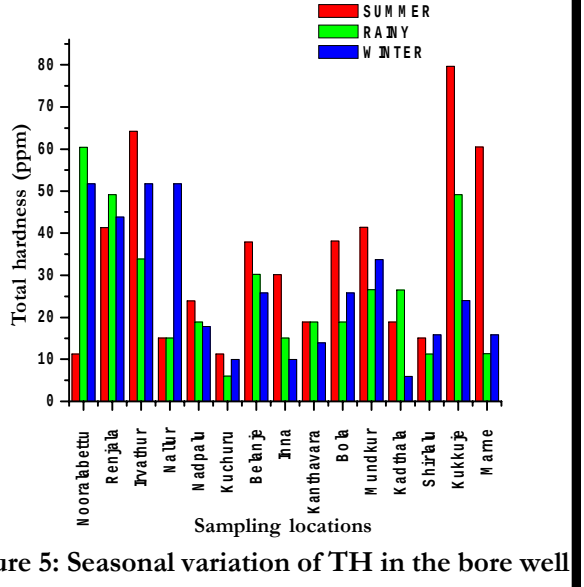

Figure 5: Seasonal variation of TH in the bore well waters in the sampling locations.

In the present study, TDS values of the samples range between 25.6ppm and 243.2ppm. TDS depend on the value of EC or vice versa. The change in TDS due to different seasons is depicted in figure 4. According to the TABLE 1, no samples show values above tolerance limit during any of the seasons.

TH

The ions, especially Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, CO_3^{2-}, HCO_3^- impart hardness to water. The salts of bicarbonate and carbonate produce temporary hardness since they can be precipitated simply by boiling, in contrast to the salts with chlorides and sulphates, which produce permanent hardness. Hardness is usually expressed in terms of the equivalent quantity of $CaCO_3$. The salt content of the bodies of water often increases by the developmental activities in the catchments' area. The drainage of irrigation water also leaches out significant quantities of salts from the soil that finally contaminate the groundwater and other surface water bodies.

TH values range from 4.00ppm to 37.86ppm. Temperature plays an important role in dissolution of salts and minerals in water. Hence in summer time the total hardness is more. In some cases, higher values are recorded during rainy season(Figure 5) due to the leaching out of carbonates and bicarbonates present in the soil profile due to the rainwater infiltration

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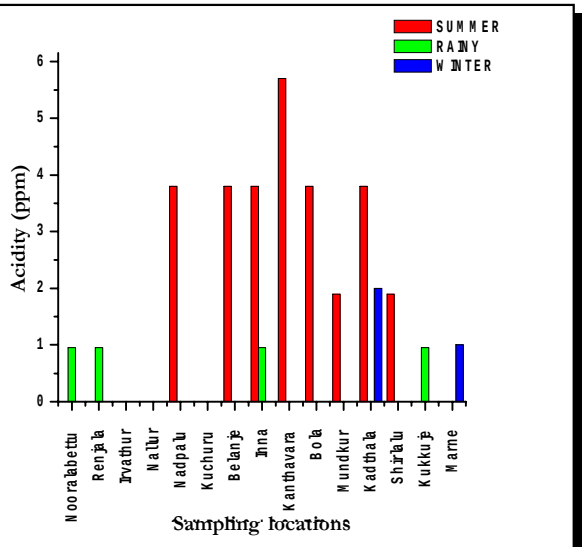

Figure 6: Seasonal variation of acidity in the bore well waters in the sampling locations.

