Assesment of borewell irrigation water quality in HiriyurtalukChitradurga district, Karnataka, India

Abstract

In the quest for understanding the suitability of borewell groundwater for irrigation purposes in HiriyurTaluk, Chitradurga District, we embarked on a comprehensive assessment of key physico-chemical parameters. Our study involved the collection and analysis of thirty water samples, drawn from both banana leaf margin-affected and their healthier counterparts within the taluk. These samples were meticulously scrutinized for pH levels, electrical conductivity (EC), calcium, magnesium, sulphate, nitrate,Exchangable sodium percentage (ESP), chloride, residual sodium carbonate (RSC) and sodium adsorption ratio (SAR), all vital components in the evaluation of irrigation water quality. The findings from this study not only underscore the importance of assessing and understanding these parameters but also advocate for proactive measures in promoting the development of borewell groundwater for sustainable and productive irrigation practices within the region.

Key Words: Irrigation water, Borewell, Healthy Banana Garden, Affected Banana Garden, Hiriyur.

Introduction:

The foundation of irrigated agriculture rests upon the availability of a consistent and dependable water supply of appropriate quality. Over time, the issue of water quality has often been relegated to the background, primarily because abundant high-quality water sources were easily accessible (Shamsad and Islam, 2005; Islam *et al*., 1999). However, as the extensive use of pristine water sources has become the norm, both new irrigation ventures and existing projects in search of supplementary or alternative water sources now face the pressing need to consider lower quality and less desirable alternatives (Cuena, 1989; Hundal 2011). This paradigm shift signifies the mounting challenges associated with guaranteeing water quality for the sake of sustainable agriculture. It highlights the evolving landscape of agricultural water use, emphasizing the urgency of addressing water quality concerns in the face of changing circumstances.

The quality of irrigation water stands as a pivotal determinant with far-reaching consequences for the health of both soil and crops, and it demands nothing short of rigorous and efficient management. The cornerstone of cultivating high-quality crops invariably

hinges upon the utilization of pristine irrigation water, while concurrently fine-tuning other pivotal input variables. The intricacy of irrigation water quality is underscored by a tapestry of defining characteristics, each subject to significant variations contingent upon the water source. Regional disparities in water quality attributes, primarily rooted in geological and climatic influences, add further complexity to the equation. Additionally, localized variations in water quality can be striking, contingent upon the source—be it surface water bodies like rivers and ponds or groundwater aquifers, each boasting unique geological compositions. Moreover, the treatment, or lack thereof, further amplifies these nuances. It's important to acknowledge that the chemical constituents within irrigation water wield the potential to exert direct impacts on plant growth, whether by means of inducing toxicity or deficiency, or indirectly by influencing the accessibility of essential nutrients for plants (Ayers and Westcot, 1985; Rowe *et al*., 1995). This intricate web of relationships underscores the paramount importance of understanding and proficiently managing irrigation water quality, as it forms the bedrock for nurturing sustainable agricultural practices.

The evaluation of irrigation water quality necessitates a systematic approach that entails identifying the pivotal characteristics influencing plant growth and determining their acceptable concentration levels (Yadav and Kumar, 2021). This comprehensive process commences with a thorough water analysis. Upon obtaining the results, the role of knowledgeable interpretation becomes paramount, enabling the effective resolution of water quality concerns. Furthermore, this interpretation equips us to make informed decisions concerning the selection of fertilizers and irrigation techniques, thus diminishing the risk of crop damage. In the case of utilizing lower-quality water sources, sound planning is indispensable to ensure the optimal utilization of available water resources, thereby pre-empting potential issues and maximizing yield potential. By adopting this multifaceted approach, we bolster our ability to harness irrigation water effectively and foster agricultural practices that are both sustainable and productive.

Nestled within the heart of the Karnataka region, HiriyurTaluk in Chitradurga district finds its place in the midst of the arid Central Dry Zone. This expanse stretches across 2919.9 square kilometres and experiences an annual average maximum temperature of 36.3°C, while the minimum temperature hovers at 16.6°C. With an annual total rainfall of 586 mm and an annual average relative humidity of 85 percent, this region's agriculture relies primarily on irrigation. Yet, surprisingly, a detailed investigation into the quality of irrigation water and its suitability for the crops in this area has remained conspicuously absent. In light of this glaring

gap in knowledge, the present research embarks on a benchmark survey of irrigation water quality in HiriyurTaluk, Chitradurga District, Karnataka. This research endeavour seeks to unravel the mysteries of water quality, ultimately contributing to the betterment of agricultural practices, ensuring they are both sustainable and productive.

