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## Analysis of salt, water, and soil samples from selected areas in Jaffna Peninsula

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### ABSTRACT

Salt is the maximum commonly spread inorganic chemical in all over the world. It is a part of human food, and life without salt is improbable. Salt is widely used for cooking, preserving and for preventing roads from icing up. The study was carried out from March 2010 to September 2010. The salt samples were collected from Araly, Thanuvil, Uppuveli, Chemmani and vallai in the Jaffna peninsula, Sri Lanka. To determine the standard value, salt samples were collected from Puttalam and Palavi salt producing areas. The water, salt and soil sample were collected from Araly, Thanuvil, Uppuveli, Vallai, Chemmani, Kalundaiveli, and Kaarainagar in the Jaffna peninsula Sri Lanka.

In this study salt, water, and soil were analyzed for physical (pH, color, taste) and chemical ( $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{PO}_4^{3-}$ ,  $\text{Fe}^{3+}$ , total alkalinity and total solids) characteristics. The salt quality in all the salt samples except Thanuvil, are chemically safe for human consumption. Even though there are some visible impurities present in the salt. Chloride content of the Vallai and Chemmani areas were highly deviated from standard levels. In water analysis, magnesium, and calcium contents of both of Araly and Thanuvil, chloride content of the Uppuveli, potassium content of the Araly and sodium content of the Vallai were highly deviated from standard levels. In the soil samples, chloride content of the Uppuveli and Vallai, magnesium content of the Araly and Thanuvil, potassium content of the Kaarainagar were highly deviated from other places. In the correlation analysis between water and soil samples most of the quality parameters such as pH,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ,  $\text{Fe}^{3+}$ , total alkalinity and total solids are closely correlated to each other (70%-81%) and other parameters,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ , weakly related to each other (40%-70%).

**Keywords:** Soil Samples, Jaffna Peninsula, Food Processing, Sulphate Content

## INTRODUCTION

Salt is the most widely distributed inorganic chemical throughout the world and it is known to mankind from time to time. Salt is a part of human food, and life without salt is improbable. It is used as pure sodium chloride and as the raw material for obtaining sodium and chlorine for other process. Most of the salt is obtained from the salt beds [1]

Sea water is then allowed into the salt pans. The water evaporates under the heat of the sun becoming very salty “brine”. Gradually salt crystals form and settle out at the bottom of the brine. The rest water is known as bitten and drawn off. About 200 meters of sea water have to evaporate in order to get one meter of salt, so getting salt from salt pans is a slow process. [1]

There are no rivers in Jaffna peninsula. But there are three drainage channels, Valukkai aru – 8 miles in length, Upp aru – 9 miles in length and Thondamanaru aru – 22 miles in length. Which have their natural formations to drain out excess water into the adjoining lagoons. The topography of the peninsula is such that the elevation is only 40 feet high which is in the north of the peninsula. Tellippalai coastal is belt running down southwest towards the Araly Village area- lagoon. Valukkai Aru is also hedged in the East by stretch of land, whose height varies from 40 feet in the north K.K.S. running south wards ranging from 40 feet to 30 feet, 20 feet and 10 feet while ending up in the Jaffna lagoon area [2]

The mean annual precipitation of Jaffna peninsula is 1209 mm with a mean deviation of 30 mm and the mean annual temperature is 27.6°C. This atmospheric behavior prevails both in dry and rainy periods. The rain fall for the peninsula results from a depression or convectional rain, from about October to November followed by northeast monsoonal rains from December to February together this period constitute the wet season. In this region, often there are brief spells of rain is due to convectional currents in March / April and again around July.

Soil is one of the important national resources of any country. It is a living dynamic resource that supports plant life. It is made up of different size of mineral particles (sand, silt, clay, etc), organic / inorganic matter and numerous species of living organisms. Soil has biological, chemical, and physical properties that are always changing. Some of the important properties such as colour, texture, structure, density, porosity and etc are used for the classification of the soil.

The Jaffna peninsula’s formation of “soil structures” consists of 3 different categories.

1. The lowest strata are of the “Maosin” period with crevices where water seeps in goes underground (The soil in these strata is either red in colour or ash in colour.)
2. The second strata consist of mixture of two varieties, via red soil and clay.
3. The third strata consist of sandy soil which has been formed the effects of wind and rain.

### Importance of salt

Sodium chloride is the salt most responsible for the salinity of the ocean and of the extracellular fluid of many multicellular organisms. As the major ingredient in edible salt, it is commonly used as a condiment and food preservative. Salt is the basic raw material for a large no of inorganic chemical industries such as caustic soda and chlorine, soda ash, sodium sulphate, hydrochloric acid, etc. It also finds use in a large no of other industries such as oil hydrogenation, soap manufacture, dyes, leather, textile, food processing etc. [3]

Sodium chloride is sometimes used as a cheap and safe desiccant because it appears to have hygroscopic properties, making salting an effective method of food preservation historically; the salt draws water out of bacteria through osmotic pressure preventing them from reproducing and causing food to spoil. Even though more effective desiccants are available, few are safe for humans to ingest.

