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Physical and chemical quality of well water and its impact on the health of people in Sinnasippikulam in Vavuniya District, Sri Lanka

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ABSTRACT

Quality ground water is important as it is the main factor determining its suitability for drinking, domestic, agricultural and industrial purposes. Scarcity of clean drinking water is being felt by billions of people around the world. Present study was conducted during 2014 to determine the ground water quality especially total hardness of water in Sinnasippikulam village which is located in Vavuniya District. In addition, a questionnaire survey was conducted to analyze the water related diseases in Sinnasippikulam village.

Survey showed more than 86% of household members were not sick from Cholera and Dengue diseases over last 6 months while 8% of respondents suffered from diarrhea. Indirect

water related diseases such as skin stomach and skin rashes were with 6% and 2%, respectively. Further, around 30% of the total populations who use this water for domestic consumption were significantly identified with Chronic Kidney Disease (CKD). According to that, water samples were randomly collected from the wells located (twenty locations) in those particular area and undergone for further analysis of water specially on physical and chemical quality parameters such as total dissolved solids, electrical conductivity, pH, temperature, total hardness, nitrate and phosphate. The mean values of these parameters were recorded as pH (8.70±0.49), temperature (27.32±1.66 °C), electrical conductivity (1539.90±579.31µs/cm), total dissolved solid (753.8±294.71 mg/l), turbidity (1.23±0.80 FAU), total hardness (693.22±178.69 mg/l), phosphate (0.74±0.26 mg/l) and nitrate (3.03±1.62 mg/l). Among these parameters total hardness (693.22 mg/l) and pH (8.7) were considerably higher while comparing with the WHO permissible limits for drinking water is 200-600 and 6.5-8.5, respectively for each and also this might be a reason to the kidney problem identified through primary as well as secondary analysis in Sinnasippikulam village. It shows that to have proper consideration on well water quality while focusing its quality parameters as a health issue in future.

Key words: Chronic Kidney Disease, Ground water, physical and chemical parameter, WHO standards.

1 Introduction

Water is a vital natural resource for the sustenance of mankind and millions of other species living on the earth. Freshwater on the earth comprises of 3% of the total water. Only a small percentage (0.01%) of this freshwater is available for human use (Hinrichsen, 2002). Maintaining the quality of water is very important for humans since it is directly linked with the daily life (Gosh, 2002). According to WHO, around 780 million people globally do not

have proper access to adequate water supply. Additionally, 2.5 billion people do not have access to suitable sanitation facilities. Further, access to safe water is a significant issue in developing countries with death of 2 million people every year due to diarrheal diseases. Therefore, access to safe water is a crucial requirement in developing countries, where infrastructure is not adequate and needs to be expanded. Due to the mismatches of urban planning and actual residential area, some areas must rely on inadequate private water supplies (WHO, 2012).

Sri Lanka is considered as a water rich country. However, it also faces challenges in supplying good quality water to the population due to inadequacy in quantity as well as quality deterioration due to natural and human induced factors. Dramatic incidences of Chronic Kidney Disease among farmers in Sri Lanka (WHO-SL-reports, 2013 and Jayatilake *et al.*, 2013) and other parts of the world (El Salvador (Gracia-Tabanino *et al.*, 2005), China (Lin *et al.*, 2014), South-Asia (Jessani *et al.*, 2014)) have come under much scrutiny since it is believed that the disease is related to poor quality drinking water. Guidelines for drinking water quality and standards have been designed to enable provision of clean and safe water for human consumption, thereby protecting human health.

Presence of high concentrations of Ca^{2+} and Mg^{2+} increases the hardness of water and based on the concentration of $CaCO_3$, it would be categorized further into the range from soft to hard water. Degree of hardness in groundwater resources of Sri Lanka appears to have a strong positive correlation with the distribution of prevalence of CKD patients in Sri Lanka (Fonseka, 2012 and Jayasumana, 2013). Mild dehydration is associated with a number of adverse health effects, including increased risks in susceptible groups to urinary stone formation, increased risks of urinary tract cancer and poor oral health (Howard *et al.*, 2002). In this context, this study was carried out to find out the quality of drinking water in the

domestic wells of Sinnasippikulam village, 210A Sinnasippikulam G.N Division and Cheddikulam D.S Division in Vavuniya District of Sri Lanka.