The quality of irrigation water stands as a pivotal factor with a profound influence on the successful cultivation of crops. Remarkably, this quality can exhibit substantial variations not only between different regions but also from one farm well to another. It becomes imperative for growers to not only possess knowledge about the characteristics of their irrigation water but also to have a deep understanding of potential challenges that might be linked to its use for irrigation. This comprehensive awareness equips growers with the tools needed to make informed decisions and implement effective measures, ensuring the optimal utilization of irrigation resources for successful and sustainable crop production.

In order to precisely assess the quality of a particular water source, it is of paramount importance to ensure the proper collection of samples. To facilitate this crucial process, the following guidelines are recommended for the collection of samples:

Material and Method

A field Experiment was conducted to evaluate the suitability of groundwater for irrigated agriculture of HiriyurTaluk, Chitradurga District Karnataka.For our research, we specifically selected the following villages: Babbur Farm, Chillhalli, Venakalgudda, KC Roppa, Goguddu, Gudihalli, Biranhalli, Gounahalli, and Vadadhalli. A total of 30 ground water borewell samples were collected from various sites in the cropping period(2020). Samples were collected from healthy and affected gardens of banana 10 from healthy garden and 20 from banana leaf margin affected gardens. Each sample was a composite of 20 sub-samples to minimize error and heterogeneity. The high-density PVC bottles were used for sampling. They were thoroughly cleaned by rinsing with 8N HNO_3 and deionized water followed by repeated washing with water sample as suggested by De (1989). Before sampling from a well, water was pumped out sufficiently so that the sample represents the groundwater from which the well is fed (Raghunath, 1990). The bottles were kept air tight and labelled properly for identification. Aeration during sampling was avoided by stoppering the bottle quickly. Various determinants, such as EC, pH of the samples were measured on the day of collection using portable EC-meter and pH-meter. Samples collected from study area were carefully transported to the laboratory and were preserved in a refrigerator for analysis.

The analysis for the physico-chemical parameters of the samples were carried out following the established analytical methods. pH (potentiometric method), EC(conductometric method),$Ca^{2+}$and Mg^{2+}(versenatetitration method), SO_4^{2-}spectrophotometer (turbidimetric method), NO^-_3(Kjeldahl distillation in the presence of devordas alloy), Na^+(flame photometer)and Cl^- (titrimetric method) were determined by flame photometry (Jackson, 1967); by visible spectrophotometry (Jackson, 1967 and Page et al., 1982); $C1^-$ and HCO_3 by titration method (Richard, 1954); the sodium adsorption ratio (SAR) was estimated by the equation using the values obtained for, Ca^{2+}, Mg^{2+} in me/L (Richards, 1954); the soluble sodium percentage (SSP) was determined by the equation using the values obtained for Na^+ , K^+ , Ca^{2+}, Mg^{2+} in me/l (Todd, 1980); the residual sodium carbonate (RSC) was determined by the equation using the values obtained for CO^{2-}_3, HCO_3 in me/l (Richards, 1954).

Result and Discussion

Water quality of leaf margin affected and healthy banana gardens

Chemical characteristics of irrigation water under healthy banana gardens pH, EC, Ca, Mg, SO_4, NO_3, Na and Cl concentration of banana leaf margin affected and healthy banana gardens is presented in Table 1.

pH

From the results, it was indicated that pH of banana leaf margin affected gardens ranged from 8.50 to 9.20 with a mean value of 8.92. In banana leaf margin affected gardens, the minimum pH reported in KC Roppa village and maximum pH reported in Gudihalli village andhealthy banana gardens ranged from 8.20 to 9.10 with a mean value of 8.67. In healthy banana gardens, the minimum pH reported in Bagganadu village and maximum pH reported in Biranhalli village of Hiriyur taluk. From the results.Leaf margin affected gardens of Hiriyurtaluk shows the pH of the irrigation water saline to alkaline in nature and alkaline pH was reported in healthy banana gardens. The pH is the generally used to check the acidity or alkalinity of irrigation water in banana leaf margin affected and healthy banana gardens of Hiriyurtaluk, the high pH in groundwater samples were recorded in those samples containing a higher concentration of bicarbonates, sodium, SAR and RSC. Khandelwal and Lal (1991) reported a higher pH trend observed in soil pH with increasing SAR of irrigation water. Divekar *et al*. (2005)was also reported the higher concentration of bicarbonates in water samples responsible for the development of alkalinity and thereby the higher pH values, This is because of that higher pH of a water sample from the weathering of carbonaceous rocks.

Khandelwal *et al*. (1990) reported a decreasing trend of pH in soil when irrigated with higher EC water. Poor quality irrigation water and its adverse impact observed on physical properties of soil and similar problems were reported in arid and semi and regions of the country (Raghav *et al*., 2005).