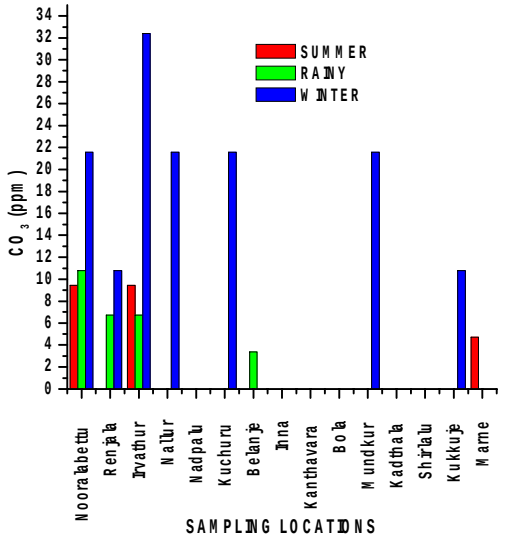

Figure 7: Seasonal variation of acidity in the bore well waters in the sampling locations.

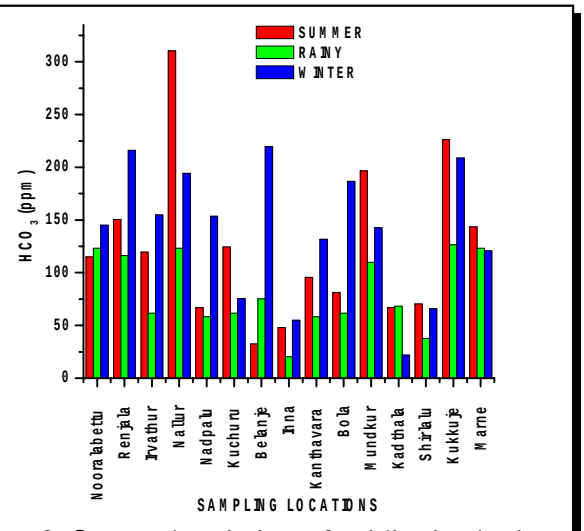

Figure 8: Seasonal variation of acidity in the bore well waters in the sampling locations.

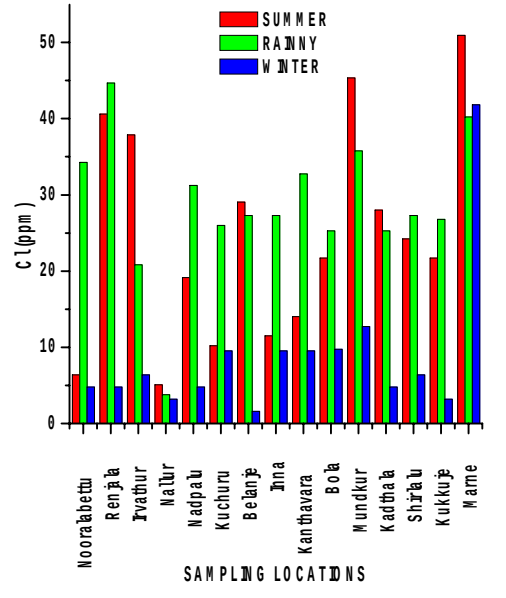

Figure 9: Seasonal variation of Cl in the bore well waters in the sampling locations.

Acidity

Acidity in the natural water is caused by free carbon dioxide or by mineral acids. The carbon dioxide can remain present in waters at pH range between 4.5 and 8.5 with the values usually declining at higher pH due to conversion of some carbon dioxide into bicarbonate and carbonate. The acidity, which may be considered of great significance as regard to pollution, is mineral acidity caused by the presence of mineral acids. These acids can decrease pH to much lower levels than can be achieved by carbon dioxide, i.e., below 4.5.

Acidity of bore well water ranges from 0.00ppm to 5.00ppm. Acidity of water causes dissolution of salts from the surrounding bedrocks and percolating layers. During summer season, the acidity of ground water is more(Figure 6) which also leads to an increase in EC and TDS.

Alkalinity

Alkalinity of water is a measure of its capacity to neutralize acids. The salts of weak acids usually impart the natural alkalinity of water. Among these bicarbonate is a dominant chemical species along

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with minor quantities of carbonates, borates, silicates, phosphates and the salts of humic and fulvic acids. Organically polluted water may have alkalinity derived from the salts of organic weak acids like acetic acids, propionic acids and hydrosulphuric acid. Ammonia and hydroxides are also important sources of alkalinity in certain conditions.