1.1 Objectives

The objectives of the study are

1. To identify the health problems related to drinking water quality in Sinnasippikulam village in Cheddikulam D.S Division, Vavuniya District.
2. To analyze the quality of well water in Sinnasippikulam village, Cheddikulam D.S Division, Vavuniya District in respect to physical and chemical parameters.
3. To compare the physical and chemical parameters of well water quality with WHO drinking water standards.

2 Materials and methods

2.1 Description of the study area

Vavuniya District has four Divisional Secretary (D.S) divisions and covers 102 Grama Niladharies (G.N) divisions with 505 villages. This study was carried out in Sinnasippikulam village (210A, Sinnasippikulam G. N. Division, Cheddikulam D.S division in Vavuniya District) where around 220 families reside. Economy of this particular village is based on agriculture. The major livelihood activities of the village are linked to paddy and chena cultivation, home gardening, livestock rearing and small businesses. There are about 25 hactare of paddy land and 18 hectare of chena cultivation lands located in the area with an adequate supply of water from two minor tanks.

2.2 Methods of data collection

A total of 55 families were randomly selected from Sinnasippikulam village for the questionnaire survey. This survey was mainly focused on the water source, condition and satisfaction on water quality, problems about water quality and health problem due to poor water quality. Health impacts (direct and indirect water related diseases) were centre theme during the questionnaire survey. Due to such health impacts, water samples were undergone for further evaluation in laboratories where the critical conditions were analyzed to promote the study in broad manner.

2.3 Water sample collection and analysis

Twenty (20) wells were randomly selected to collect the water samples during the period of February 2014 to June 2014 where each sampling was successfully carried out thrice per month (60 water samples per month). Hence, for the whole study period three hundreds (300 samples) samples were undergone for the quality parameters analysis.

2.4 Sampling procedure

New disposable, clean, and sterile bottles were used to collect water samples and placed on ice packs from the collected area to laboratory to maintain temperature below 4°C. Samples were analyzed in the laboratory of Department of Agricultural Engineering, Faculty of Agriculture, Eastern University of Sri Lanka and also, the laboratory of National Water Supply and Drainage Board, Vavunatheevu, Batticaloa.

2.5 Water quality parameters

2.5.1 Temperature

Temperature was measured immediately after sampling by using Portable Mercury Thermometer.

2.5.2 Turbidity

10 ml of water sample was taken in the recommended sample cell and analyzed by using spectrophotometer (HACH DR/2010).

2.5.3 Electrical Conductivity, Total Dissolved Solid (TDS) and pH

Electrical conductivity, total dissolved solid and pH were measured immediately after sampling by using Portable pH/EC/TDS meter **(**Model: HI 98130).

2.5.4 Nitrate and Phosphate

Nitrate and phosphate were measured by using spectrophotometer (HACH DR/2010).

2.5.5 Hardness of water

The volume of 20 ml of water sample was pipette out into a titration flask and 2 ml of the buffer solution (pH 10 buffer solution was prepared by mixing 142 ml of NH_4OH and 17.5 g of NH_4CI) and 2 drops of Eriochrome Black-T were added in to the flask. Then the solution was titrated with the standard of 0.02 M EDTA solution until the color changed from red to pure blue (EDTA solution for titration was prepared by dissolving 3.7224 g of EDTA in to the 1000 ml of distilled water).

2.6 Data analysis

Responses to the questionnaire, SPPS (Statistical Package for Social Science) version 11.5 and MS Excel version 2007 were used to analyze the percentage of health impacts and its

relationships. Further, both physical and chemical parameters of collected water sample were analyzed by following the standard procedure of each parameter, in laboratory. Finally, mean values were compared with the World Health Organization (WHO) standards for the quality drinking water and its suitability.