Electrical Conductivity

The results indicated that EC of banana leaf margin affected gardens of Hiriyurtaluk ranged from 0.94 to 3.21 dS m^{-1} with a mean value of 1.28 dS m^{-1}. In banana leaf margin affected gardens, the minimum EC reported in Venakalgudda village and maximum EC reported in Bagganadu village and healthy banana gardens of Hiriyurtaluk ranged from 0.2 to 1.01 dS m^{-1} with a mean value of 0.51 dS m^{-1}. In healthy banana gardens, the minimum EC reported in Biranhalli village and maximum EC reported in Venakalgudda village of Hiriyur taluk, From the results, in banana leaf margin affected and healthy banana gardens of Hiriyurtaluk showed that the EC of irrigation water was high and within the safer limits in case healthy banana gardens. The most important water quality guideline on crop productivity is water salinity. The effect of higher EC of water on crop productivity make the plant to compete with ions in the soil solution for water (physiological drought). Higher the EC, less is the water available to plants. In the investigated area of Hiriyurtaluk of banana leaf margin affected and healthy banana gardens, the higher level of EC was observed in banana leaf margin affected gardens. The higher electrical conductivity (EC) in groundwater samples were also noticed by Bathusha*et al.* (2007) and Shahid *et al*. (2008). Continuous use of higher EC water may generate soil salinity and which deteriorates the physical and chemical properties of soil.

Calcium

The results indicated that calcium concentration in irrigation water under banana leaf margin affected gardens ranged from 0.25 to 11.15 me $L^{-1}$with a mean value of 1.41 me L^{-1}. In banana leaf margin affected gardens, the minimum calcium concentration reported in Chillahalli village and maximum calcium concentration reported in KC Roppa village and healthy banana gardens of Hiriyurtaluk ranged from 0.70 to 9.20 me $L^{-1}$with a mean value of 4.54 me L^{-1}. In healthy banana gardens, the minimum calcium concentration reported in Chillahalli village and maximum calcium concentration reported in KC Roppa village of Hiriyur taluk. From these results of banana leaf margin affected gardens showed that calcium concentration of the irrigation water low to medium in calcium concentration and water was

within the range for the irrigation, healthy banana gardens of Hiriyurtaluk showed that the calcium concentration of the irrigation water low to medium.

Magnesium

The results indicated that magnesium concentration of the banana leaf margin affected gardens of Hiriyurtaluk ranged from 0.3 to 20.25 me $L^{-1}$with a mean value of 5.23 me L^{-1}. In banana leaf margin affected gardens the minimum magnesium concentration reported in Bagganadu village and maximum magnesium concentration reported in KC Roppa village and healthy banana gardens of Hiriyurtaluk ranged from 0.50 to 24.65 me $L^{-1}$with a mean value of 9.66 me L^{-1}. In healthy banana gardens, the minimum magnesium concentration reported in Chillahalli village and maximum magnesium concentration reported in Vadadhalli village of Hiriyur.from the results it was observed that banana leaf margin affected gardens the magnesium concentration ranged with low to high whereas healthy banana gardens of Hiriyurtaluk showed that the magnesium concentration ranged with low to high.

Soluble sodium

The results indicated that the sodiumconcentration of the healthy banana gardens of Hiriyurtaluk ranged from 1.70 to 9.10 me L^{-1} with a mean value of 4.09 me L^{-1}. In healthy banana gardens, the minimum sodium concentration reported in Vadadhalli village and maximum sodium concentration reported in Gounahalli villagesodium concentration of the banana leaf margin affected gardens of Hiriyurtaluk ranged from 0.8 to 8.5 me L^{-1} with a mean value of 3.08 me L^{-1}. In banana leaf margin affected gardens, the minimum sodium concentration reported in Biranhalli village and maximum sodium concentration reported in Bagganadu village of Hiriyur. From the results, healthy banana gardens of Hiriyurtaluk showed that the sodium concentration of the irrigation water low to high.whereas in case of banana leaf margin affected gardens of Hiriyurtaluk shows that sodium concentration of the irrigation water low to high.Sodium (Na) is one of the common ion present in tube well or well water. All the samples of banana leaf margin affected and healthy banana gardens of Hiriyurtaluk low to high sodium. The sodium concentration was reported to be higher in the groundwater samples of Vijaypur tehsil. Brar *et al*. (2006) also reported that the dominance of Na^{+} ion in all the studied tube well samples of Bathinda district of Punjab. The important source of this sodium is weathering of feldspar mineral in igneous rocks. Similar findings were made by Sharma and Jain (2006), Banerjee and Prasad (2020). Using of such higher concentration of sodium in irrigation water may pose the problem of soil alkalinity hazards.

