Identification of Factors Affecting the Groundwater Quality in Velanai Divisional Secretariat Area, Jaffna.

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Abstract: **Groundwater is a precious natural water resource. In Sri Lanka, 72% of the rural population and 22% of the urban population are depending on groundwater. Jaffna district is only depending on groundwater sources. Velanai Divisional Secretariat area groundwater resources are a danger due to salinity problem. In the dry season, people most affected to obtain good quality water. A detailed literature review was carried out to understand the reasons and how to overcome them. A survey with a questionnaire was conducted and chemical parameters analyzed also done. According to the analysis only one well's water, the quality was below the permissible level. 97.50 % of wells were not suitable for drinking. The quality is depending on the soil geology and elevation from the mean sea level. The maximum elevation of Velani area is 9m and Pungudutivu is the flat terrain and average ground surface elevation from MSL is 2m. The groundwater table is 0 – 1.85m in the Pungudutivu area and the major reason for water pollution is mixing saline water with fresh water. The main reasons were seawater intrusion into the wells, over extraction and the solutions were water treatment plant for desalinization and alternative water resources should be identified.**

Keywords: **Groundwater quality, Water pollution, Salinity, Seawater intrusion, Desalination**

I. INTRODUCTION

Water is an immense natural resource. Groundwater is the second largest fresh water source in the world. 87% of the fresh water is ice and 12% of the fresh water is groundwater. In Sri Lanka, 72% of the rural population and 22% of the urban population are depending on groundwater. It is about 60% of the total population (Villholth & Rajasooriyar, 2009). According to the World Health Organization report, 80% of the diseases are caused by water (V.Jeevaratnam, S.Balakumar, T.Mikunthan, & M.Prabaharan, 2018).

Two types of water sources are available in Northern Province such as groundwater and surface water. Jaffna districts are using surface and groundwater for domestic and agriculture purpose. The main source of recharge to the groundwater is rainfall. Pure drinking water is the main problem faced by the people in the Jaffna district. The total area of the Jaffna district is 1025 Km^2. Land area is 929 Km^2 and water area is 96 Km^2. The administrative regions of Jaffna district include many islands. The main islands are Kayts, Pungudutivu, Nainativu, Analaitivu, Eluvaitu, Neduntivu and Karainagar. Velanai Divisional Secretariat area is covered Mandativu, Allaipiddy, Velanai, Pungudutivu and Nainativu. These areas surrounded by seawater. This division covers an area of 98.4 Km^2. The population of the division was 18,674. Total Velanai divisional area people are depending on the groundwater resource. Agriculture and fishing are the main income source in the area. In this area, Agro wells in their own land and 44 small ponds are being used for agriculture purpose and open dug wells and tube wells are using for drinking purpose.

The groundwater in this area is in danger due to the salinity problem. In the dry season, people most affected to obtain good quality and salinity was increased in the dry season. Before a few decades, this area water was quality good and now the water quality is decreased by human impacts and other external factors. Several wells once used to supply potable water are not in use now due to the increase of salinity.

Objectives

- To identify the factors and reasons affecting the groundwater quality in Velanai Divisional Secretariat area, Jaffna.
- To provide suggestions to overcome the problem.

Figure 1 Project location

II. LITERATURE REVIEW

Jaffna district is mainly underlain by Miocene limestone, the limestone is flat bedded, and vertical thickness is over 100m (Janen & Sivakumar, 2014). Jaffna district has less percentage of surface water because the terrain is flat (Hidayathulla & Karunaratna, 2013). Groundwater is stored in the sub terrain layer of miocene limestone in Jaffna district (Hidayathulla & Karunaratna, 2013). Whole areas depend on groundwater source (Hidayathulla & Karunaratna, 2013).

Jaffna district people are using groundwater sources for home, agricultural and manufacturing purposes (Jeevaratnam, Balakumar, Mikunthan, & Prabaharan, 2018). Jaffna district is depending on the groundwater source for all water requirements (V.Jeevaratnam et al., 2018).

Climate variability and change influences groundwater systems both directly through recharge and indirectly through changes in groundwater use (Taylor, 2013). Salination of fresh groundwater is highly associated with groundwater withdrawal (Lee & Song, 2006). The lifespan of the ground water is determined by the rate of groundwater withdrawal (Taylor, 2013). Which wells are located near lagoon are totally contaminated by salt water (Hidayathulla & Karunaratna, 2013). The over extraction of groundwater also creates the salt water intrusion and the best groundwater sources are located in sand dune aquifer (Hidayathulla & Karunaratna, 2013). Taylor (2013) discusses of seawater intrusion into coastal aquifers depends on the factors including coastal topography, recharge and groundwater abstraction from coastal aquifers.

