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# Suitability of groundwater for irrigation in Manmunai West Divisional secretariat area of Batticaloa District

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## Abstract

*Groundwater quality has become a critical issue due to fresh water scarcity. Suitability of irrigation water is directly influences on the plant growth and its development, yield of the plant and deteriorates soil fertility. Irrigation waters, pumped from wells contain appreciable quantities of chemical substances and always carry substances derived from its natural environment or from domestic and industrial effluents. In the present study, the physical and chemical parameters of well water from Manmunai West DS area were analyzed to find the quality and the suitability of well water for irrigation. Water samples from 80 randomly selected wells which are presently used for irrigating crops were collected during the period from July to September 2017. Collected water samples were tested for water quality parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Hardness, Sodium (Na), Pottasium (K), bicarbonate, carbonate and Total Suspended Solids (TSS). The relative proportions of sodium to other cations were determined by the Sodium Adsorption Ratio (SAR) and Soluble Sodium Percentage (SSP). Residual Sodium Carbonate (RSC) of the well water also determined using cation, bicarbonate and carbonate concentrations. According to the results, parameters such as pH, TDS, Mg, Bicarbonate, hardness and SAR were within the FAO recommended range for irrigation purpose while other parameters such as TSS, K, Na, Carbonate, RSC, SSP and EC were above recommended range. The study concluded that, about 85% of the well water of the study area is not suitable for irrigation in reference to Na, K, Carbonate, Bicarbonate, RSC, SSP and EC. Therefore, awareness on proper management of land against the poor irrigation water quality especially for sodium and bicarbonate hazards is important in the study area.*

***Keywords*: Groundwater, irrigation, salinity, sodium hazard, water quality**

## Introduction

Water is an important and abundant component of the ecosystem. Fresh water comprises 3% of the total water on earth and the rest is salt water and small percentage (0.01%) of this freshwater is available for human use (Hinrichsen and Tacio, 2002). Freshwater has become a scare commodity due to over exploitation and pollution (Gupta and Shukle, 2006; Patil and Tijare, 2001; Singh and Mathur, 2005). Groundwater plays an important role in agriculture which estimated that, about 45% of irrigation water requirement is met from groundwater sources (Singh *et al*., 2014). Groundwater quality reflects inputs from the atmosphere, soil and water rock reactions as well as pollutant sources such as mining, land clearance, agriculture, acid precipitation, and domestic and industrial wastes (Zhang *et al*., 2011).

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In the East coast of Sri Lanka, coastal sand aquifer and alluvial aquifer are the very precious resources of groundwater which have been used for domestic and irrigation purposes. The coastal sand aquifers are re-charged annually during rainy seasons. Hence, the volume of the fresh water in these aquifers expands during the rainy seasons and contracts during the dry seasons. Farmers in this region extract groundwater by using shallow dug wells, agro-wells and tube wells in order to irrigate the crops. However, there is high chance for groundwater deterioration due to natural and anthropogenic activities. Higher amount of TDS and other parameters like salt, hardness, Na and variation in pH level are causing problem to the irrigation water.

The water used for irrigation differs greatly in its quality, depending on the concentration and composition of the dissolved salts (Elamin *et al.*, 2015). Suitability of irrigation water is directly influences on the plant growth and its development. Therefore, it is important to irrigate with suitable water for the proper growth and development of the plant, it could ultimately effect on the yield of the plant. Furthermore, it is essential to assess the quality of groundwater used for irrigation purpose that will contribute to the effective management and utilization of the groundwater resources. So far no qualitative study was carried out to assess the groundwater quality in the Manmunai West DS division area. In this view the present work aimed to assess the quality parameters of the groundwater to find the suitability of well water for irrigation at Manmunai West DS division area of Batticaloa district.

## Materials and methods

### Study area

Manmunai West DS division is one of the 14 DS divisions of Batticaloa district with the area of 352 $km^2$. It consists of 24 G.N. divisions and 117 villages. Population of this area is 31,357 from 9009 families. This area contains 2 Agrarian service centers to provide services to the farmers. There are 70 dug wells and 53 agro-wells in this area which have been used to extract groundwater for irrigation purposes.

### Sample collection

Total of 80 wells (i.e. 26 and 54 wells from Mandapathadi and Aithiyamalai Agrarian service center divisions respectively) which are presently used for irrigating crops were selected randomly (Figure 1) to collect the water samples during the driest period from July to September 2017. Water samples were collected using one liter plastic containers. The bottles prior to take water samples were rinsed two to three times with sample water. After taking in-situ measurements, samples were transferred to water quality laboratory of the department of Agricultural engineering, Faculty of Agriculture, EUSL for further analysis.