Sulphate

The results indicated that sulphateconcentration of the banana leaf margin affected gardens of Hiriyurtaluk ranged from 0.47 to 3.71 me L^{-1} with a mean value of 1.98 me L^{-1}. In banana leaf margin affected gardens, the minimum sulphate concentration reported in Venakalgudda village and maximum sulphate concentration reported in Biranhalli village andhealthy banana gardens of Hiriyurtaluk ranged from 2.31 to 4.66 me $L^{-1}$with a mean value of 3.49 me L^{-1}. In healthy banana gardens, the minimum sulphate concentration reported in Bagganadu village and maximum sulphate concentration reported in Gudihalli village of Hiriyurtaluk. From the results, it was observed that banana leaf margin affected gardens and healthy gardens of Hiriyurtaluk shows that sulphate was within the range for agricultural use.

Nitrate

The results indicated that the nitrate concentration of the banana leaf margin affected gardens of Hiriyurtaluk ranged from 21.85 to 83.72 me $L^{-1}$with a mean value of 43.32 me L^{-1}. In banana leaf margin affected gardens, the minimum nitrate concentration reported in Gudihalli village and maximum nitrate concentration reported in Goguddu village the healthy banana gardens of Hiriyurtaluk ranged from 37.81 to 61.45 me $L^{-1}$with a mean value of 49.31 me L^{-1}. In healthy banana gardens, the minimum nitrate concentration reported in Biranhalli village and maximum nitrate concentration reported in Chillahalli village of Hiriyur taluk. From the results in banana leaf margin affected gardens of Hiriyurtaluk showed that nitrate concentration medium to high and in healthy banana gardens it was high.

Chloride

The results indicated that the chloride concentration of the banana leaf margin affected gardens of Hiriyurtaluk ranged from 11.61 to 18.66 me L^{-1} with a mean value of 14.01 me L^{-1}. In banana leaf margin affected gardens, the minimum chloride concentration reported in Babbur farm village and maximum chloride concentration reported in Bagganadu villagethe chloride concentration of the healthy banana gardens of Hiriyurtaluk ranged from 0.6 to 2.2 me L^{-1} with a mean value of 1.28 me L^{-1}. In healthy banana gardens, the minimum chloride concentration reported in Bagganadu village and maximum chloride concentration reported in Goguddu village of Hiriyur.From the results, banana leaf margin affected gardens of Hiriyurtaluk shows that chloride concentration was high, whereas chloride was low to medium in case of healthy banana gardens. Water containing chloride concentration of 3 to 10 me L^{-1} of chloride was safe for most crops, provided that proper irrigation management

practices are applied. Chloride toxicity normally occurs when certain ions are taken up with the soil-water and accumulate in the leaves during water transpiration. The presence of chloride in the soil solution also reduces the ability of the plants to take up water, and this leads to a reduction in the growth rate, which also known as the osmotic effect. The most common toxicity is from chloride in the irrigation water. Chloride is not adsorbed or held back by the soil therefore it moves readily with the soil-water, is taken up by the crop and moves to the transpiration stream and accumulates in the leaves. If the chloride concentration in the leaves exceeds the tolerance of the crop, injury symptoms develop such as leaf burn or drying of leaf tissue. Normally, plant injury occurs first at the leaf tips (which is common for chloride toxicity) and progresses from the tip back along the edges as severity increases. Excessive necrosis (dead tissue) is often accompanied by early leaf drop or defoliation. With sensitive crops these symptoms occur when leaves accumulate from 0.3 to 1.0 per cent chloride on a dry weight basis but sensitivity varies among these crops. Many crops begin to show injury above 0.3 per cent chloride (dry weight).

The independent t-test for the chemical characteristics of irrigation water in leaf margin affected and healthy banana gardens

The information on independent t-test for irrigation water pH, EC, Ca, Mg, SO_4, NO_3, Na and Cl concentration of banana leaf margin affected and healthy banana gardens is presented in Table 2.

Water concentration in banana leaf margin affected and healthy banana gardens of Hiriyurtaluk, it was observed that pH, electrical conductivity, sulphate and chloride concentration of irrigation water increases significantly whereas calcium concentration decreases significantly, but there is no significant difference observed for nitrate and sodium concentration in banana leaf margin affected gardens compared to healthy banana gardens of Hiriyurtaluk.

Carbonates, bicarbonate, residual sodium carbonates and sodium adsorption ratio of leaf margin affected and healthy banana gardens

The data pertaining to carbonate and bicarbonate concentration in irrigation water of banana leaf margin affected gardens is presented in Table 3.

Carbonates and bicarbonates

The data pertaining to carbonate and bicarbonate concentration in irrigation water of banana leaf margin affected gardens is presented in Table 2.