### **Physical and Chemical Characteristics of seawater**

Seawater is a mixture of various salts and water. Most of the water in the ocean basins is believed to originate from the condensation of water found in the early atmosphere as the Earth cooled after its formation. This water was released from the lithosphere as the Earth's crust solidified. Additional water has also been added to the oceans over geologic time from periodic volcanic action. Some scientists have recently speculated that comets entering the Earth's atmosphere may be another important source of water for the oceans [4]

Maximum of the dissolved chemical constituents or salts found in seawater have a central origin. It seems that these chemicals were released from continental rocks through weathering and then carried to the oceans by stream runoff. Only six elements and compounds comprise about 99% of sea salts: chlorine (Cl<sup>-</sup>), sodium (Na<sup>+</sup>), Sulphur (SO<sub>4</sub><sup>2-</sup>), magnesium (Mg<sup>2+</sup>), calcium (Ca<sup>2+</sup>), and potassium (K<sup>+</sup>) The relative richness of the major salts in seawater are constant regardless of the ocean. Only the amount of water in the mixture varies because of differences between ocean basins because of regional differences in freshwater loss (evaporation) and gain (runoff and precipitation).

### **Physical and chemical properties of soil**

Soil may be defined as a thin layer of earth's crust which serves as a natural medium for growth of plants. It is the unconsolidated mineral matter that has been subjected to, and influenced by, genetic and environmental factors- parent material, climate, organisms and topography all acting over a period of time. Soil differs from the parent material in the morphological, physical, chemical and biological properties. Also, soils differ among themselves in some or all the properties, depending on the differences in the genetic and environmental factors. Thus, some soils are red, some are black; some are deep and some are shallow; some are coarse textured and some are fine-textured. They serve as a pool of nutrients and water for crops, provide mechanical anchorage and favorable tilth. The constituents of soil are mineral matter, organic matter, water and air, the proportions of which vary and which composed form a system for plant progression; therefore, the need to study the soils in perspective.

The aim of this research work is to study the physical and chemical characteristics of salt, water, and soil from some selected salt bunds in Jaffna, comparison of the salt with puttalam salt (Sri Lanka std), and correlation analysis between water and soil use the physical and chemical parameters.

## **EXPERIMENTAL METHODS AND MATERIALS**

### **Sampling plan**

Water and soil samples were collected from following areas

1. Araly (A)
2. Thanuvil (B)
3. Vallai (C)
4. Chemmani (D)

5. Uppuveli (E)
6. Kalundaiveli (F)
7. Kaarainagar (G)

The salt samples were collected from Araly, Thanuvil, Vallai, Chemmani, Uppuveli, in Jaffna areas, puttalam and palavi.

### Collection of water and soil samples

The water was collected of 10-30 cm deep, using plastic bucket and stored in clean, security sealed polyethylene bottles. The soil samples were collected of 10-30 cm deep in land. The research project was carried out during the period from March 2010 to September 2010.

### Analytical techniques

Water, soil and salt samples, were brought to the advanced inorganic chemistry laboratory of the University of Jaffna for the determination of quality indicators. The chemical analysis was carried out on each sample within 48 hours of collection.

### Physical Characteristics

The physical characteristics of sea water, such as, pH, taste, colour were determined by the standard methods [5].

### Chemical characteristics

The Chemical characteristics of sea water and salt, such as, Chlorides, Salinity, Total alkalinity, Calcium, Magnesium, Total hardness, Sulphate, Sodium, Potassium, Phosphate, and Iron were determined by the standard methods [5-7].

All the results were analyzed statistically in 95% confidence level.

## RESULTS AND DISCUSSION

### Analysis of sea water samples

The results in the Figure 1 indicate that the pH values of the Jaffna sea water ranges from 6.8 to 8.3. This is slightly acidic and alkaline. Normally pH of sea water found to be in the range of 8.0 to 8.6. While we are collecting samples, due to the rain in the sampling areas, the pH range is decreased.

Total solids of water sample can be determined by evaporating a known amount of sample and after that weighing the residue. The results in the Figure 2 indicate that the total solid of sea water sample's maximum range is observed in Araly, but most of the areas are under the safe level.