Sivakumar (2013) through their study concluded the reasons for water pollution are planned usage of groundwater resources has not implemented since the eighties, planned recharging process also has not implemented since eighties and saltwater intrusion is being taken place due to the none maintenance of saltwater exclusion bunds. Garbage and soakage pit pollution and increased the usage of fertilizer affect groundwater quality (Sivakumar, 2013). Nirojan, Subramanium, & Sivakumar, (2016) discusses an early period groundwater was take using pulleys, the rate of extraction was slow comparing to recharge by annual rainfall but later three decades groundwater has polluted by variability of rainfall, indiscriminate extraction of water, instruction of salt water, increasing the population, increasing the usage of chemical fertilizers, unplan development and directly opening sewerage to soil. In the dry season water table fall below the sea level due to over extraction and the static equilibrium of the freshwater lens into smaller units and the salt water ingress in the wells from the lagoon (Nirojan et al., 2016).

All groundwater sources should be protected from over extraction (Hidayathulla & Karunaratna, 2013). Janen & Sivakumar (2014) recommended increasing the groundwater resources through recharge from off stream reservoirs and prevention of saltwater intrusion into the aquifers of the land region are reduce the groundwater pollution. Due to the lack of surface and groundwater sources, alternative water sources should be identified (Ariyananda & Aheeyer, 2011). Ariyananda & Aheeyer (2011) concluded through their study the importance of rainwater harvesting as a solution to overcome the water scarcity in Sri Lanka. Nirojan et al. (2016) concluded through their study the short term solutions are water supply through common tanks and construct the water treatment plant for desalinization and use the by product of the treatment as the raw material for salt production, long term solutions are rehabilitating the Jaffna lagoon scheme and rehabilitate the ponds.

III. METHODOLOGY

Secondary data and information of the area were collected from various organizations such as Divisional secretariat, Velanai, Office of the medical officer of health and Velanai predeshiya sabha. Additional Director of Planning provided some area well locations and reports. The collected secondary data were related to Velanai and Pungutivu areas. Therefore, the balance areas (Mandativu, and Allaipiddy) data were collected through an experiment. A well-structured questionnaire was prepared to identify influencing reasons and suggestions. The questionnaires were personally administered and close ended. A questionnaire survey with a 5-point Likert scale was chosen to identify the objectives. A Likert scale of 1-5, where 1 is strongly disagree, 2 is disagree, 3 is neutral, 4 is agree, 5 is strongly agree was provided to gather and analyze the level of importance of each factor. Forty water testing samples from experiment and secondary data were selected randomly for analysis of the parameters. 30 prominent were selected from the technical and public. The data collected from the questionnaire survey were analyzed according to the mean value by mean value therm. Weighted average mean value on each variable was calculated and assigned by descending order. Water quality was experimentally checked in terms of electrical conductivity, salinity and total dissolved solids which are most critical water quality parameters in Jaffna peninsula.

IV. FINDINGS

Questionnaire Survey

As per the questionnaire survey, 96.67% of residences have wells and 3.33% of residences have water supply lines and 76.67% of people are using wells and 20.00% of people using water supply and 3.33% of people are using water supplied by water bowsers to their daily activities. 26.67% of people wells were very bad and bad, average, good and very good percentage was 26.67%, 23.33%, 6.67% and 16.67% respectively. Most of the wells water quality was less and less amount of wells were of good quality. Water quality was changing seasonally. It is clearly indicating that many people are not using good quality water for their daily activities. Through this analysis, 50.00% of people wells were using water supplied by bowsers and 20.00%, 20.00% and 10% of people were using well, water supply and other sources respectively. Pure drinking water is the main problem in this area. As per the above chart, 80% of the people are not using well water for drinking purpose.

Through the survey, Reasons for the problem differed with public and technical staff. The main reason was seawater intrusion into coastal aquifers or wells. Because Velanai divisional area is covered by the sea. That is why seawater is intrusion into the wells. The freshwater lens is floating above the saline water. Any over extraction from these freshwater lenses results in the coming or entering of the underlying

saline water into the fresh water. Another main reason was over extraction of groundwater from the wells. This reason related to the first reason. Other reasons were mostly the same as two surveys. Most of the reasons were protected from seawater intrusion into the aquifers or wells.