The results indicated that the carbonates and bicarbonateconcentration in irrigation water of banana leaf margin affected gardens of Hiriyurtaluk ranged from 0 to 2 me L^{-1} and 3 to9.6 me $L^{-1}$with a mean value of 0.38 me L^{-1} and 6.62 me L^{-1}, respectively. In banana leaf margin affected gardens the minimum carbonates concentration reported in the majority of the villages, the minimum bicarbonates recorded in Gounahalli village and maximum carbonates and bicarbonate concentration reported in Gounahalli and Babbur farm villagesof healthy banana gardens of Hiriyurtaluk ranged from 0 to 8 me L^{-1} and 0.4 to 10.97, respectively. In healthy banana gardens, the majority of the villages reported very less concentration carbonates in irrigation water and minimum bicarbonates recorded in Chillahalli village and maximum carbonates and bicarbonates concentration reported in Chillahalli and Gudihalli villages of Hiriyurtaluk, respectively. From the results it was observed that in banana leaf margin affected gardens of Hiriyurtaluk showed that the concentration of the carbonate in irrigation water was within the range for agriculture production and the majority of banana gardens irrigation water showed very less carbonate content, whereas bicarbonates content in irrigation water was medium to high whereasbanana leaf margin affected gardenscarbonates in irrigation was within the range and majority of banana gardens irrigation water shows very less carbonates content whereas bicarbonates of irrigation water was medium to high.

Residual sodium carbonate

The RSC is used to evaluate alkalinity due to carbonates and bicarbonates and SAR has been used to assess the tendency of irrigation water to produce the sodic soils. Thus it is useful to for measure of sodium hazard of water and the results indicated that the RSC and SAR of irrigation water under banana leaf margin affected gardens of Hiriyurtaluk ranged from 0 to 2 me $L^{-1}$and 3 to 9.60 me L^{-1}, respectively. In banana leaf margin affected gardens the minimum RSC and SAR concentration reported in KC Roppa and Biranhalli villages respectively and maximum RSC and SAR concentration reported in Babbur farm and Bagganadu villages of Hiriyurtaluk respectively. From the results, it was reported that the RSC in irrigation water of banana leaf margin affected gardens low to high and SAR within the range for the agriculture use.

RSC and SAR of irrigation water

From the results, it was reported that RSC in irrigation water of banana leaf margin affected and healthy banana gardens of Hiriyurtaluk was low to high. The soluble carbonates and bicarbonates in groundwater samples of Hiriyurtaluk were low to high. The concentration of these ions is important because they affect the precipitation of calcium and thereby result in higher sodium accumulation in the soil. The carbonate and bicarbonate concentrations are very useful to judge the hardness and alkalinity. Girdhar (1996) reported the adverse impact of higher RSC of waters on the physical properties of soil. Likewise, Sharma and Minhas (1998) obtained an increasing trend in soil pH with higher RSC values of irrigation water. Tek and Rai (1993) observed that water samples were saline to sodic in nature and were found in Asalwas village of Mahendragarh district of Haryana.

Sodium Adsorption Ratio

The RSC is used to evaluate alkalinity due to carbonates and bicarbonates and SAR has been used to assess the tendency of irrigation water to produce the sodic soils. Thus, it is useful to measure sodium hazard of water and the results indicated that the RSC and SAR of healthy banana gardens of Hiriyurtaluk ranged from -24.25 to 6.4 me L^{-1} and 0.414 to 5.34, respectively. In healthy banana gardens, the minimum RSC and SAR concentration reported in Vadadhalli village and maximum RSC and SAR concentration reported in Gudihalli and Babbur farm villages of Hiriyurtaluk, respectively. From the results, it was reported that RSC in irrigation water of healthy banana gardens was low to high and SAR within the range for agriculture use

From the study, it was observed that SAR within the range for the agriculture use in case of both banana leaf margin affected and healthy banana gardens of Hiriyurtaluk.

The sodium hazard is typically expressed as sodium adsorption ratio (SAR). This index quantifies the proportion of sodium (Na^+) to calcium (Ca^{2+}) and magnesium (Mg^{2+}) in a sample. Higher sodium disperses soil particles. This dispersed soil readily forms a crust and creates water infiltration and permeability problems. The total ionic concentration of sodium in the collected groundwater samples of banana leaf margin affected and healthy banana gardens were low to medium and within the safe limits. The yield of wheat decreased with an increase in SAR of irrigation water as reported by Khandelwal *et al*. (1990) and Khandelwal and Lal (1991).

Independent test on carbonates and bicarbonates of the banana leaf margin affected and healthy banana gardens

The information on carbonates and bicarbonates of the affected and healthy banana gardens is presented in Table 5.

It was observed that there was no significant difference observed between banana leaf margin affected and healthy banana gardens for carbonates and bicarbonates.

