

## Study on water quality status for drinking and irrigation purposes from pond, open well and bore well water samples of four taluks of kanyakumari district

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### Abstract

Water resources available for drinking and other domestic purposes must possess high degree of purity, free from chemical contamination and microorganisms. Irrigation water quality refers to the kind and amount of salts in the water that has an influence on crop growth and development. So in this present study, the surface (pond) and ground (open well & bore well) water samples one each from four taluks of kanyakumari district are taken and analyzed for their suitability for drinking and irrigation purposes. Water Quality Index (WQI) is formulated that indicates the quality of water in terms of index number which represents the overall quality of water. Irrigational status of water samples were analyzed based on TH, TDS, EC, SAR and % Na. The results were found that except Kalkulam taluk bore well water sample all other water samples are fit for drinking purpose, whereas all the water samples from four taluks are suitable for irrigation purposes.

**Keywords:** Water Quality Index, Irrigation water quality and kanyakumari district

### 1. Introduction

Water is a finite resource and it is becoming a scarce resource in many parts of the world. The chemistry of water is an important factor determining its use for domestic, irrigation or industrial purposes. Majority of people around the world depend upon fresh water supplies from open wells, bore wells, springs and like. The composition of surface and ground water is dependent on natural factors (geological, topographical, meteorological, hydrological and biological) in the drainage basin and varies with seasonal differences in run-off volumes, weather conditions and water levels [1]. The availability of surface and ground water depends upon the rate at which it is recycled by hydrological cycle than on the amount that is available for use at any moment in time. Ground water is generally less susceptible to contamination and pollution when compared to surface water bodies. As a consequence of urbanization and industrialization water becomes unfit for agricultural and drinking purposes. It is observed that during the last decade, ground water is being polluted drastically because of increased human activities [2]. Ground water is very difficult to remediate, once contamination of ground water occurs in an aquifer, it persists for hundreds of years because of very slow movement in them [3]. The ionic composition of ground water and surface water should be analyzed to ascertain its quality before being used for drinking, irrigation and other purposes. For the present study, surface (pond) water and ground (bore well and open well) water samples are taken one each from four taluks of kanyakumari district namely: Vilavancode, Kalkulam, Thovalai and Agasteeswaram. Their water quality statuses for drinking and irrigation purposes were analyzed using water quality index for drinking purpose. Similarly their suitability for

irrigation purposes were found based on Total Hardness (TH), Total Dissolved Solids (TDS), Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR) and percent of sodium. Finally the comparative picture of the hydrochemistry of surface and ground waters are depicted using Wilcox diagram, Gibb's diagram, Piper trilinear diagram and US salinity diagram to indicate their quality for drinking and irrigation purposes..

### 2. Experimental

The quality of ground waters and surface water are analyzed from four taluks viz Vilavancode, Kalkulam, Thovalai and Agasteeswaram of Kanyakumari district Tamil Nadu, India, with the objective of understanding the spatial distribution of hydrogeochemical constituents of ground water and surface water related to its suitability for irrigation and domestic use. In each taluk one location was selected from which bore well, open well and pond water samples were collected at regular monthly intervals from August 2011- August 2012. The physico-chemical analysis of these water samples were done following the methods of APHA [4] & Trivedy and Joel [5].

#### 2.1 Water Quality Index (WQI) for drinking water

WQI indicates the quality of water in terms of index number which represents the overall quality of water for any intended use. Mostly it is done from the point of view of its suitability for human consumption. The calculation of WQI was made using a weighed arithmetic index method given by brown *et al* [6] below in the following steps.

#### I. Calculation of sub index of quality rating (q<sub>n</sub>)

$$q_n = 100[(V_n - V_{io}) / (S_n - V_{io})] \quad (1)$$

Where,

$q_n$  = quality rating for the  $n^{\text{th}}$  water quality parameter.

$V_n$  = observed value of the  $n^{\text{th}}$  parameter.

$S_n$  = standard permissible value of  $n^{\text{th}}$  parameter.