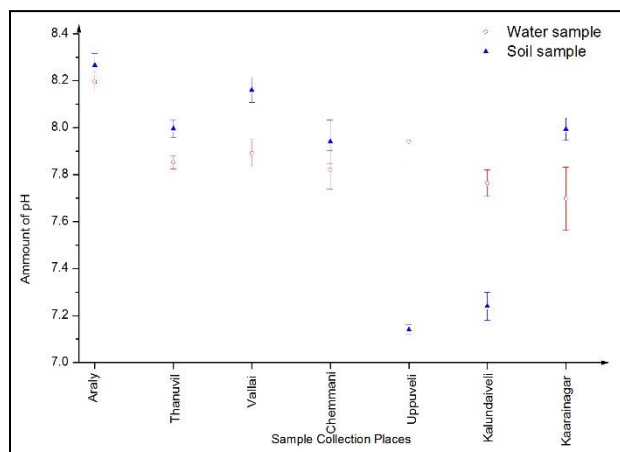


Figure 1: pH values of sea water and soil samples

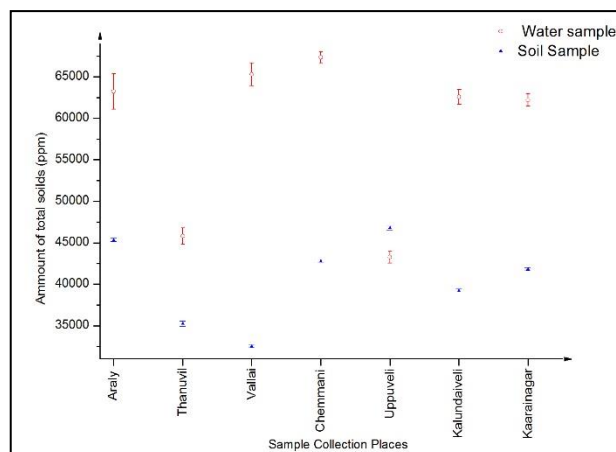


Figure 2: Total solids values of sea water and soil samples

Interestingly most of the areas have lower chloride content than standard level. Due to the rain water the chloride content was decreased than dry season. In Figure 3, Araly showed maximum value of the chloride content.

Most of the areas have showed lower alkalinity than standard level. Due to the rain water the alkalinity was decreased than dry season. In Figure 4, Chemmani area showed maximum alkalinity value.

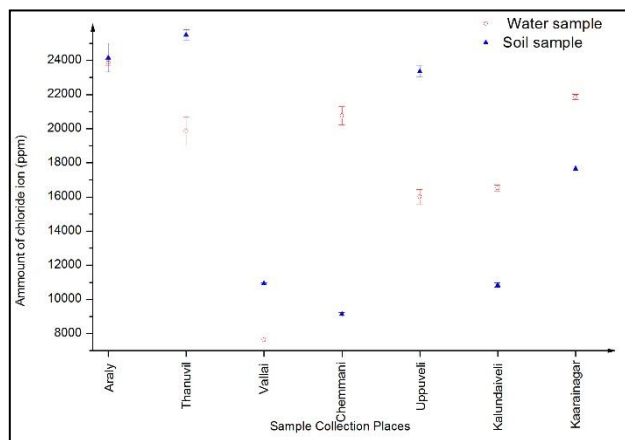


Figure 3: Chloride values of sea water and soil samples

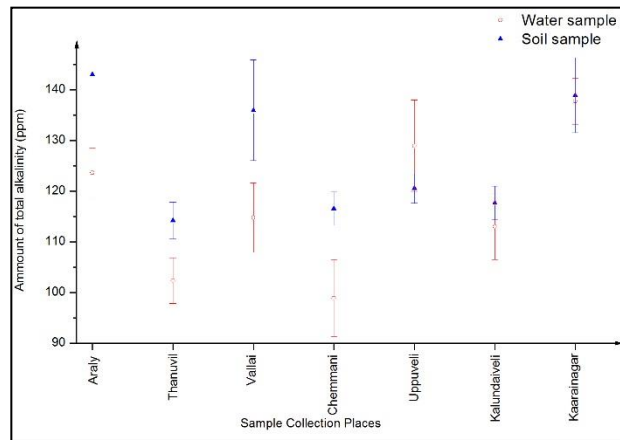


Figure 4: Alkalinity values of sea water and soil samples

The analysis show that the amount of sulphate (Figure 5) in water samples is well below the standard level.

Most of the areas have lower calcium content than standard level. Due to the rain, it was decreased than dry season. Araly and thanuvil showed maximum values of calcium in Figure 6.