Conclusion

The findings from our study unmistakably highlight a stark contrast in the quality of water samples obtained from healthy banana gardens and those affected by banana leaf margin issues. In the case of the latter, water samples fell into the saline to alkali water categories, while those from healthy gardens ranged from neutral to slightly saline. Groundwater samples in the HiriyurTaluk, as determined by their electrical conductivity (EC), pose limitations when used on soils with inadequate drainage. Even with adequate drainage, these sources may necessitate special management for controlling salinity and the selection of plants with robust salt tolerance becomes imperative. Notably, water in healthy banana gardens exhibited lower to medium sodium contentand our analysis further extended to include additional quality parameters, specifically the sodium adsorption ratio (SAR) and residual sodium carbonate (RSC). In contrast, the banana leaf margin affected gardens showed medium to high sodium content.

One of the critical findings was the concentration of chloride in borewell irrigation water from banana leaf margin-affected gardens, which surpassed safer limits at 14.01 me L^{-1}. Conversely, the chloride content in water from healthy banana gardens remained within an acceptable range. The elevated chloride levels in the affected gardens raised concerns about potential chloride toxicity, which, in turn, has serious implications for both fruit quality and banana yields. In light of these findings, farmers are strongly encouraged to adopt judicious irrigation practices. This may involve the concurrent use of borewell water and canal water, alongside a strategic alternation between saline and non-saline irrigation water at different stages of the crop cycle to mitigate the adverse impacts on banana cultivation.