$V_{io}$  = ideal value of  $n^{\text{th}}$  parameter in pure water.

### Calculation of quality rating for pH

$$q_{\text{pH}} = 100[(V_{\text{pH}} - 7.0) / (8.5 - 7.0)] \quad (2)$$

Where,

$V_{\text{pH}}$  = observed value of pH during the study period

### Calculation of quality rating for dissolved oxygen

$$q_{\text{DO}} = 100[(V_{\text{DO}} - 14.6) / (6 - 14.6)] \quad (3)$$

Where,

$V_{\text{DO}}$  = Observed value of dissolved oxygen

### Calculation of quality rating for fluoride

$$q_{\text{F}} = 100[(V_{\text{F}} - 1) / (1.5 - 1)] \quad (4)$$

Where,

$V_{\text{F}}$  = Observed value of fluoride.

## II. Calculation of unit weight ( $W_n$ )

$$W_n = K / S_n \quad (5)$$

Where,

$W_n$  = Unit weights of  $n^{\text{th}}$  parameters

$S_n$  = Standard values for  $n^{\text{th}}$  parameters

$K$  = Constant for proportionality

$$K = 1 / [1/V_{S1} + 1/V_{S2} + \dots + 1/V_{Sn}] \quad (6)$$

## III. Calculation of WQI

$$\text{WQI} = \frac{\sum_{i=1}^n q_n W_n}{\sum_{i=1}^n W_n} \quad (7)$$

## 2.2 Quality of Water for Irrigation

### 2.2.1 Sodium Adsorption Ratio (SAR)

$$\text{SAR} = \frac{\text{Na}}{\sqrt{\frac{\text{Ca} + \text{Mg}}{2}}} \quad (8)$$

### 2.2.2 Percent Sodium

$$\text{Na}\% = (\text{Na}^+ + \text{K}^+) \times 100 / (\text{Ca}^{2+} + \text{Mg}^{2+} + \text{Na}^+ + \text{K}^+) \quad (9)$$

### 2.2.3 Total Hardness (TH)

$$\text{TH (as CaCO}_3\text{) mg/l} = (\text{Ca}^{2+} + \text{Mg}^{2+}) \text{ meq/l} \times 50 \quad (10)$$

## 2.3 Wilcox diagram

Wilcox diagram is especially implemented to classify ground water quality for irrigation and is used to understand the suitability of water for irrigation.

## 2.4 US Salinity diagram

According to US salinity diagram, water types that are recognized pertaining to irrigation are C1S1, C1S2, C1S3, C1S4; C2S1, C2S2, C2S3, C2S4, C3S1, C3S2, C3S3, C3S4, C4S1, C4S2, C4S3 & C4S4.

## 2.5 Gibb's diagram

The Gibb's ratio for the ions  $-\text{Na}^+ / (\text{Na}^+ + \text{Ca}^{2+})$  and  $\text{Cl}^- / (\text{Cl}^- + \text{HCO}_3^-)$  of ground water samples were plotted against the respective values of TDS to determine the types of water

namely rock dominance category, evaporation dominance category or precipitation dominance category.

## 2.6 Piper Diagram

A piper diagram is a graphical representation of the chemistry of water samples. The cations and anions are shown by separate ternary plots. The apexes of the cation plot are calcium, magnesium and sodium plus potassium cations. The apexes of the anion plot are sulphate, chloride and carbonate plus hydrogen carbonate anions. The two ternary plots are then projected onto a diamond. The diamond is a matrix transformation of graph of the anions (sulphate + chloride / total anions) and cations (sodium + potassium / total cations).

## 3. Results and Discussion

The WQI values for the open well and bore well water samples from four taluks of kanyakumari district were analyzed and the water samples from all four taluks were found to lie in the excellent category (i.e. with  $< 50$  WQI value) which indicates their potability for drinking purpose except the bore well water sample from Kalkulam taluk which was found to have the WQI value of 162.3 (which lies between 100 – 200 i.e. poor water category) (Table 1-3).