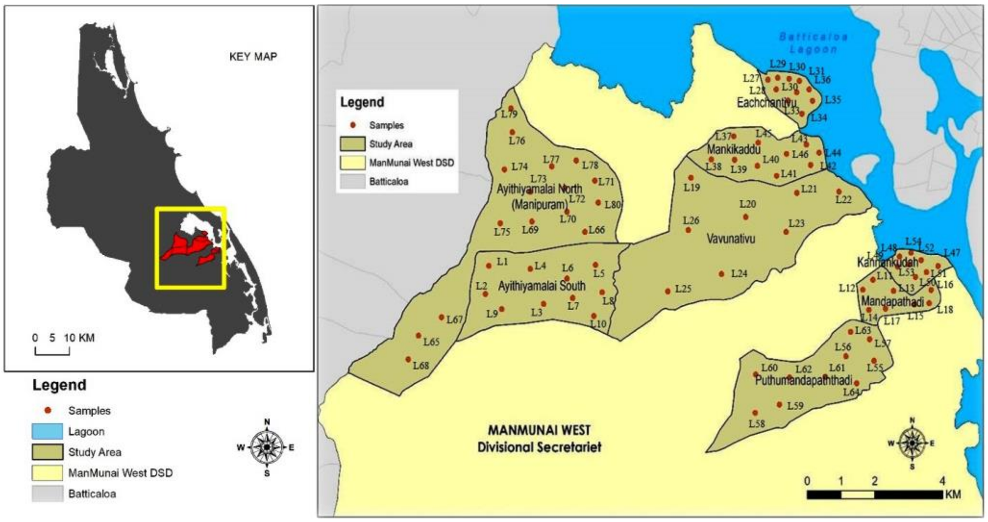


**Figure 1: Sample locations at Manmunai West D.S. division**

**Sample analysis**

In-situ measurements were taken for pH, Electrical Conductivity (EC) and Total Dissolved Solid (TDS) of water samples using digital pH meter (pH /EC/ TDS Meter model HI 98130). The parameters such as Calcium (Ca) and Magnesium (Mg), Sodium (Na), potassium (K), bicarbonate, carbonate and Total Suspended Solid (TSS) were also tested for the collected water samples using standard procedures (USDA handbook No. 60). The Ca and Mg concentrations of the water samples were determined by the Versanate titration method. Sodium (Na) and potassium (K) were estimated by the flame photo meter using standard solution of NaCl and KCl. Bicarbonate and carbonate were tested using standard titration method according to Richards (1954). TSS concentrations of the water samples were determined using oven dry method.

The derived parameters such as calcium magnesium ratio, residual sodium carbonate (RSC), Sodium Adsorption Ratio (SAR) and Soluble Sodium Percentage (SSP) were found using following equations (Richards, 1954). Results obtained from the quality analysis were entered in MS Excel and analyzed using descriptive statistics.

Calcium Magnesium ratio = $Ca^{2+}/Mg^{2+}$

$$RSC = [(CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$$

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

$$SSP = \frac{Na^{+}}{Na^{+} + Ca^{2+} + Mg^{2+} + K^{+}} X100$$

Where the concentrations of each ion is expressed in meq$L^{-1}$

**Results and discussions**

**Well water quality and its suitability**

**pH**

The pH of the well water of the study area varied within a narrow range of 6.32- 7.84 (Figure 2).