The CO_3 and HCO_3 content of the bore well samples range from 0ppm to 34ppm and 0ppm to 350ppm respectively(Figures 7 and 8).

Bicarbonate occurs in low salinity waters and its concentration decreases with increase in electrical conductivity. The proportion of bicarbonate ions higher than calcium has been considered to be undesirable because after evaporation of irrigation water, bicarbonate ions tend to precipitate calcium ions.

Chloride

Chloride is an anion found in variable amount in natural water and waste water. The chloride content normally increases as the mineral content in the water increases. The origin of chloride in ground water is from various sources such as weathering and leaching of sedimentary rock and soils, infiltration of seawater, windblown sea salt in precipitation, domestic and industrial waste discharge, municipal effluents, etc. Excessive chloride in potable water is not particularly harmful and the criteria set for this anion is also based primarily on palatability and its potentially high corrosiveness. The concentrations of chloride in natural water generally bear a strong correlation with the sodium content and specific conductance. The determination of chloride in water serves to indicate the intrusion of water of different composition or to trace and measure rates and volume of water mass movements. From an environmental standpoint chloride is basically a conservative parameter and occurring in natural fresh water from primary sources[3].

In the present study the chloride content ranges from 1.39ppm to 50.88ppm(Figure 9), which is well within the maximum tolerance limit prescribed, and the usual range found in water(TABLE 1). The most common toxicity is due to excess chloride in the irrigation water. Chloride moves with soil water readily since it is not adsorbed by soil. Excessive necrosis is often accompanied by early leaf drop or defoliation.

NO_3

Excessive use of nitrogen based or nitrogen rich fertilizers may cause nitrogen enrichment in groundwater. This might lead to a similar effect as that of soil leading to over-stimulation of growth, delayed maturity or poor quality[1].

The nitrate-nitrogen in the bore well samples during different seasons range between 0-4.18ppm(Figure 10). The concentration of nitrate

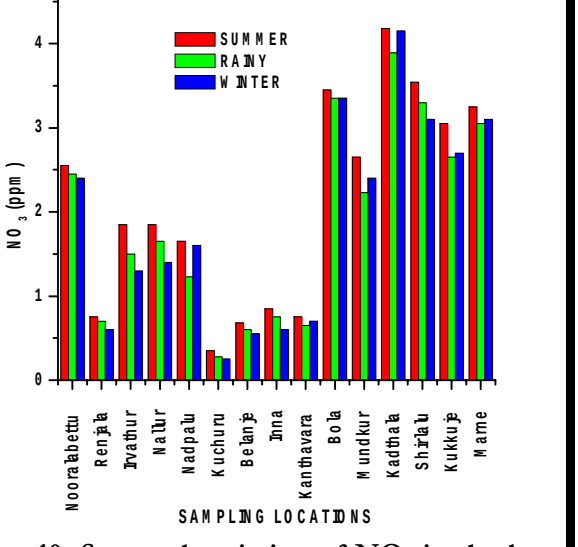

Figure 10: Seasonal variation of NO_3 in the bore well waters in the sampling locations.