The water samples of pond, bore well and open well were analyzed for their suitability on irrigation purpose and was found that SAR values and percent of sodium for the entire water sample lie well below the permissible limit. In case of Total Hardness, Kalkulam bore well water sample is found to be very hard and the water samples from Thoivalai and Agastheeswaram bore well and open well are found to lie under hard category, whereas all other taluk water samples are soft to moderately hard in nature. Regarding the Total Dissolved Solids in water samples, all water samples are lying under fresh category except the Kalkulam bore well water sample which is found to have slightly alkaline nature (Table 4-6).

## 4. Conclusion

So from the present study it was found that the ground (open well and bore well) water samples from all four taluks can be used for drinking purpose except Kalkulam bore well water sample which should be subjected to some appropriate treatments to make them fit for drinking purpose. With regard to the irrigation purpose all four taluk ground (bore well and open well) and surface (pond) water samples are found to be good for irrigation purposes.

**Table 1:** Water quality status based on WQI values.

WQI value	Water quality status
< 50	Excellent
50 – 100	Good water
100 – 200	Poor water
200 – 300	Very poor water
> 300	Water unsuitable for drinking

**Table 2:** WQI values for bore well water samples

SL. NO	TALUKS	WQI ratings
1	Vilavancode	8.45
2	Kalkulam	162.3
3	Thoivalai	20.75
4	Agastheeswaram	21.33

**Table 3: WQI values for open well water samples**

SL.NO	TALUKS	WQI ratings
1	Vilavancode	8.47
2	Kalkulam	20.39
3	Thovalai	17.36
4	Agastheeswaram	20.12

**Table 4: Classification of bore well water samples for irrigation purpose on the basis of Na%, SAR, EC, TH & TDS**

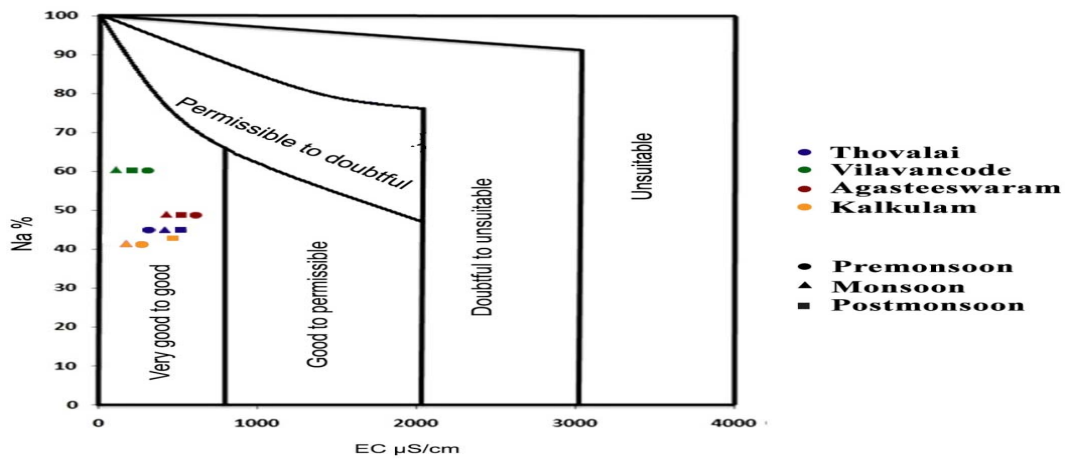
Parameters	Range	Water class	Status of water quality in the taluks
Na%	<20	Excellent	-
	20-40	Good	Thovalai
	40-60	Permissible	Vilavancode, Kalkulam, Agastheeswaram
	60-80	Doubtful	-
	>80	Unsuitable	-
SAR	<10	Excellent	Thovalai, Vilavancode, Kalkulam, Agastheeswaram
	10-18	Good	-
	18-26	Permissible	-
	>26	Doubtful	-
EC	<250	Excellent	-
	250-750	Good	Vilavancode
	750-2000	Permissible	Thovalai, Kalkulam, Agastheeswaram
	2000-3000	Doubtful	-
	>3000	Unsuitable	-
TH	<75	Soft	-
	75-150	Moderately Hard	Vilavancode
	150-300	Hard	Thovalai, Agastheeswaram
	>300	Very Hard	Kalkulam
TDS	<1000	fresh	Vilavancode, Thovalai, Agastheeswaram
	1000-3000	Slightly alkaline	Kalkulam
	3000-10000	Moderately saline	-
	10000-35000	High saline	-