3 Result and discussion

3.1 Analysis of Questionnaire survey

According to the figure 1; around 78% of the people of this village depend on protected shallow well water source. The 16% of the villagers depend on semi protected shallow well and rests of the people depend on unprotected well. These people depends only ground water source and there are no any water sources.

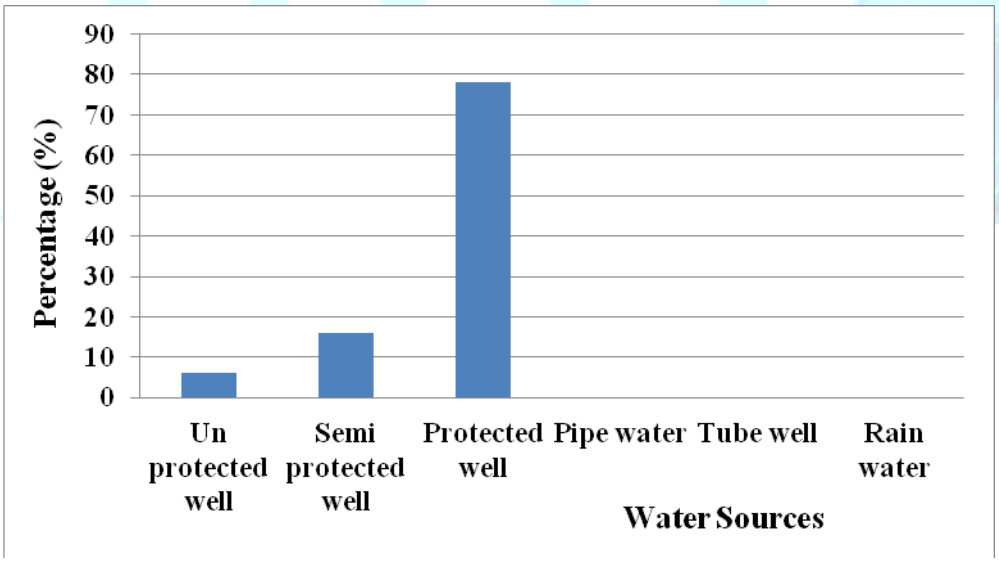

Figure 1: Engagement of people with different water sources

In Sinnasippikulam village, wells were identified with sedimentations of turbidity and floating substances. Turbidity and floating were higher (36%) while comparing with those turbidity (12%) and floating (36%), individually.