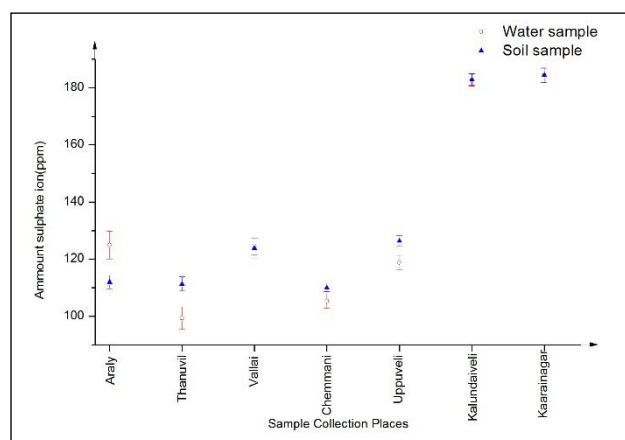


Figure 5: Sulphate values of sea water and soil samples

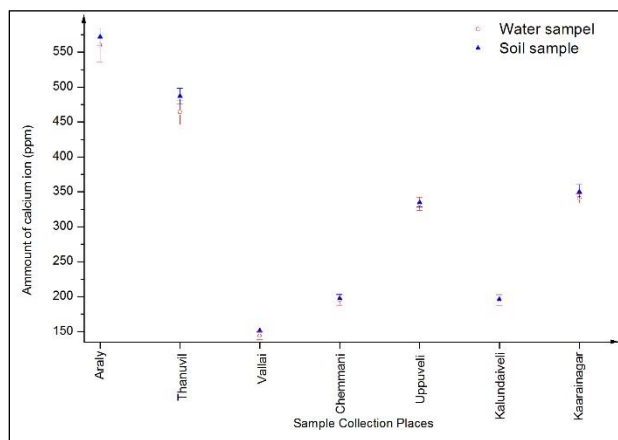


Figure 6: Calcium values of sea water and soil samples

Most of the areas sea water sample have lower the Mg content than standard level, Figure 7 indicates that Araly and thanuvil showed above the standard level. This phenomenon observed due to presence of rain water.

Standard addition method was used to determine the amount of sodium content. Direct determination from calibration curve will not give accurate value because the sample contains a considerable amount of calcium, which will interfere with the absorption of sodium. This Figure 8 indicates most of the areas have safe level of sodium content. Due to the rain water the sodium content was decreased than dry season. Araly showed maximum value of sodium content.

Most of the areas of sea water sample have lowered the K<sup>+</sup> content than standard level, In Figure 9, Araly showed maximum range. Due to the rainy season, most areas showed below the standard level.