**Table 5: Classification of open well water for irrigation purpose on the basis of Na%, SAR, EC, TH & TDS**

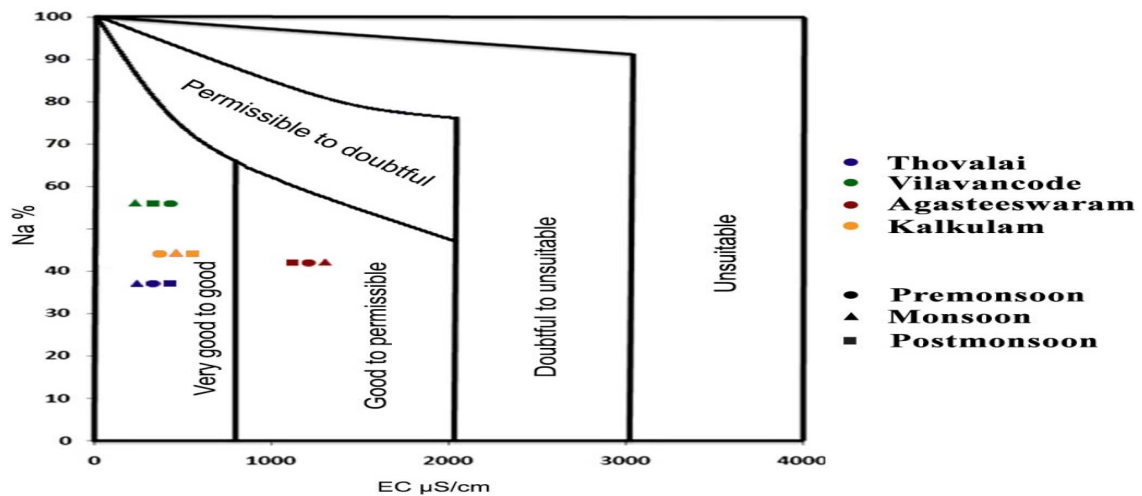
Parameters	Range	Water class	Status of water quality in the taluks
Na%	<20	Excellent	-
	20-40	Good	-
	40-60	Permissible	Vilavancode, Kalkulam, Thovalai, Agastheeswaram
	60-80	Doubtful	-
	>80	Unsuitable	-
SAR	<10	Excellent	Vilavancode, Kalkulam, Thovalai, Agastheeswaram
	10-18	Good	-
	18-26	Permissible	-
	>26	Doubtful	-
EC	<250	Excellent	-
	250-750	Good	-
	750-2000	Permissible	Vilavancode, Thovalai, Kalkulam, Agastheeswaram
	2000-3000	Doubtful	-
	>3000	Unsuitable	-
TH	<75	Soft	-
	75-150	Moderately Hard	Vilavancode
	150-300	Hard	Kalkulam, Thovalai, Agastheeswaram
	>300	Very Hard	-
TDS	<1000	Fresh	Vilavancode, Kalkulam, Thovalai, Agastheeswaram
	1000-3000	Slightly Alkaline	-
	3000-10000	Moderately Saline	-
	10000-35000	High Saline	-