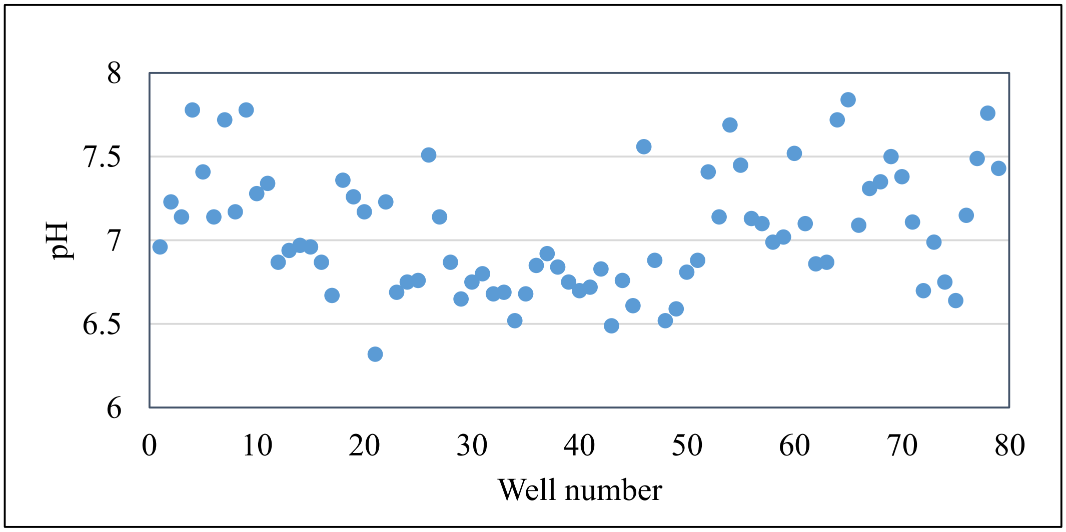


**Figure 2: Variation of pH of well water at different locations of the study area**

According to FAO (1985), almost all the water samples (98.8%) show the pH values within the acceptable pH range (6.5- 8.4) for irrigation purpose. Therefore as far as the pH is concerned, no harmful effects are expected using the well water of the study area. High pH values in some wells of the study area, could be attributed to the presence of considerable amount of Na, Ca, Mg, carbonate and bicarbonate ions. Kale (2016) also mentioned that bicarbonate and carbonates are responsible for increase the pH of water.

### Electrical conductivity (EC) and Total dissolved solids (TDS)

EC of well water samples in the study area varied in between 7 mS/m and 360 mS/m. Based on the salinity hazard and the classification of irrigation water by USDA Agriculture handbook No.60 (Richards, 1954), water samples collected in 5% of the locations falls within the low salinity class whereas 28%, 57% and 10% of the locations falls within the medium, high and very high salinity classes (Figure 3). According to Sugirtharan and Rajendran (2015) geological conditions, evaporation of water from the open wells and groundwater table might influence on the levels of EC in the present study.

Similarly, the TDS of the well water used for irrigation at different locations in the Manmunai West DS Division was ranging from 400 ppm to 4800 ppm. It was also found that the water samples collected in fifty-two locations (65%) were within the FAO recommended limit of 450- 2000 ppm of TDS for irrigation purpose. Whereas 11% and 24% of the well water samples were found below and above the FAO recommended level respectively. Wells which are located closer to Unnichchai irrigation canal and lagoon areas showed higher EC values. High concentration of EC and TDS (in 24% of the locations) may impacts on the concentration of soil water and then affects the absorption of water and nutrients from the soil. At the same time, water containing TDS less than 450 ppm at 11% of the locations can be considered to be 'fresh water' (Hakim *et al.*, 2009) for irrigation use and will not affect the osmotic pressure of soil solution.