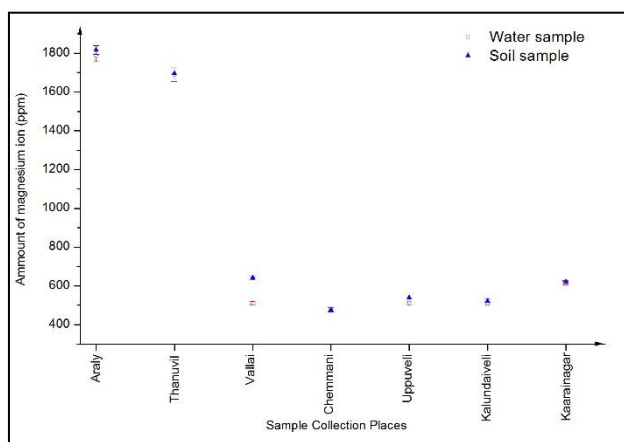


Figure 7: Magnesium values of sea water and soil samples

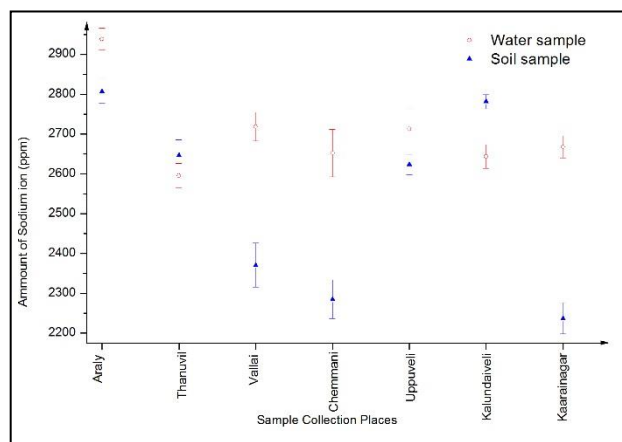


Figure 8: Sodium values of sea water and soil samples

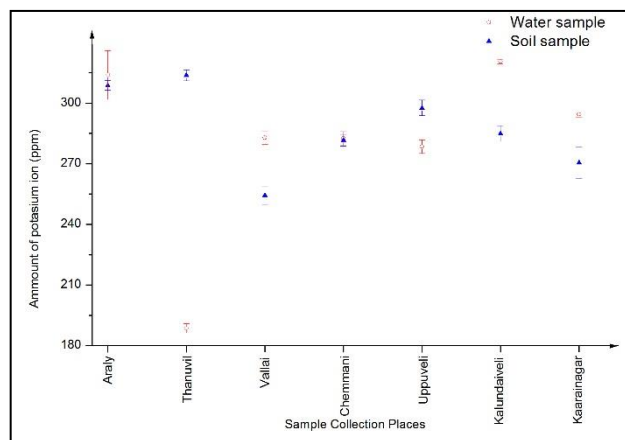


Figure 9: Potassium values of sea water and soil samples

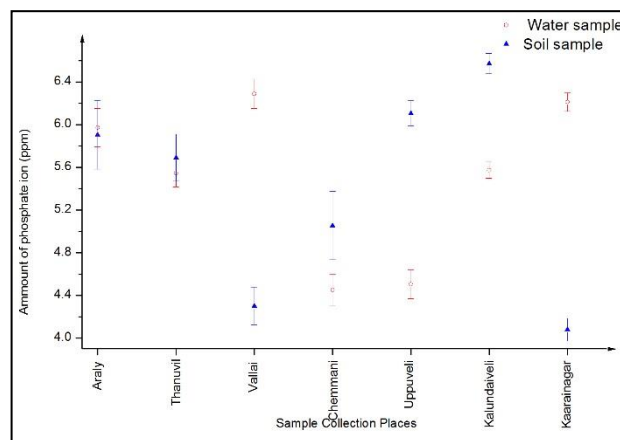


Figure 10: Phosphate values of sea water and soil samples

Araly showed the maximum range of phosphate content in the Figure 10. But vallai shows high value of phosphate content. Others show medium level of phosphate content. The Figure 11 indicates Araly, Thanuvil, Chemmani shows large range of iron content. Remaining areas show very low value.

Analysis of soil samples

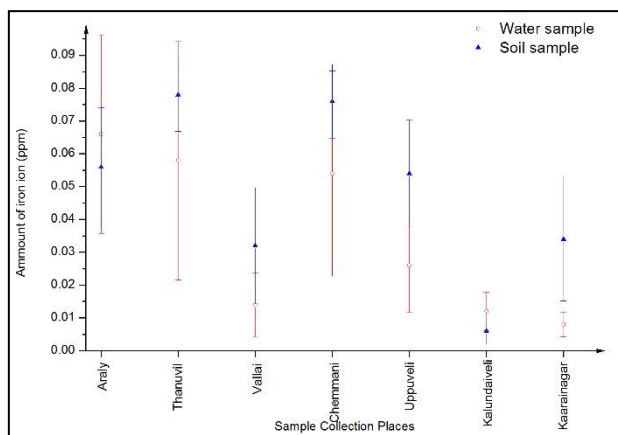


Figure 11: Iron values of sea water and soil samples

The results in Figure 1, indicates that the pH values of the Jaffna soil samples near the salt bund, ranges from 6.8 to 8.3, which is slightly acidic to alkaline. Vallai area has the maximum range of pH value (7.3 to 8.5). In Figure 2, Chemmani has high value of total solids content in soil samples. Uppuveli has lowest value of total solids contents. In Figure 3, it is clearly shows that Araly has maximum value of chloride content in soil samples near salt bunds. Uppuveli and Vallai have low value due to the rainy season chloride content is low value [8]. The Figure 4, indicate Uppuveli has maximum range of alkalinity content. Other places show average range of alkalinity content. Kalundaiveli and kaarainagar have high value of sulphate content [9,10] and other places have average sulphate content in Figure 5. Araly soil sample has maximum range of calcium and magnesium content in the Figure 6 and 7 respectively. Remaining all other places has low range of the both calcium and magnesium content. The Figure 8 shows that many of the area’s sodium content found to be above 2500 ppm. But Araly shows high value of sodium content, (2600 -3000 ppm). Meantime kaarainagar area showed low range between 2000-2400 ppm. In the case of potassium content, all the analyzed areas places showed above 250 ppm in the Figure 9. Kaarainagar showed maximum range as 220-325 ppm. Further the analysis indicates in the Figure 10, that the Araly and vallai have high range of phosphate content. All the places showed below 8.0 ppm. The average range of iron content of the analyzed areas found to be as 0 to 0.18 ppm in the Figure 11.

Analysis of salt samples.

The letters denoting the sample locations in the Figures are, **A** – Araly, **B** – Thanuvil, **C** - Uppuveli, **D** – Vallai, **E** – Chemmani, **H** - Puttalam A, **I** - Puttalam B

Estimation of pH of salt samples

Normally pH values of the salt of Sri Lanka Standard ranges from 7.5 to 8.5 at 25° -29°C. It is slightly acidic to alkaline. The