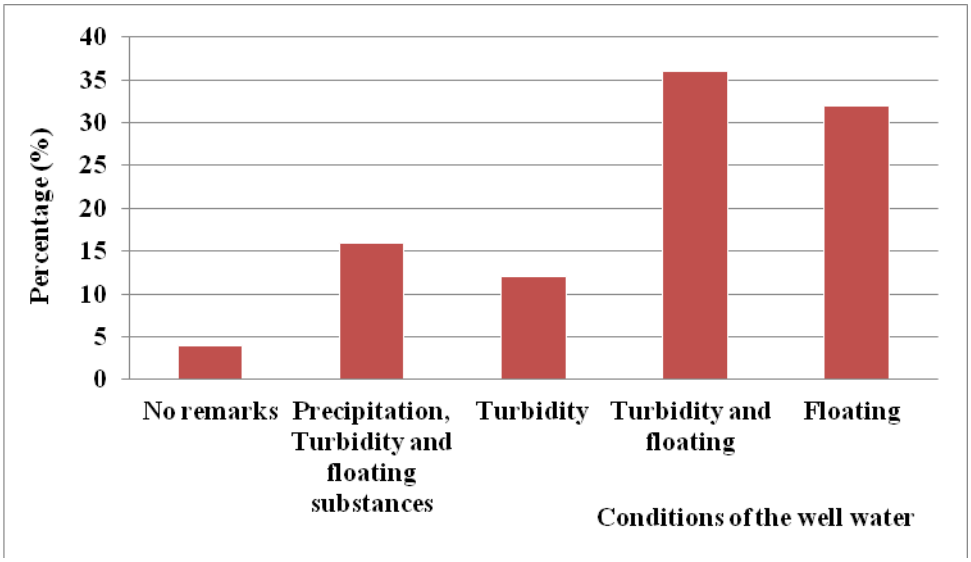

Figure 2: Conditions of well water and satisfaction of quality

Most of the people said that they have the problem in getting enough water from their sources in dry season and in rainy season they have problem because of the turbid water (Ocheri Maxwell Idoko *et al.*, 2006). According to the sensory evaluation on water taste, approximately 90% of the well water had slight changes while rest having bad conditions (10%) on its taste (Figure 2).

3.2 Rainfall during the sampling period

Higher precipitation occurred from October to December and January to May and the peak period of rainfall was in February during the study period (Meteorological Department, 2014).

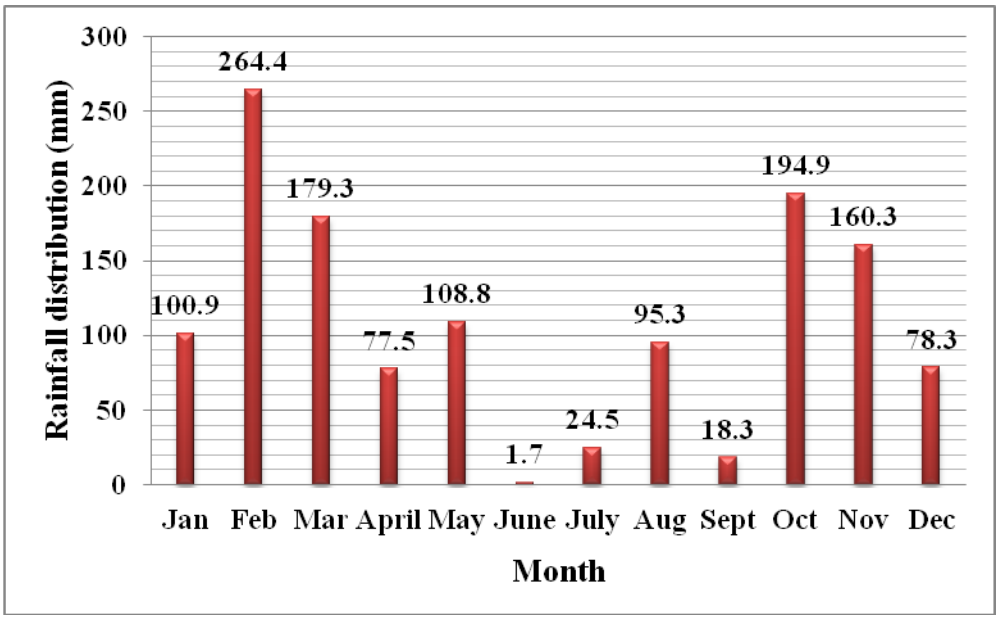

Figure 3: Monthly average rainfall for the year 2013 in Vavuniya.

Rainfall event is one of the most important causes of degradation of water quality of surface water and ground water. Rainfall event is useful in predicting deterioration in water quality and permit appropriate precautionary measures to be taken to safeguard the water quality (Payment, 1997). However, during the study period (February to June 2014) the pattern and distribution of rainfall varied with the decreasing and increasing trends (Figure 3).

3.3 Health problem due to poor water quality

According to the conducted survey on 55 families, about 86% of household members have not suffered from direct water related diseases during the last 6 months while 8% of respondents have suffered from diarrhea. Further, Cholera and Dengue plays a minor role among this population (Infectious diseases in Sri Lanka, 2014).

Table 1: Health problem due to poor water quality

		Frequency	Percentage (%)
Suffered from	Diarrhea	4	8

direct water related disease	Cholera	1	2
	Dengue	1	2
	Not applicable	43	86
	Diarrhea and Cholera	1	2
Suffered from indirect water related disease	Skin stomach	3	6
	Skin rashes	1	2
	Kidney problem	15	30
	Cancer	0	0
	non applicable	31	62

Indirect water related diseases occurrence is shown in Table 1. Among these diseases, kidney problem was in the highest concern where 30% of the survey population suffered from kidney disease. Survey revealed that people are not aware about the possible link between kidney disease and the poor quality drinking water.