**Table 6:** Classification of pond water for irrigation purpose on the basis of Na%, SAR, EC, TH & TDS

Parameters	Range	Water class	Status of water quality in the taluks
Na%	<20	Excellent	-
	20-40	Good	-
	40-60	Permissible	Vilavancode, Kalkulam, Thovalai, Agastheeswaram
	60-80	Doubtful	-
	>80	Unsuitable	-
SAR	<10	Excellent	Vilavancode, Kalkulam, Thovalai, Agastheeswaram
	10-18	Good	-
	18-26	Permissible	-
	>26	Doubtful	-
EC	<250	Excellent	Thovalai
	250-750	Good	Vilavancode, Kalkulam, Agastheeswaram
	750-2000	Permissible	-
	2000-3000	Doubtful	-
	>3000	Unsuitable	-
TH	<75	Soft	Thovalai, Agastheeswaram
	75-150	Moderately Hard	Kalkulam, Vilavancode
	150-300	Hard	-
	>300	Very Hard	-
TDS	<1000	Fresh	Vilavancode, Kalkulam, Thovalai, Agastheeswaram
	1000-3000	Slightly Alkaline	-
	3000-10000	Moderately Saline	-
	10000-35000	High Saline	-



**Fig 1:** Classification of bore well water for irrigation based on Wilcox 1955.



**Fig 2:** Classification of open well water for irrigation based on Wilcox 1955.

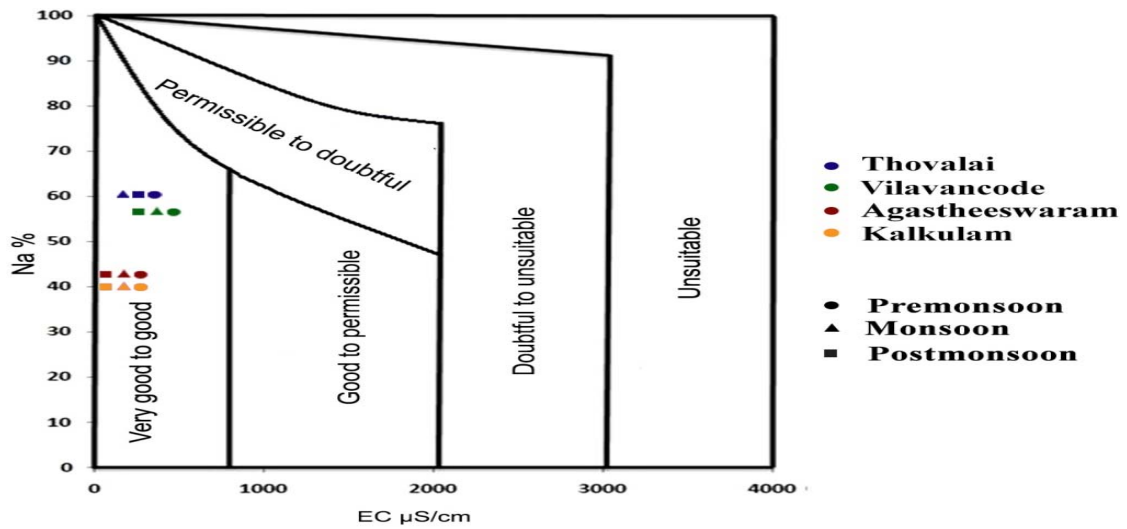


Fig 3: Classification of pond water for irrigation based on Wilcox 1955.