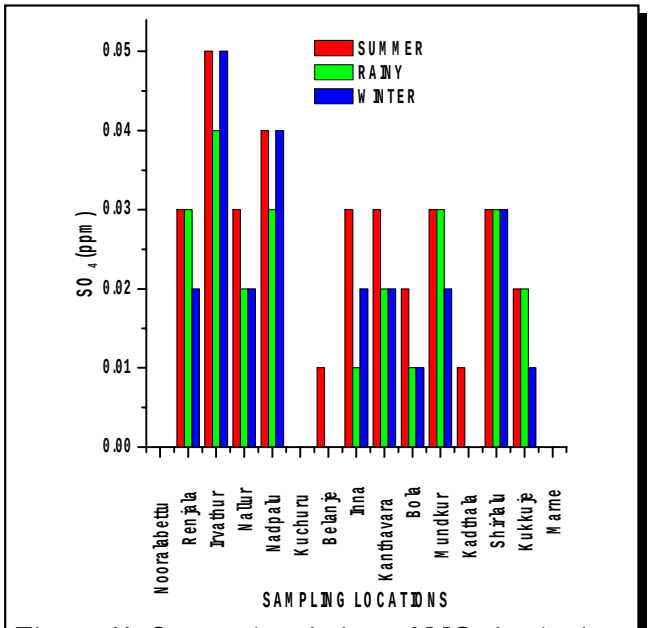

Figure 11: Seasonal variation of NO_3 in the bore well waters in the sampling locations.

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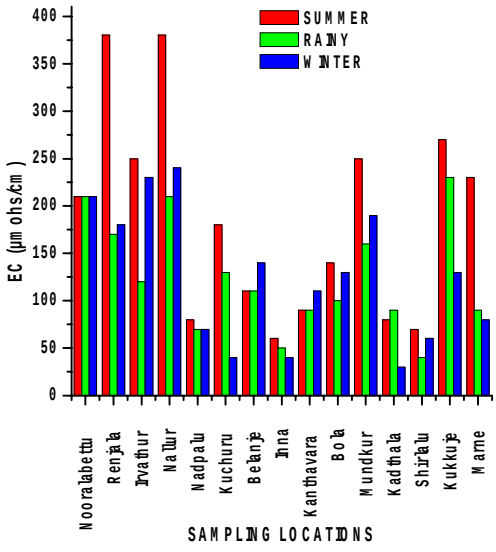

Figure 12: Seasonal variation of EC in the bore well waters in the sampling locations.

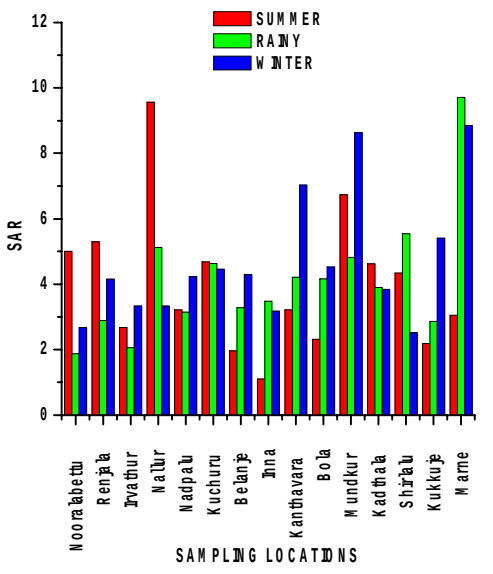

Figure 13: Seasonal variation of SAR in the bore well waters in the sampling locations.

TABLE 2: Classification of irrigation waters based on EC values

Class	EC value (µmohs/cm)	Suitability
C_1	≤250	Excellent
C_2	250-750	Good
C_3	750-2000	Permissible (Leaching is required if used)
C_4	2000-3000	Doubtful (Good drainage needed if used)
C_5	>3000	Unsuitable (Good drainage needed if used)

nitrogen in both surface and ground water is usually less than 5mg/L.

SO_4

Sulphate is one of the major anions occurring in natural waters. Sulphate, being a stable, highly oxidized and soluble form of sulphur, is the form in which the element is generally present in natural surface water and ground water. Sulphate may enter natural water bodies through weathering of sulphide bearing or by direct dissolution of evaporation deposits. It may be leached from sedimentary rocks and particularly from sulphate deposits such as gypsum and anhydride. Another significant source of sulphate in natural water system is air borne industrial pollutants containing oxides of sulphur, which converts to sulphuric acid in precipitation. Sulphate can also be produced by bacterial or oxidizing action as in the oxidation of organo-sulphur compounds in water are generally bound to alkali and alkaline earth metals and are readily soluble[3].