Chronic Kidney Disease (CKD) has become a serious medical concern in Sri Lanka mainly from North Central Province (NCP) in Sri Lanka reports the highest number of CKD patients and mortality rates due to CKD. It might be due to the beyond and lower limits of WHO standard for drinking water. Further, with high Ca in the presence of Flouride, Calcium Fluoride (CaF_2) is said to form which is insoluble in water causing Kidney Tubular Damage (Chandrajith *et al.*, 2011).

3.4 Physical and chemical quality of water

Important physical parameters namely total dissolved solids (TDS), electrical conductivity (EC), temperature, turbidity and pH of water and chemical parameters such as hardness, phosphate and nitrates were tested and the results were compared with WHO standards.

Table 2: Summary of physical and chemical parameters of well water

	N	Range	Minimum	Maximum	Mean	Std. Deviation	WHO 2012
pH	20	2.45	7.00	9.45	8.7040	0.49040	6.5-8.5
Electrical conductivity	20	1840	910	2750	1539.90	579.316	750-3500
Turbidity	20	2.11	0.45	2.56	1.2313	0.80625	1-5
Total hardness	20	835	245	1080	693.22	178.694	200-600
Temperature	20	7.00	23.20	30.20	27.3220	1.66294	-
Nitrate	20	4.12	0.50	4.62	3.0333	1.62005	45
Phosphate	20	0.93	0.29	1.22	0.7487	0.26886	3.5
Total dissolved solid	20	980	390	1370	753.8	294.717	500-2000

N= Total number of data points World Health Organization (WHO) (Provide the units)

At the village, pH value was ranged from 7 to 9.45 with mean value of 8.70 (Table 2). Generally, low pH indicates the absence of carbonate in solution, as carbonates usually occur in solution at pH of 8.2 and above (Ahiarakwem *et al.*, 2002). The results show high values indicating presence of carbonates in solution. Some wells exceed the standard of World Health Organization Standards (WHO, 2011) for drinking water. This indicates either a threat to biological life or causing skin-eye irritation problems during contact of water (Gampson, 2013). According to Jayasumana (2013) Chronic Kidney Disease (CKD) has been observed more in people where the well water shows alkaline.

3.5 Monthly average values of physical and chemical parameters of the well water (February - June, 2014)

According to the Figure 4, the pH was peak in April. This range is higher compared with the World Health Organization Standards (WHO, 2011) for drinking water. Thus indicating either a threat to biological life or causing skin-eye irritation problems during contact due to water spots (Gampson, 2013). Here, the well water shows alkaline through the study period.