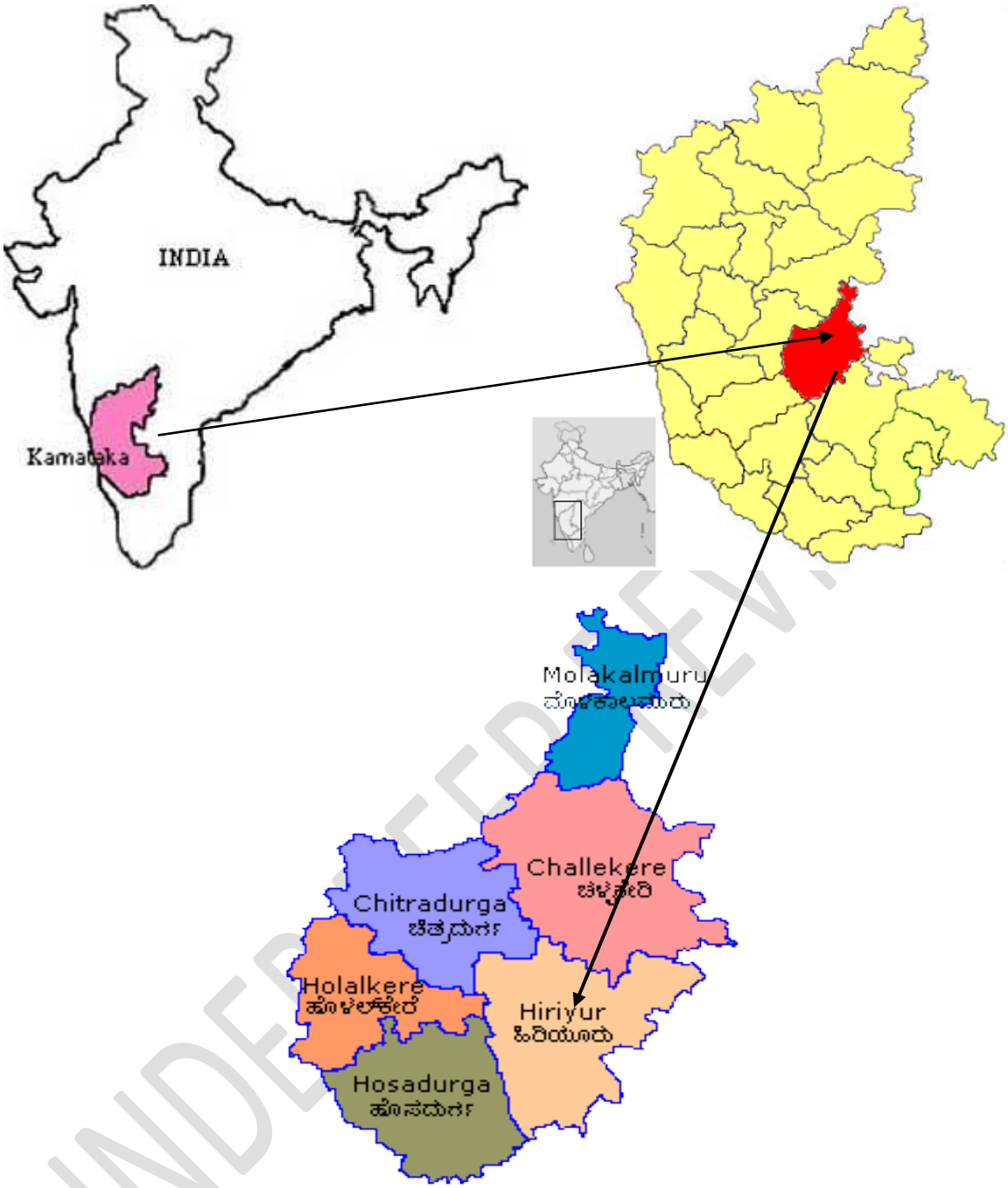

Fig.1: Location map of study area

Table 1: Chemical characteristics of irrigation water under banana leaf margin affected gardens

Villages	Location	pH	EC dS m^{-1}	Ca^{++} (me L^{-1})	Mg^{++} (me L^{-1})	SO^{-2}_4 (me L^{-1})	NO^{-}_3 (me L^{-1})	Na^{+} (me L^{-1})	Cl^{-} (me L^{-1})
Babbur farm	1	9.10	1.04	0.35	1.25	2.96	41.08	2.10	11.61
	2	9.20	1.60	0.35	1.05	2.62	36.78	2.80	12.80

Chillahalli	3	9.20	1.12	0.25	5.15	2.29	32.15	3.30	11.91
	4	9.10	1.05	0.45	5.25	3.39	43.53	2.10	12.31
Venakalgudda	5	8.50	1.04	1.80	8.50	0.86	43.53	2.10	13.10
	6	9.10	0.94	0.30	0.70	0.47	49.63	2.20	12.62
K C Roppa	7	8.50	1.00	11.15	20.25	1.99	45.90	3.10	13.40
	8	9.10	0.99	0.35	0.85	1.79	41.81	3.10	15.88
Goguddu	9	9.20	1.05	0.30	3.20	1.57	83.72	3.60	14.69
	10	8.90	1.14	0.25	1.45	2.57	41.87	1.80	13.45
Gudihalli	11	8.70	1.11	1.25	10.45	1.47	45.90	3.40	11.76
	12	9.20	1.04	0.35	11.05	1.08	21.85	3.80	15.77
Biranhalli	13	8.90	1.56	0.75	1.95	1.45	42.00	2.20	12.80
	14	8.60	1.52	0.90	6.90	3.71	37.33	0.80	16.28
Gounahalli	15	8.70	1.15	4.70	12.80	0.91	41.08	3.10	13.47
	16	9.10	1.17	1.00	7.50	0.86	36.60	5.20	13.85
Vadadhalli	17	9.10	1.47	1.25	0.95	2.21	41.75	2.00	17.21
	18	9.01	1.03	1.15	4.45	3.61	38.85	3.10	15.32
Bagganadu	19	8.80	1.53	0.50	0.70	2.11	51.30	3.30	13.36
	20	8.50	3.21	0.90	0.30	1.80	49.91	8.50	18.66
Range	**Min**	**8.50**	**0.94**	**0.25**	**0.3**	**0.47**	**21.85**	**0.80**	**11.61**
	Max	**9.20**	**3.21**	**11.15**	**20.25**	**3.71**	**83.72**	**8.50**	**18.66**
	Mean	**8.92**	**1.28**	**1.41**	**5.23**	**1.98**	**43.32**	**3.08**	**14.01**
	S D	**0.25**	**0.50**	**2.49**	**5.27**	**0.94**	**11.56**	**1.57**	**1.93**

Table 2: Chemical characteristics of irrigation water under healthy banana gardens

Villages	Location	pH	EC (dS m^{-1})	Ca^{++} (me L^{-1})	Mg^{++} (me L^{-1})	SO^{-2}_4 (me L^{-1})	NO^{-}_3 (me L^{-1})	Na^{+} (me L^{-1})	Cl^{-} (me L^{-1})
Babbur farm	1	8.70	0.63	1.25	0.50	3.78	57.37	5.00	6.80
Chillahalli	2	9.10	0.41	0.70	0.50	3.22	61.45	2.20	7.20
Venakalgudda	3	8.80	1.01	8.20	13.80	2.98	43.23	3.60	6.60
K C Roppa	4	8.60	0.26	9.20	21.00	4.10	39.36	4.00	6.10
Goguddu	5	8.20	0.41	3.80	11.00	3.39	53.20	2.50	7.60
Gudihalli	6	8.70	0.31	1.25	1.75	4.66	46.62	4.60	6.80
Biranhalli	7	9.10	0.20	1.75	9.05	2.55	37.81	4.40	7.10
Gounahalli	8	8.80	0.68	9.05	9.00	4.48	41.26	9.10	7.50
Vadadhalli	9	8.50	0.24	9.00	24.65	3.52	54.62	1.70	6.80
Bagganadu	10	8.20	0.99	1.25	5.35	2.31	58.23	3.80	4.60
Range	**Min**	**8.20**	**0.20**	**0.70**	**0.50**	**2.31**	**37.81**	**1.70**	**4.60**
	Max	**9.10**	**1.01**	**9.20**	**24.65**	**4.66**	**61.45**	**9.10**	**7.60**
	Mean	**8.67**	**0.51**	**4.54**	**9.66**	**3.49**	**49.31**	**4.09**	**6.71**
	S D	**0.31**	**0.30**	**3.81**	**8.31**	**0.77**	**8.66**	**2.06**	**0.86**