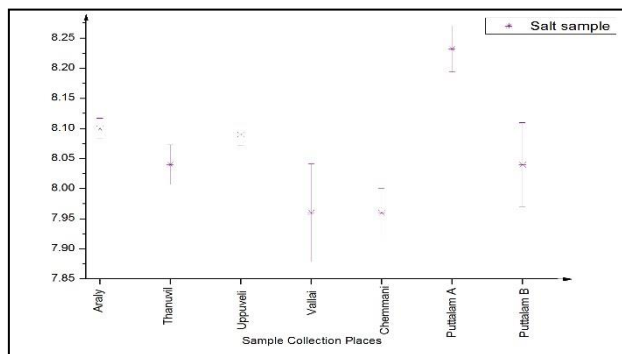


Figure 12: pH values of salt samples

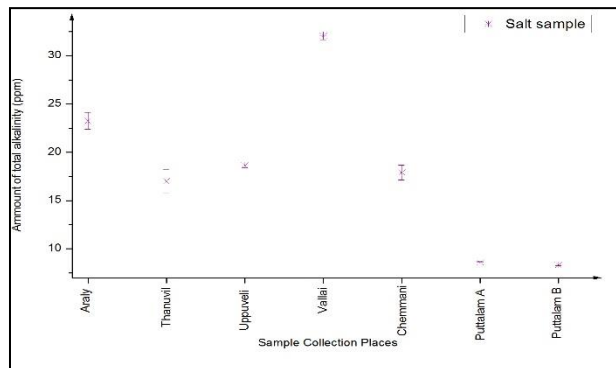


Figure 13: Alkalinity values of salt samples

results indicate that the range maximum in Jaffna is 7.4 to 8.4. Most of the areas contain included in this range (7.5 to 8.5). The pH values obtained from all the places were analyzed statistically in 95% confidence level is shown in Figure 12.

### Estimation of amount of total alkalinity

Total alkalinity was determined by direct titration with standard acid. This result indicates most of the areas have lower alkalinity than standard level. Vallai area shows highest than standard level. Due to the rain water the alkalinity was decreased than dry season. Total alkalinity content is obtained from all places were analyzed statistically in 95% confidence level. The result of this analysis is shown in Figure 13.

### Estimation of amount of chloride

The amount of soluble chlorides was determined by Mohr method, by titrating with standard  $\text{AgNO}_3$  solution using  $\text{K}_2\text{CrO}_4$  as an indicator. The sea water is normally in slightly alkaline medium. So, Mohr method is preferred for determination of chloride ion. The major component of the salt is sodium and chloride. Vallai and Chemmani show higher than the standard level. Araly and thanuvil show low value. Chloride content is obtained from all places were analyzed statistically in 95% confidence level. These analyses are shown in Figure 14.

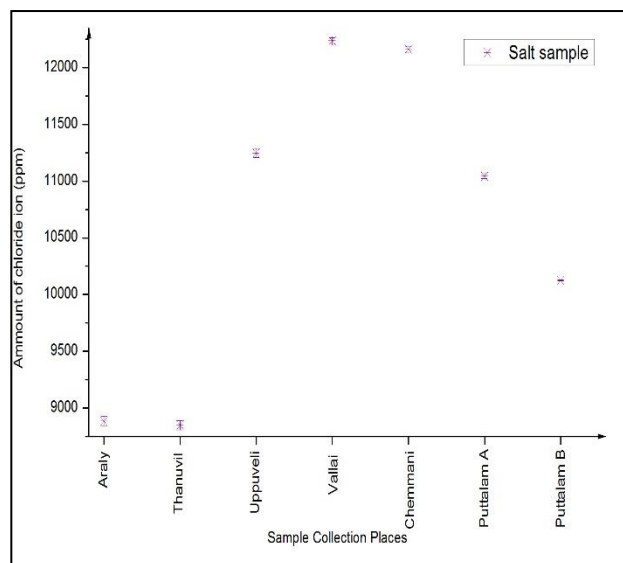


Figure 14: Chlorides values of salt samples

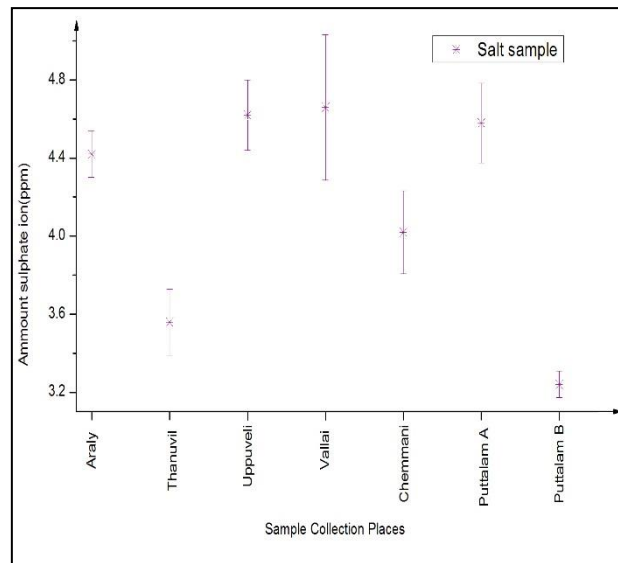


Figure 15: Sulphates values of salt samples

### Estimation of amount of Sulphates

Sulphate is determined by Complex metric titration with standard EDTA. Vallai area show maximum range of sulphate content, other areas show lower than the standard level. Sulphate content obtained from all places were analysed statistically in 95% confidence level. Statistical analysis is shown in Figure 15.