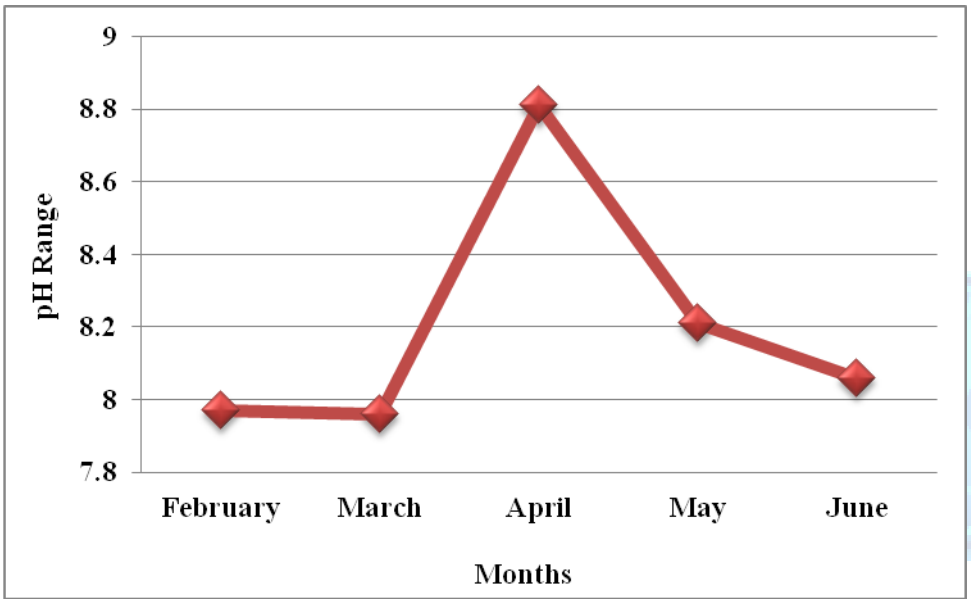

Figure 4: Monthly average pH range.

A sudden increase in conductivity of water is the indicator of the addition of pollutant to the water (Trivedi, 1986). At village, the average values of electrical conductivity were varied between 1488±130.11 µs/cm to 1481±120.1 µs/cm. The minimum and maximum conductivity is 910 and 2750 µs/cm with the mean value of 1539.90 µs/cm. The maximum Electrical conductivity value observed is less than WHO (2012) standard for drinking water.

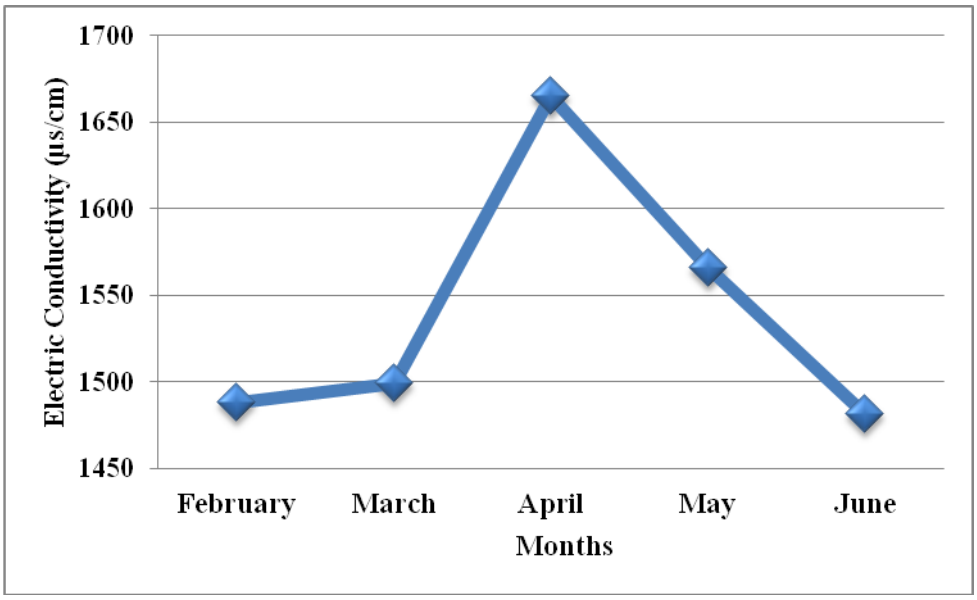

Figure 5: Monthly average Electric Conductivity (EC) range in (µs/cm).