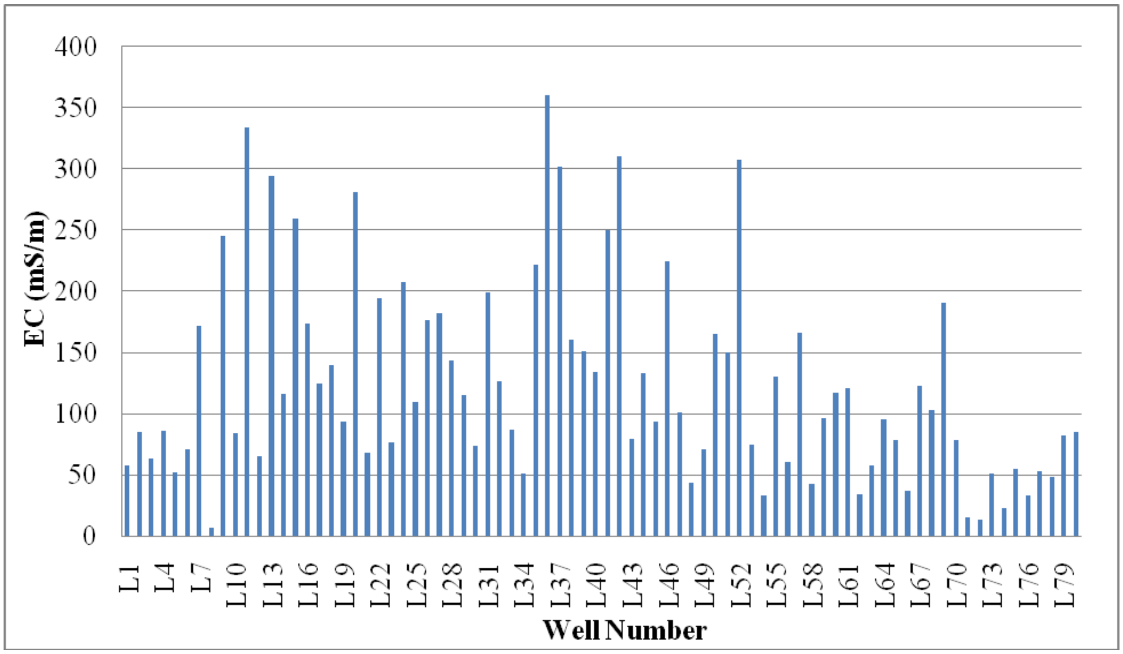


**Figure 3: Electrical conductivity of well water samples in different Locations**

**Total Suspended solids**

The TSS of the well water used for irrigation at different locations in the Manmunai West DS Division were found within the range of 40 ppm to 1240 ppm (Figure 4). TSS concentrations in 98.8 % (79 locations) of the well water samples were above the FAO limit (50- 100 ppm). Water extraction through pumping and using buckets can stir up sediments. These sediments including organic and inorganic materials, decaying plants and algae can contribute to high TSS in the well water. Therefore, infiltration problems can be expected in the study area because, suspended solids present in the well water can deposited on the soil surface and reduce the porosity during irrigation. The presence of suspended solids can also affect the operation of micro irrigation system by blocking the nozzles and emitter openings and valves. This may affects the irrigation system efficiency and could lead to additional cost for operation and maintenance.

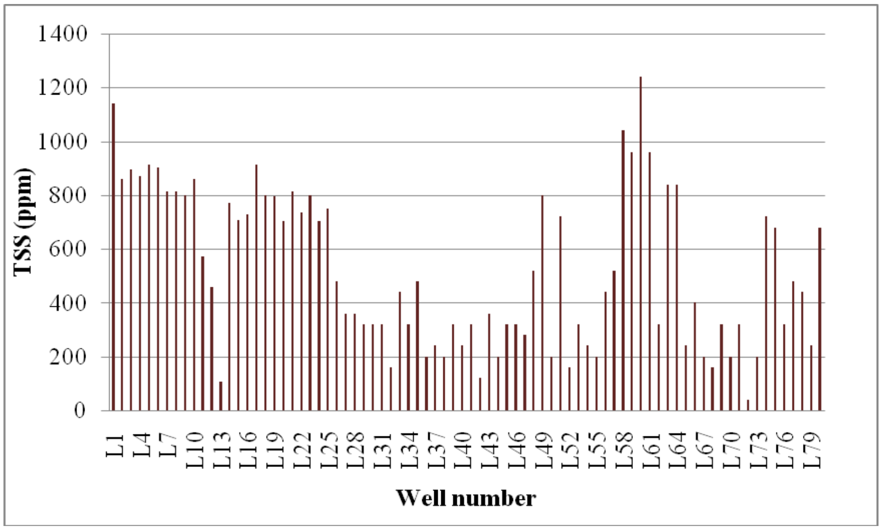


**Figure 4: Total Suspended solids of the well water at different locations in the study area**

### Pottasium (K) and Sodium (Na)

The concentration of K in well water used for irrigation at the Manmunai West DS Division was ranging from 0.34 ppm to 105 ppm (Figure 5).The acceptable K range for irrigation water is 5-10 ppm (FAO, 1985). As far as the K concentration is concerned, only 10% of the water samples in the present study were within the FAO recommended range for irrigation purpose. Whereas, samples collected at 76.2% of the locations are not suitable for irrigation.

JanardhanaRaju *et al.* (1992) reported that the percentage Na is an indication of the soluble sodium content of the groundwater and used to evaluate sodicity hazard. In all natural waters, Na is a common parameter to assess its suitability for irrigation purposes since it affects the soil permeability. The present study found that, Na concentration of well water was ranging from 10.8 ppm to 950 ppm. According to FAO (1985), only 2.5 % of the water sample collected were falls within the FAO recommended range of <70ppm.