Reasons

1. Seawater intrusion into coastal aquifers/wells
2. Over extraction of groundwater from the wells
3. Non maintenance of saltwater exclusion bunds
4. Less amount of recharge
5. Less amount of annual rainfall/variability of rainfall
6. Not maintenance of the ponds/tanks
7. Not maintenance or implement the rainwater harvesting system
8. Non proper management of existing water resources
9. Non proper management of existing water resources
10. Shallow groundwater table

The first recommendation to overcome the problem was water treatment for desalinization. This solution is cost effective and needs high technology. However, this is the most suitable method to overcome the problem. Because other solutions and available practices can reduce problems only. Other solutions were reducing the seawater intrusion into the coastal aquifers. Another solution was identifying the alternative water source. Such as the rainwater harvesting system and pipe water from other areas.

V. RECOMMENDATIONS

Following were concluded through the survey to overcome the problem.

1. Water treatment plant for desalinization
2. Maintenance of salt water exclusion bunds
3. Maintenance of the ponds/tanks
4. Maintenance or implement the rainwater harvesting system
5. Prevention of saltwater intrusion
6. Groundwater sources should be protected from over extraction
7. Promoting of micro irrigation
8. Alternative water sources should be identified

Chemical Parameters of the wells

Three chemical parameters mostly related to coastal area groundwater quality were analyzed from selected testing reports. The parameters are salinity, electrical conductivity and total dissolved solids. These are the main parameter affecting the water quality in the area. Salinity, TDS and EC are interconnected. The TDS analysis is generally considered a more accurate measure of salinity. However, determining EC is much simpler and quicker, using a portable instrument.

Table 1 Water Quality Standards

Parameters	SLS 614:2013	WHO 4th edition (2011)	SLS 614:1983		Maximum permissible level (Accepted)
	Permissible Level (Max)	Permissible Level (Max)	Desirable Level	Permissible Level (Max)	
Electrical Conductivity (µs/cm)	-	-	750	3,500	-
Total Dissolved Solid (mg/l)	500	600	500	1,500	-
Salinity (mg/l)	-	-	-	-	1000*

Salinity

Salinity relates to the amount of salt in the water. Salinity is the total of all non-carbonate salts dissolved in water. Usually measured in parts per thousand (1 ppt = 1000 mg/L).

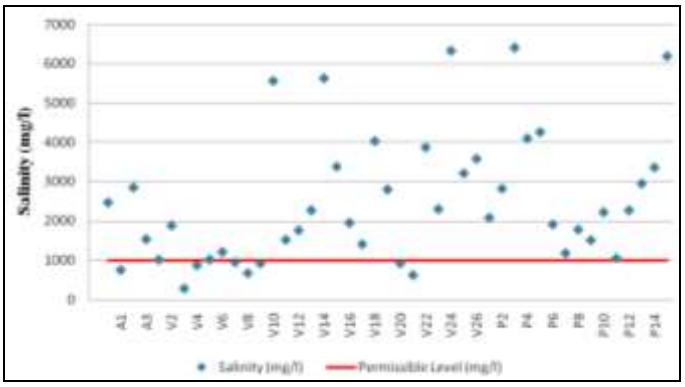

Figure 2Salinity content of selected wells

The salinity Value of the water samples ranges in 0.28 ppt to 6.41. Higher salinity value was observed in the wells Pungudutivu area. Figure 2 shows the salinity values of selected samples. Only 10 numbers of selected samples wells were below the permissible level of salinity (1 ppt) and these wells were located in Velanai and Allaipiddy areas. These wells were located near to the ponds and sandy soil area. Reasons for this water quality were the water was filtered the sand filter and the amount of recharge was high near the ponds. The soil type in the Allaipiddy area was sand. Sandy soil thickness is 10 – 50m. However, the mean sea level in the area is 2-3 m. Therefore, saline water was filtered through sand. Other all selected well samples were more than the permissible level. All the well samples in Punguditu area was more than permissible level and other wells were located in Velanai, Allaipiddy and Mandativu. The water quality of these wells samples was brackish water, salinity level between 1ppt to 10 ppt. Based on salinity 75% of wells are not suitable for drinking.

Electrical Conductivity (EC)

The high degree of salinity means high value of electrical conductivity (Jeyaruba & Thushyanthy, 2009). So Electrical conductivity is the most important parameter for assessing

drinking water quality. Electrical conductivity is normally indicated the level of salinity.