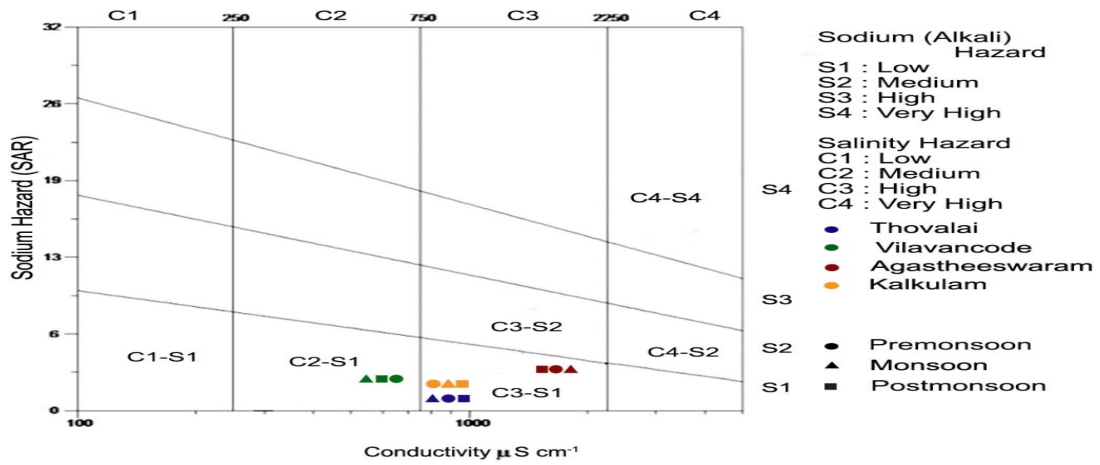


Fig 4: US Salinity diagram for classification of irrigation waters (bore well) based on Richards 1954.

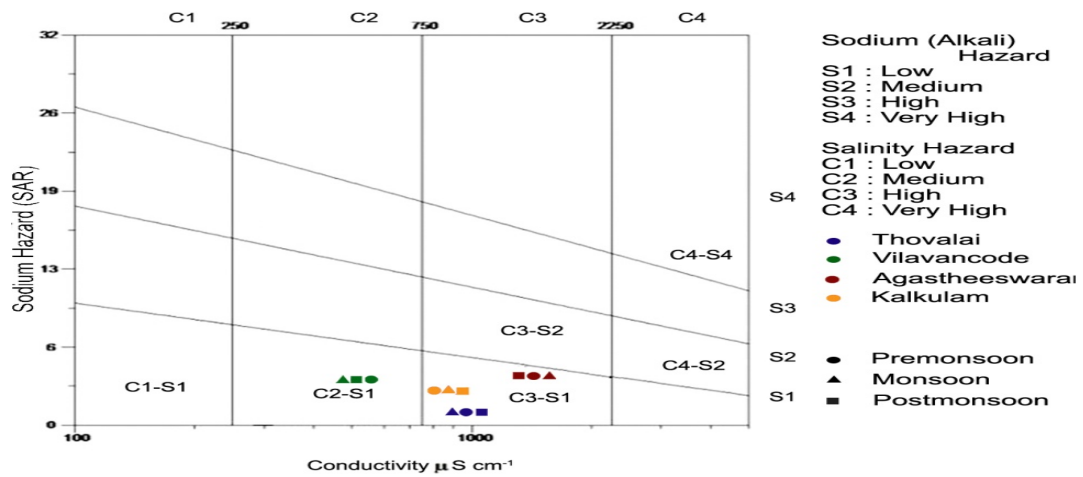


Fig 5: US Salinity diagram for classification of irrigation waters (open well) based on Richards 1954.

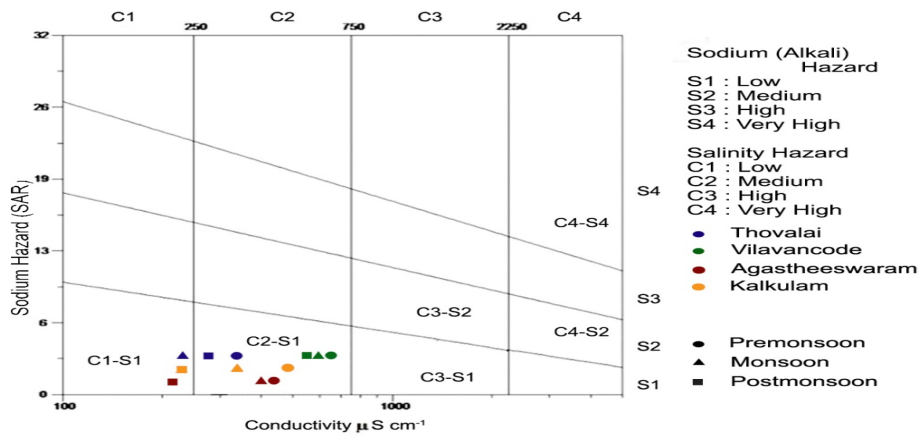


Fig 6: US Salinity diagram for classification of irrigation waters (pond) based on Richards 1954.