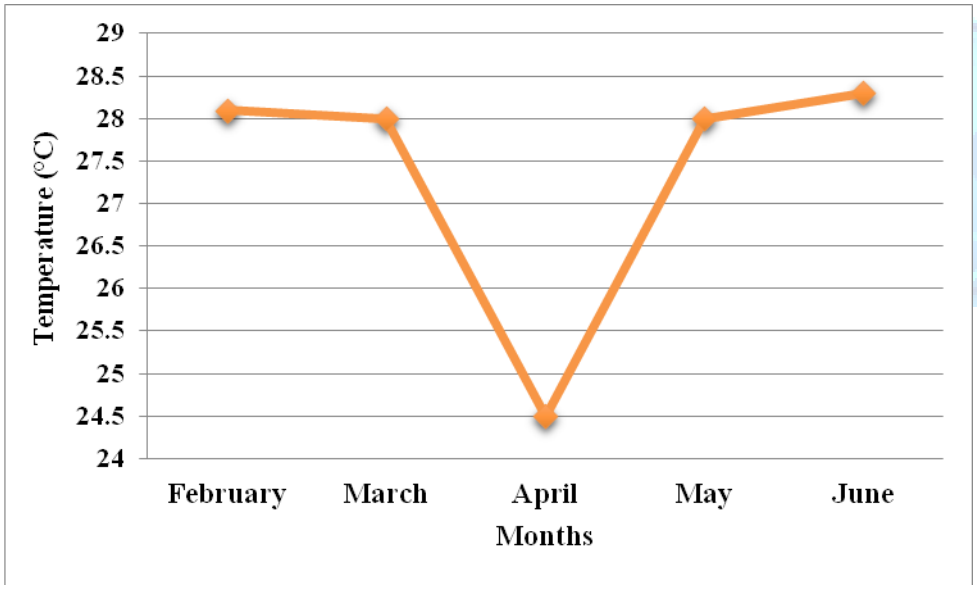

Figure 6: Monthly average Temperature range in (°C).

Temperature is considered as a critical parameter. It has an impact on many reactions including the rate of disinfectant decay and by-product formation (Volk *et al*., 2002). At village, the average temperature values varied between 28.11±0.12°C to 28.32±0.15°C and

the minimum and maximum value of temperature is 23.20°C and 30.20°C with mean value of 27.3°C.

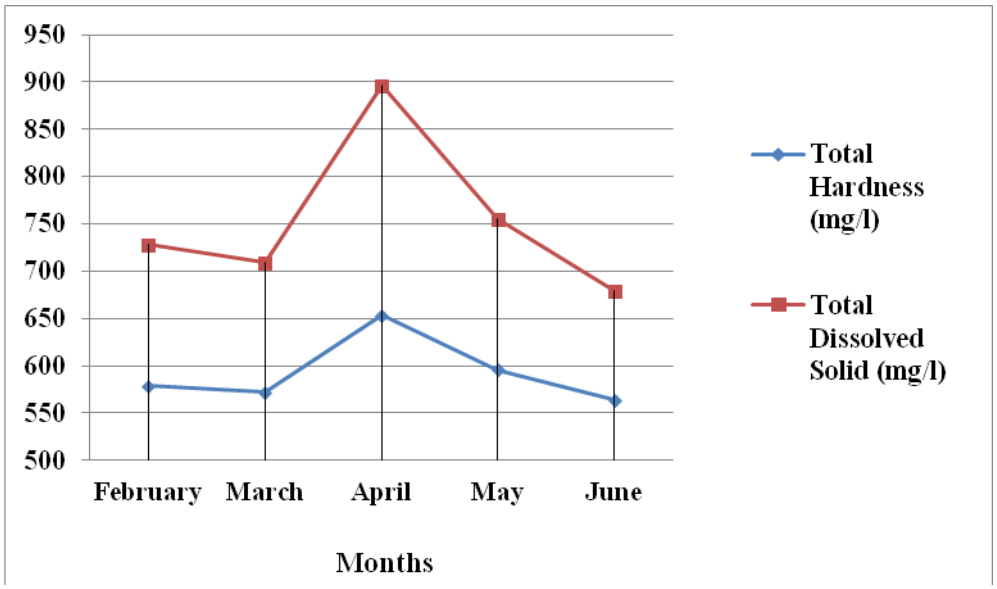

Figure 7: Monthly average Total Hardness and Total Dissolved Solid.

The average ranges of hardness were varied between 579.5±167.8 to 564.75 ±172.1 mg/l. "Soft" and "hard" water have been associated with total hardness over the years and this has been classified by Durfor and Becker (1964) as follows: soft (0 to 60 mg/l), moderately hard (61 to120 mg/l), hard (121 to 180 mg/l) and above 180 mg/l as very hard. Most of the sampled water felt within the very hard category, hence the water in the study area could be said to be "very hard". And also the maximum value of hardness is above the WHO (2012) standards for drinking water. The water containing excess hardness is not desirable for portable water as it forms scales on water heater and utensils when used for cooking and consume more soap during washing of cloths (Gupta preeti, 2009).

Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates, etc. These minerals produce un-wanted taste and dilute color in appearance of water (Mohsin *el al.*,

2013**)**. At village, the average total dissolved solid values varied between 728.5±293 to 679.5±248.92 mg/l and the minimum and maximum values of TDS are 390 and 1370 mg/l with mean value of 753.8 mg/l. The mean value of the TDS observed is less than WHO, (2012) standard for drinking water

Hence, the total hardness was higher might be the one reason of kidney diseases due to the presence of calcium ions in well water as well.

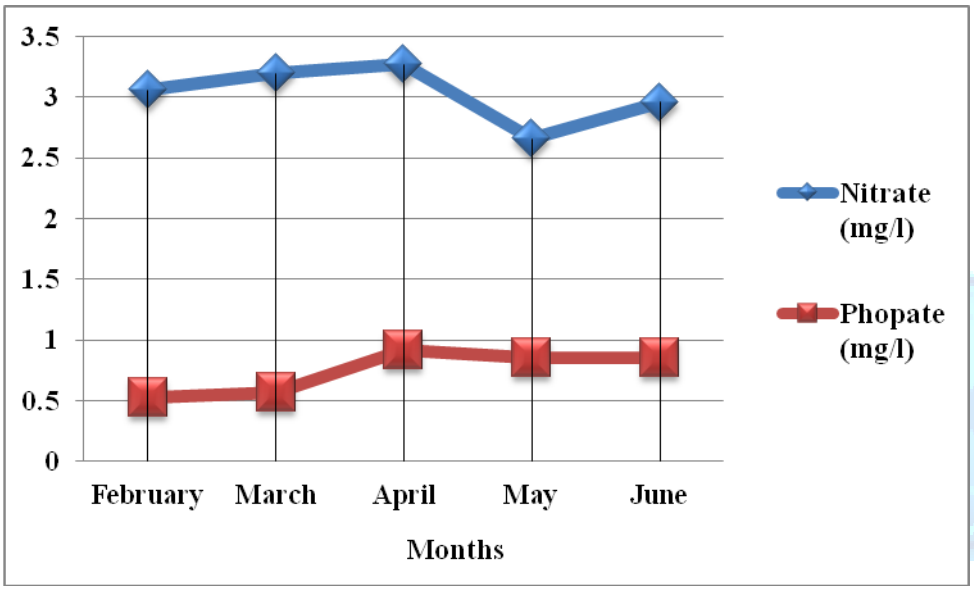

Figure 8: Monthly average Nitrate and Phosphate range in mg/l.

At the village, the minimum value of nitrate is 0.5mg/l and maximum value of nitrate is 4.2 mg/l with mean value of 3.03 mg/l. The average values at village varied from 3.66±1.99 to 2.96±2.15. All the values were below the WHO (2012) standards for drinking water. Nitrate is one of the most important diseases causing parameters of water quality particularly blue baby syndrome in infants (Self and Waskom, 2013).

Phosphates are not toxic to people or animals unless they are present in very high levels. But digestive problems could occur from extremely high levels of phosphate (Morrison *et al.*, 2001). All the values were below the WHO (2012) standards for drinking water.

4 Conclusions

In Sinnasippikulam Village, health impact was higher due to the poor quality water and its poor sanitation facilities. Higher percentage of Kidney disease was significantly recognized in this village which comes under indirect water related diseases. For further supports, analyzed water quality parameters also reveal that hardness might be a one reason to those particular health impact observed there.

In addition, the well water in the study area did not show high levels of NO_3^- or phosphates. However, hardness and pH showed values which are higher than the WHO standards for drinking water. According to the hardness classification, almost all the well waters are fallen under very high hardness category.

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