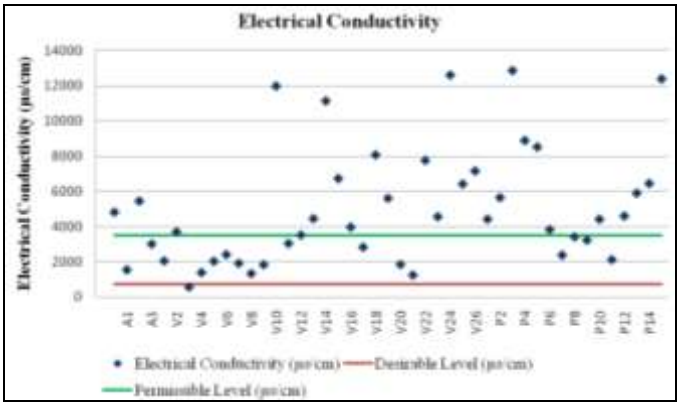

Figure 3 Electrical conductivity values of selected wells

Electrical conductivity values varied from 557 µs/cm to 12850 µs/cm. Figure 3 shows the electrical conductivity of the selected samples. Only one sample located in Velanai was under 750 µs/cm. It is less than the desirable level of Sri Lankan standard of drinking water (SLS 614:1983). 18 well samples were less than Sri Lankan standard of drinking water (SLS 614:1983) permissible level of 3500 µs/cm and these wells were suited for drinking. Electrical conductivity values were increased in dry season such as May to October. The electrical conductivity of the water depends on the water temperature. Normally in the dry season, the temperature is 36 degrees Celsius. Therefore, EC was increased in the dry season. Another reason for high EC was leaching of salts from agriculture land due to fertilizer usage.

Total Dissolved Solid (TDS)

Total dissolved solids are inorganic compounds that are found in water such as salts, heavy metals and some traces of organic compounds that are dissolved in water. TDS are recorded in milligrams per litre (mg/l) or parts per million (ppm). The TDS analysis is generally the more accurate measure of salinity.

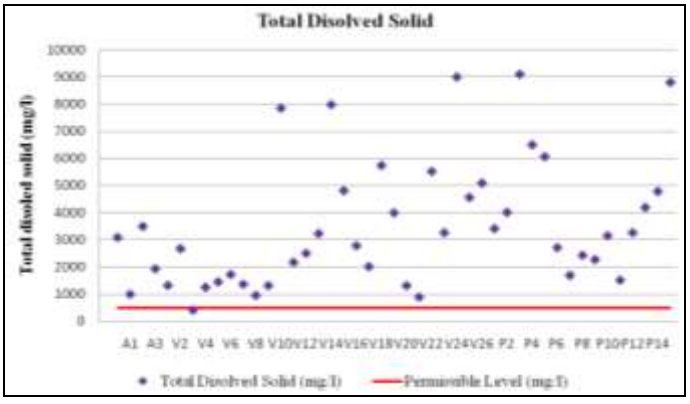

Figure 4 Total dissolved solid values of selected wells

Figure 4 shows the TDS of selected samples. Total dissolved solid values from selected well samples were varied from 396 mg/l to 9090 mg/l. Only one well from selected wells was below the Sri Lankan standard for drinking water (SLS 614:2013) permissible value as 500 mg/l. Other all wells were above the permissible level.

All the above three parameters, most of the samples were measured from November to February. The value may be increased in the dry season (April to October). These aquifers are recharged mainly during the November to February of rain and water in these aquifers then get collected in the form of a freshwater lens floating above the saline water. Then during the dry season, the freshwater lens is entering into the saline water boundary due to the over extraction from the aquifers. That time above three parameters will be increased.

VI. CONCLUSION

The researcher was identified Pungudutivu area was the most polluted area in Velanai divisional secretariat area. The quality of the water depending on the topography, soil geology and elevation from the mean sea level. Chatty, Mankumban and Allaipitty consist of sandy soil and that water quality is high than the other areas. Sandy soil is acting as a filter to filter the saline water. Therefore, saline water was filtered through sand. Other area consists of clayey sandy soil with seashells type soil. Another geological condition is elevation from mean sea level. Pungudutivu is flat terrain and average ground surface elevation from MSL is 2m. The groundwater table is 0 – 1.85m in the Pungudutivu area and the major reason for water pollution is mixing saline water with fresh water by less amount of elevation difference. Main reasons are seawater intrusion, over extraction and not maintenance of saltwater exclusion bunds, ponds and less amount of rainfall.

VII. RECOMMENDATIONS

As per the Velanai Divisional area topography, the groundwater quality does not change to fully good quality. Only little changes in seasonally. Therefore, a water treatment plant for desalination is the appropriate solution to overcome the problem. However, cost and technology wise this is a difficult method. However, other water sources are not available in the area. So currently, this solution is the most suitable. Another solution is alternative water sources should be identified. This method is cost effective. The only initial cost is high and maintenance cost is less. Common solutions are the maintenance of SWE bunds, maintenance of ponds, implementation of rainwater harvesting system and protection from over extraction. Relevant authorities should find a solution to overcome the problem in the Velanai divisional secretariat area for public health and safety.

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