The SO_4 values range between 0 ppm and 0.05 ppm. Figure 11 depicts the sulphate content of bore well water during different seasons.

Salinity hazard

An electrical conductivity(EC) of up to 700µmohs/cm has no effects; whereas, an EC of 700µmohs/cm to 3000µmohs/cm has slight to moderate effect. EC values of more than 3000µmohs/cm will severely affect the crop water availability[1]. TABLE 2 gives the classification of irrigation waters based on EC values.

In the present study, the EC values range between 30µmohs/cm and 380µmohs/cm. In general the EC of ground water is more when compared to the surface water; due to the dissolved salts and some rock forming mineral particles in the water. The reduction in EC was observed during the rainy season, which is due to the interference of rainwater with ground water through infiltration.

By comparing the seasonal EC values with TABLE 2, it can be concluded that though there are changes in EC of the bore well water in the study area during different seasons(Figure 12), it does not make any difference to the irrigation activities since

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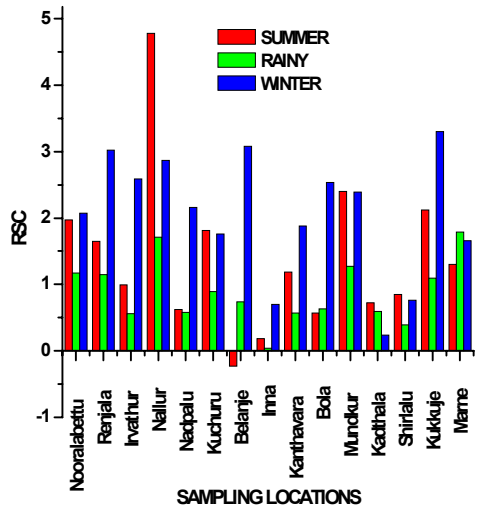

Figure 14: Seasonal variation of RSC in the bore well waters in the sampling locations.

TABLE 3: Sodium hazard classification of irrigation water

Class	SAR value	Hazard
S_1	1-10	low
S_2	10-18	medium
S_3	18-26	high
S_4	>26	very high

the EC of the bore well waters remain excellent to good throughout the year.

SAR

The sodium adsorption ratio of water samples from different sampling locations in different seasons has been represented in figure 13 Though there is a seasonal variation in sodium, potassium, calcium and magnesium concentrations(Na:13.90ppm-115.20 ppm;K:0.30ppm-22.30ppm;Ca:0.80ppm-15.20ppm; Mg:0.91ppm-18.24ppm) it makes no difference to the suitability of bore well waters for irrigation purpose as all the water samples fall within low sodium hazard category according to SAR classification given in TABLE 3.

RSC

RSC value less than 1.25 indicates low hazard, whereas a value of 1.25-2.5 indicates medium hazard and more than 2.5 indicates high hazard to crop growth, according to[9].

The residual sodium carbonate values for different seasons have been depicted in figure 14. On an average around 40%(6) samples are safe, 53%(8) are of average quality and 7%(1) of bore well waters are unsuitable for irrigation due to the dissolved carbonate and bicarbonate contents.

CONCLUSIONS

The bore well waters show significant variation in the parameters like pH, TDS, TH, acidity, alkalinity, Cl, NO_3, SO_4, EC, SAR, and RSC when analyzed seasonally. In most of the samples the values of these parameters drop down during the rainy season which is due to the dilution caused by the rain water through percolation, but in a few cases, there is an increase in these parameters which is due to the leaching of the salts and minerals from the bedding rocks and dissolution of salts, minerals and organics present in the soil. But in majority of the samples these changes are not detrimental to the suitability of water for irrigation. In areas, where higher bicarbonate content and a corresponding higher RSC have been reported, due care should be taken in order to reduce the content of these anions either by dilution or mixing with other water sources with lesser bicarbonate content preferably surface waters.

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