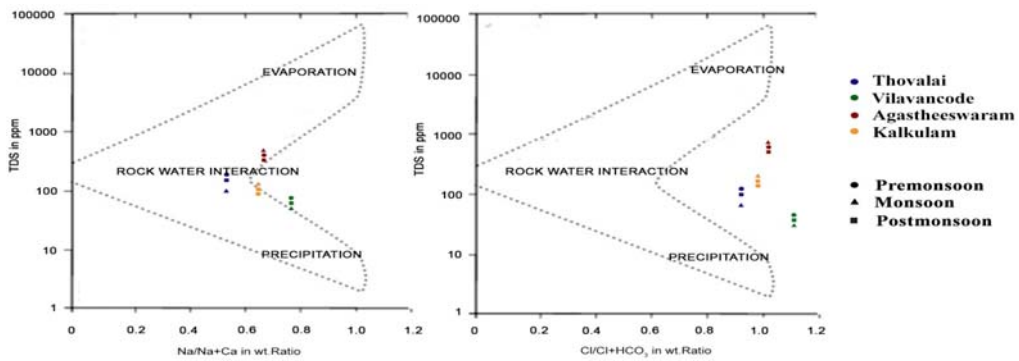


Fig 7: Gibb's diagram for the cations and anions of bore water samples.

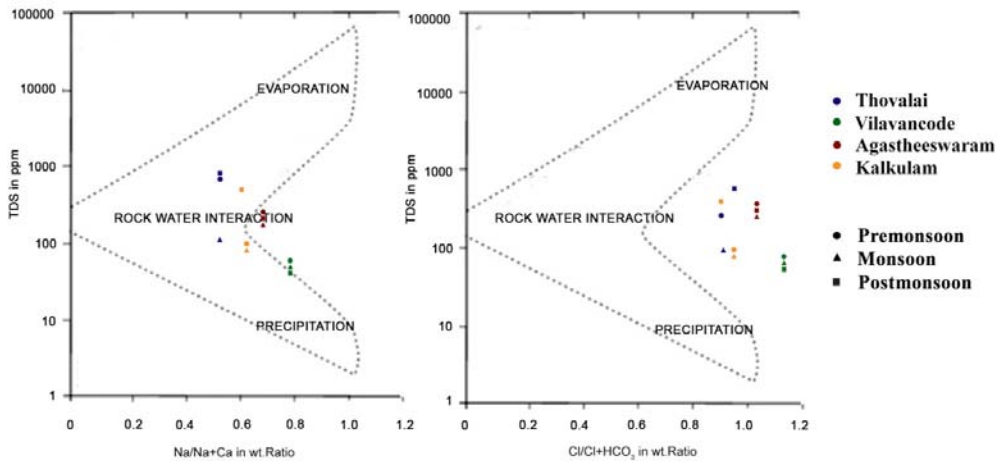


Fig 8: Gibb's diagram for the cations and anions of open well water samples.

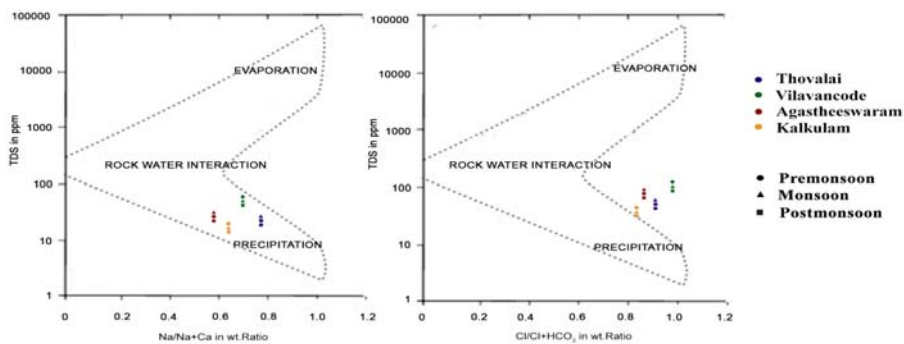


Fig 9: Gibb's diagram for the cations and anions of pond water samples.