Table 3: The independent t-test for chemical characteristics of irrigation water of banana leaf margin affected and healthy banana gardens

Parameters	pH	EC (dS m^{-1})	Ca^{++} (me L^{-1})	Mg^{++} (me L^{-1})	SO^{-2}_4 (me L^{-1})	NO^{-}_3 (me L^{-1})	Na^{+} (me L^{-1})	Cl^{-} (me L^{-1})

AG Mean value	8.92	1.28	1.41	5.23	1.98	43.32	3.08	14.01
HG Mean value	8.67	0.51	4.54	9.66	3.49	49.31	4.09	6.710
T statistic	**2.23 ***	**5.26****	**2.35***	**1.53**	**4.66****	**1.58**	**1.36**	**14.29****

*Significant at 5% level, ** Significant at 1% level, HG: Healthy garden, AG: Affected garden

Table 4: Carbonates, bicarbonate, RSC and SARof irrigation water in banana leaf margin affected gardens

Villages	Location	CO_3^- (me L^{-1})	HCO_3^- (me L^{-1})	RSC (me L^{-1})	SAR
Babbur farm	1	0.00	9.60	8.00	2.34
	2	0.00	7.40	6.00	3.34
Chillahalli	3	1.20	6.60	2.40	2.00
	4	0.00	9.20	3.50	1.24
Venakalgudda	5	0.40	6.60	-3.30	0.92
	6	0.00	6.80	5.80	3.11
KC Roppa	7	0.00	8.80	-22.60	0.78
	8	0.00	6.00	4.80	4.00
Goguddu	9	0.00	7.80	4.30	2.72
	10	0.00	6.40	4.70	1.95
Gudihalli	11	0.00	8.60	-3.10	1.40
	12	0.00	8.80	-2.60	1.59
Biranhalli	13	0.00	6.40	3.70	1.89
	14	1.20	5.60	-1.00	0.40
Gounahalli	15	0.00	6.60	-10.09	1.04
	16	2.00	3.00	3.50	2.52
Vadadhalli	17	0.80	3.10	1.60	1.90
	18	0.00	7.80	2.20	1.85
Bagganadu	19	0.40	4.20	3.40	4.20
	20	1.60	3.20	3.60	10.97
Range	**Min**	**0.00**	**3.00**	**-22.6**	**0.40**
	Max	**2.00**	**9.60**	**8**	**10.97**
	Mean	**0.38**	**6.62**		
	S D	**0.62**	**2.02**		

Table 5: Carbonates, bicarbonate, RSC and SAR of irrigation water inhealthy banana gardens

Villages	Location	CO_3^- (me L^{-1})	HCO_3^-(me L^{-1})	RSC (me L^{-1})	SAR

Babbur farm	1	0.40	4.00	2.65	5.34
Chillahalli	2	1.60	3.20	3.60	2.84
Venakalgudda	3	0.00	8.60	-13.40	1.08
KC Roppa	4	0.00	7.00	-23.20	1.02
Goguddu	5	0.00	8.20	-6.60	0.919
Gudihalli	6	0.00	9.40	6.40	3.75
Biranhalli	7	0.00	8.40	-2.40	1.89
Gounahalli	8	0.40	8.80	-8.85	3.02
Vadadhalli	9	0.00	9.40	-24.25	0.414
Bagganadu	10	0.00	9.00	2.40	2.09
Range	**Min**	**0.00**	**3.20**	**-24.25**	**0.414**
	Max	**1.60**	**9.40**	**6.40**	**5.34**
	Mean	**0.24**	**7.60**		
	S D	**0.50**	**2.22**		

Table 6: The independent t-test on carbonates and bicarbonatesof affected and healthy banana gardens

Parameters	**CO_3^- (me L^{-1})**	**HCO_3^- (me L^{-1})**
AG Mean value	0.38	6.62
HG Mean value	0.24	7.60
T statistic	**0.65**	**1.17**

*Significant at 5% level, ** Significant at 1% level, HG: Healthy garden,

AG: Affected garden,

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