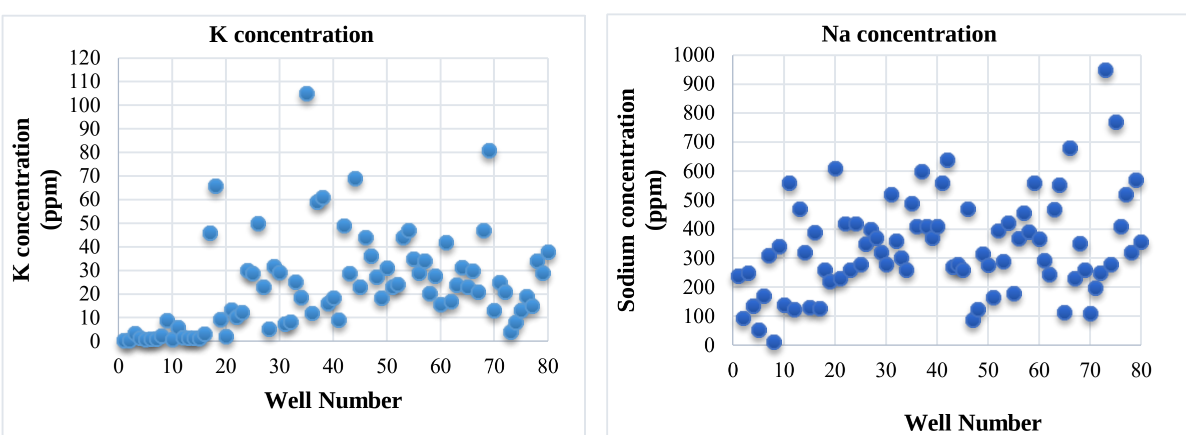


**Figure 5: Pottasium and Sodium ion concentrations of well water samples at different locations in the Manmunai west DS division**

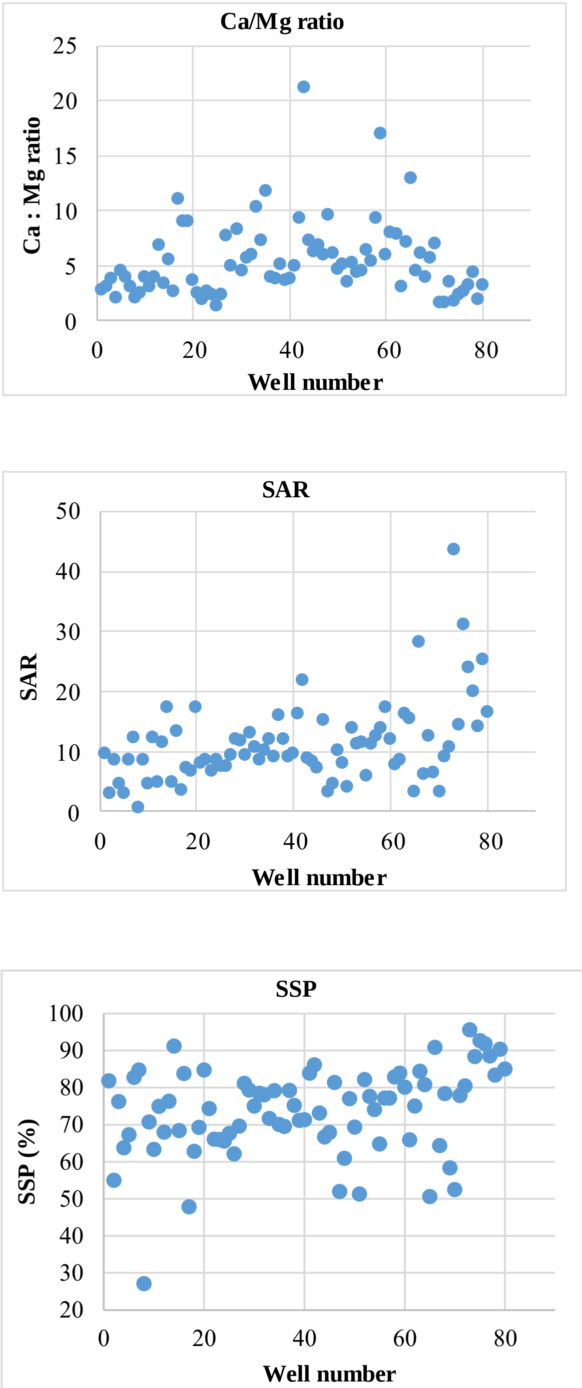


**Figure 6: Ca and Mg ratio, SAR and SSP of well water at study area**

## Ca/Mg ratio

Calcium and magnesium ions in most waters maintain a state of equilibrium. Raghunath (1987) suggested that high magnesium hazard value has an adverse effect on the crop yield as the soil becomes more alkaline. FAO (1985) also indicated that acceptable Ca/ Mg ratio for irrigation water should be more than one (01). When Mg content exceeds the Ca content, it is toxic for soil properties and crop growth (Bohn *et al.*, 1985). However, in the present study, Ca/Mg ratios of the well water were fall within the safe limit (Figure 6).