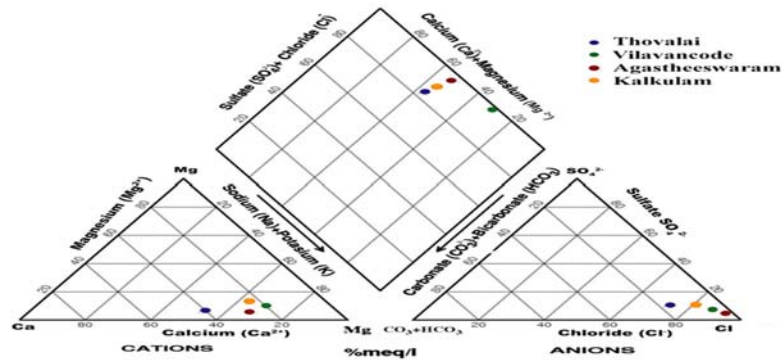


Fig 10: Piper Trilinear diagram for the various cations and anions composition of the water samples in bore well.

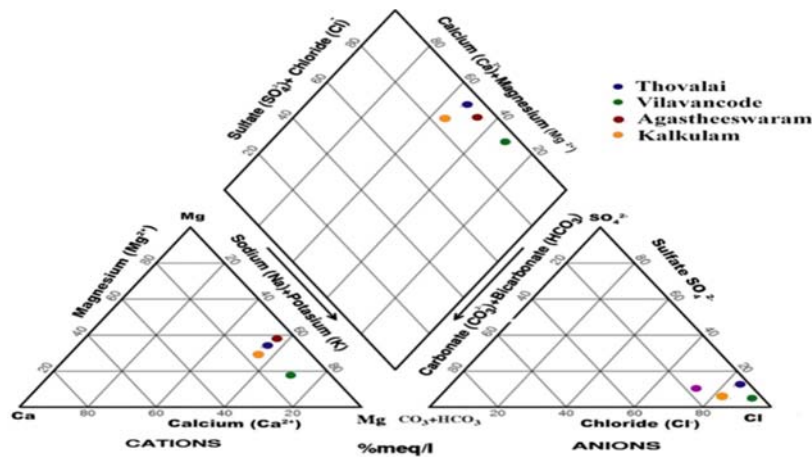


Fig 11: Piper Trilinear diagram for the various cations and anions composition of the water samples in open well.

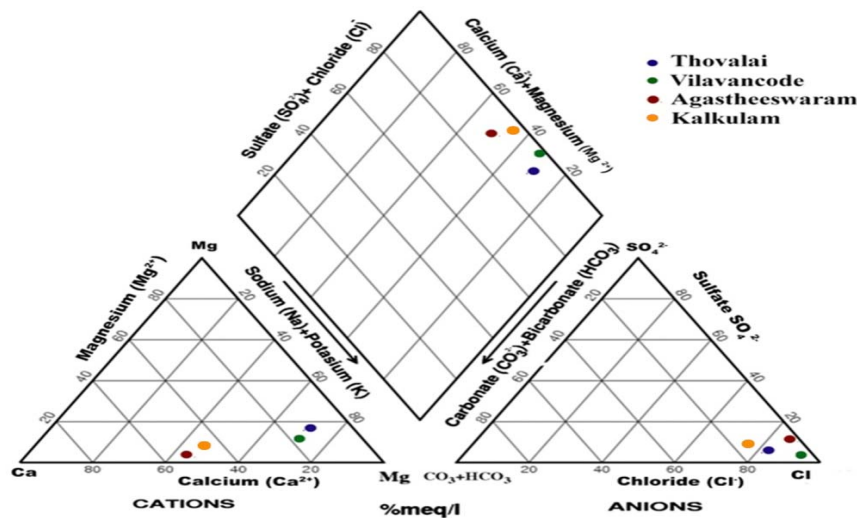


Fig 12: Piper Trilinear diagram for the various cations and anions composition of the water samples in pond.

## 5. References

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