### Estimation of the amount of soluble Ca and Mg

The classical routine method for determining Ca and Mg is by a complex metric titration using EDTA. Puttalam A shows maximum range of calcium content. But all areas show the standard level range. All areas show above the standard level (28 ppm) in magnesium content. Calcium and magnesium content were obtained from all places were analyzed statistically in 95% confidence level. This analysis is shown in Figure 16 & 17 respectively.

### Estimation of Amount of Sodium and Potassium

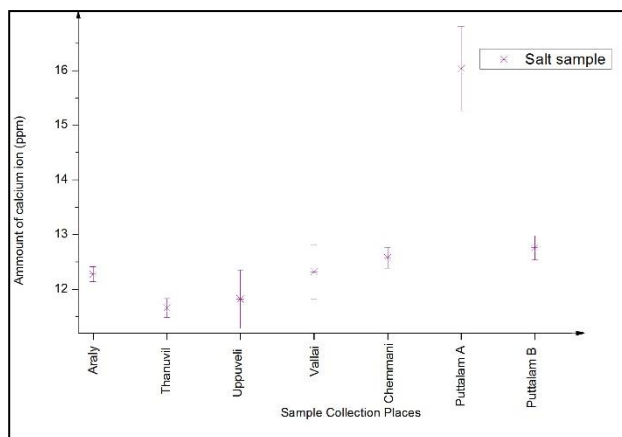


Figure 16: Calcium values of salt samples

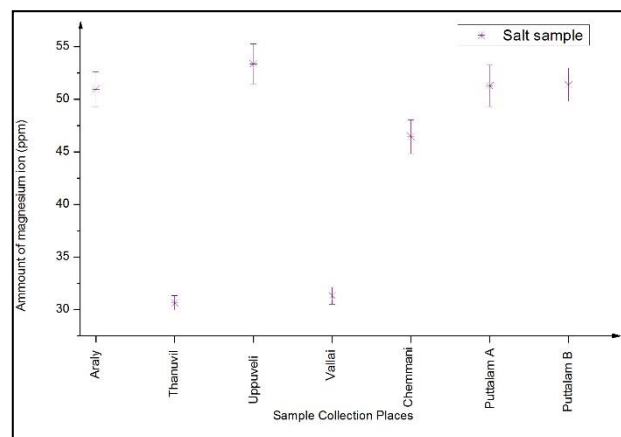


Figure 17: Magnesium values of salt samples

The flame photometry was used in salt analysis for determining the concentration of alkali and alkaline earth metals such as Na, K, Ca, Ba, and Li. Vallai and Chemmani show higher than the standard level. Araly and thanuvil show low value in sodium content. In the case of potassium content, all places showed above 280 ppm. Sodium and potassium content obtained from all places were analyzed statistically in 95% confidence level is shown in Figure 18 & 19 respectively.

### Estimation of Amount of Phosphate

The analyses indicate that the Thanuvil shows high range of phosphate content. All the places showed below 3.5 ppm. The phosphate content obtained from all the places were analyzed statistically in 95% confidence level is shown in Figure 20.

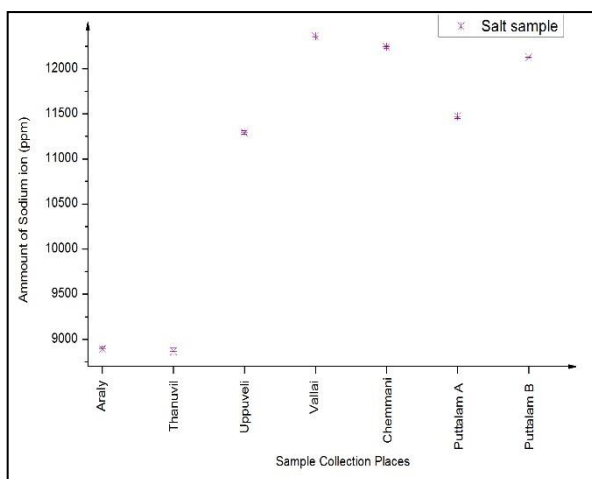


Figure 18: Sodium values of salt samples

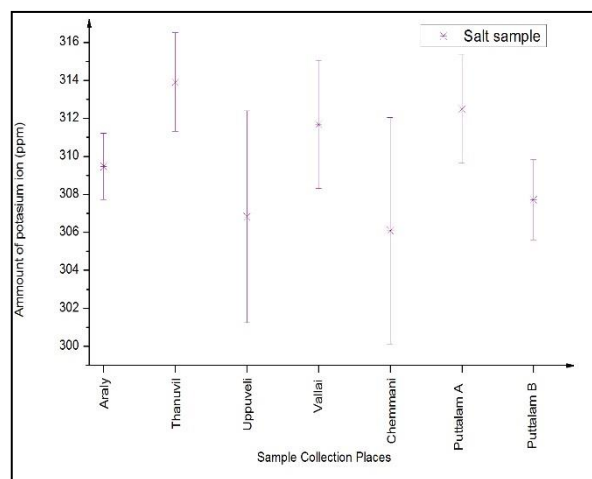


Figure 19: Potassium values of salt samples

### Estimation of Amount of Iron

The amounts of iron present in sea water samples are determined by absorbance method. The results indicate that Vallai shows high range of phosphate content. All the places showed below 0.16 ppm. Most of the areas show low range of iron content. Iron content obtained from all places analyzed statistically in 95% confidence level is shown in Figure 21.