## Residual sodium carbonate (RSC)

Based on the Richards (1954) classification, the present study results showed, water samples collected in 2.5%, 68.8% and 28.7% of locations can be used safely, can be used with certain management and unsuitable for irrigation purpose, respectively. Results indicate that only 2.5% of the samples have a good water quality where RSC values are lesser than 1.25 $meqL^{-1}$. Indiscriminate use of water from other 97.5% of the locations can often lead to crop failures and promote the development of sodic soils which require expensive treatment to make them productive again. It is also be problematic for micro irrigation systems by clogging of emitter openings.

## Sodium Adsorption Ratio (SAR)

The most common measure to assess sodicity in water and soil is called as Sodium Adsorption Ratio (SAR). The SAR defines sodicity in terms of the relative concentration of sodium (Na) compared to the sum of calcium (Ca) and magnesium (Mg) ions in a sample. The SAR assesses the potential for infiltration problems due to a sodium imbalance in irrigation water.

According to MusahSalifu *et al*. (2017), continuous use of water with high SAR leads to a soil to disperse and change the physical structure of the soil. Sodium is adsorbed and becomes attached to soil particles. The soil then becomes compact when dry and increases the imperviousness to water penetration. Fine textured soils are most subject to this action. Therefore, certain amendments may necessary to maintain soils with high SAR values.

**Table 1. Classification and suitability of irrigation water based on SAR values (**Richards (1954)**.**

| Water class | SAR value | Remarks |
|---|---|---|
| Low sodium hazard | 0-10 | Little or no hazard |
| Medium sodium hazard | 10-18 | Appreciable hazard, but can used with appropriate management |
| High sodium hazard | 18-26 | Unsatisfactory for most crops |
| Very high sodium hazard | >26 | Unsatisfactory for most crops |

The present study revealed that, well water collected in 51%, 40% and 9% of the locations has no sodium hazard, appreciable hazards and unsatisfactory for most of the crops respectively (Figure 6). The water samples fall in the low sodium class (51%) implies that no alkali hazard is anticipated to the crops. About 49% of the water samples with the SAR values of more than 10. Therefore, it is recommended to use gypsum and to apply excess irrigation to displace and leach the sodium in those 49% of the locations. However, all of these require labour, electricity for pump operation and increased wear on the irrigation system leads to high cost for inputs.

**Soluble sodium percentage (SSP)**

Eaton (1950**)** categorized the water for irrigation on the basis of SSP as follows.

**Table 2. Classification and suitability of irrigation water based on SSP values**

| Class | SSP% | Suitability of water for irrigation |
|---|---|---|
| 1 | Less than 40 | Good |
| 2 | 40-70 | Slightly injurious |
| 3 | More than 70 | Unsatisfactory |

The results revealed that, SSP of the well water at 1.3%, 36.3% and 62.4% of the locations can be used safely for the irrigation, cause slight injuries when they irrigate to the crops and unsuitable for irrigation respectively.

Water intended for agricultural use should have a lower concentration of sodium ions and higher concentrations of calcium and magnesium ions. Excessive amounts of Na ions may cause a significant decrease in the permeability of agricultural soils receiving such irrigation water.

## Conclusions

Water quality parameters such as pH, TDS, Mg, Ca were within the FAO recommended range for irrigation purpose. While other parameters such as TSS, Na, K, Carbonate, and EC were found in higher concentrations. Based on these, 85% of the well water of the study area is not suitable for irrigation. Therefore, proper management to improve the infiltration rates, use of amendments is important against the sodium, bicarbonate hazards to avoid the buildup of those elements in the agricultural land. In these areas farmers have to be advised on how they should manage and utilize the groundwater for their irrigation activities. Well water collected near the canal and lagoon area showed higher EC values. Comparatively, water collected near those areas is not suitable for irrigation than other locations. Further, awareness on the importance of water quality, causes of water quality degradation and the effects on the soil and crop can help to reduce the water quality degradation to some extent in the study areas.

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