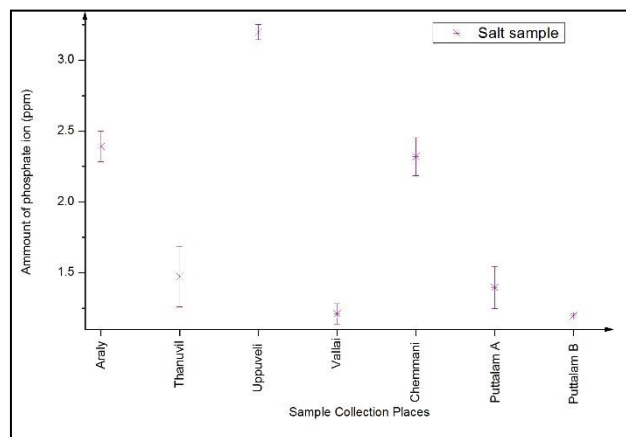


Figure 20: Phosphate values of salt samples

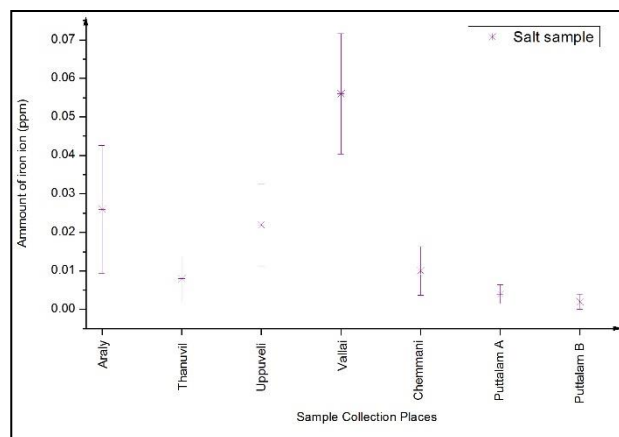


Figure 21: Iron values of salt samples

### CONCLUSION

This investigation focused on the characteristic phenomena of the quality of salt and correlation between water and soil by measuring their physical and chemical properties during the period from March 2010 to September 2010. The calcium and magnesium quality problem exists in the all selected salt samples. Magnesium content is related to higher than other quality parameters in Chemmani areas. Because in Jaffna, magnesium contents are high and found in sea water in high amount related to calcium. The pH values of all the salt samples were found to be in the range of 7.4 to 8.4. The pH was on the safe level. In most of these salt samples the total alkalinity was below the standard level. But vallai area shows higher than standard level. The major component of salt is sodium and chloride. Most of these samples show higher than the standard level of the chloride. Sulphate also higher than the standard level in these samples.

The sodium content is higher than the standard level in Chemmani and uppuveli area. In other areas amount looks below the standard level. Although the potassium content is found to be in the standard level. The phosphate and iron quality is below the standard level in all these salt samples. The salt quality in all the salt samples (except Thanuvi), are chemically consumption. But there are some visible impurities present due to the plantation. Therefore, when it is used for the human consumption it should be well washed. The water and soil samples collected from near these salt bund areas. The quality was investigated by measuring the physical and chemical parameters. The pH values of the water samples were found to be in the range of 6.8 to 8.3, in other case the soil samples were found to be the range 6.8 to 8.3. In most of these water samples the total solids was below the safe level. Both in Chemmani water and soil samples show high value of total solids. In the water selected from the Chemmani, Araly Thanuvil, Kalundaiveli, Kaarainagar, uppuveli and vallai. We found the excess amount of chloride sodium potassium and

sulphate. It is safe for the human consumption except drinking purposes. In soil samples, they were also found this problem in quality of chloride, sodium potassium and sulphate. Calcium and magnesium quality problem exists in all these area's water and soils. Phosphate and iron were below the safe level in water samples and low values in soil samples. During this study period, we can't get the details of standard in the soil quality parameters. So, we didn't compare the soil sample with standard level. The correlation analysis between water and soil samples the physical parameter pH, chemical parameters chloride, calcium, magnesium, sodium, potassium is closely related to each other (70%-82%) and other parameters weakly related to each other (40%-70%). Most of the parameters correlated in the water and soil samples. But in my study season irregular rainy season was observed. Therefore, some quality parameters were irregular change. All the parameters of water samples significantly compared with standard level.

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