Assessment of Seasonal Impacts on Groundwater Quantity and Quality in Upstream of Malwathu Oya Basin

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Abstract

Malwathu Oya Basin which covers 2350km^2 located in Anuradhapura district is considerably populated and the safety and the available quantity of water is crucial for the people. Water samples were collected from selected locations during South-West monsoon period, Second Inter monsoon period and North-East monsoon period from September 2016 to March 2017. The samples were analysed for pH, turbidity, conductivity, fluoride, chloride, magnesium and calcium as basic drinking water quality parameters. Only the shallow regolith aquifers are considered for the study. The groundwater quality variation of the area shows a considerable variation from dry season to rainy season in general water quality of the area, and is in acceptable limit for most of the basic parameters. With the seasonal changes Fluoride and Chloride content is higher than permissible limits in some areas.

Keywords: Monsoon, Parameters, Permissible limit, Variations

1. Introduction

Groundwater is the largest available fresh water source in the land [1] and proven to be quite useful as with accessibility and less pollution. In Sri Lanka, Anuradhapura district belongs to dry zone which is not blessed with rain as much as the wet zone and the highlands.

Anuradhapura area has two major river basins that supply water to the area. They are, Malwathu Oya and Yan Oya, which act as the main sources that recharge the groundwater along with the tanks in the surrounding area.

This study is focused on the shallow regolith aquifers [2] in the part of Malwathu Oya river basin which belongs to the Anuradhapura district (Figure 1).

Groundwater is a valuable source for the dry zone area however now the quality of the water is depleting drastically. Most of the dug wells are abandoned and some are used for agricultural purposes only. High hardness and fluoride content in water makes them unsafe to consume.

The rising problem of Chronic Kidney Disease [3][4] is causing a panic over the region that prevents people from using the shallow regolith aquifer water resources.

In the area around Malwathu Oya basin there are no permanent water supply lines covering every village and house.

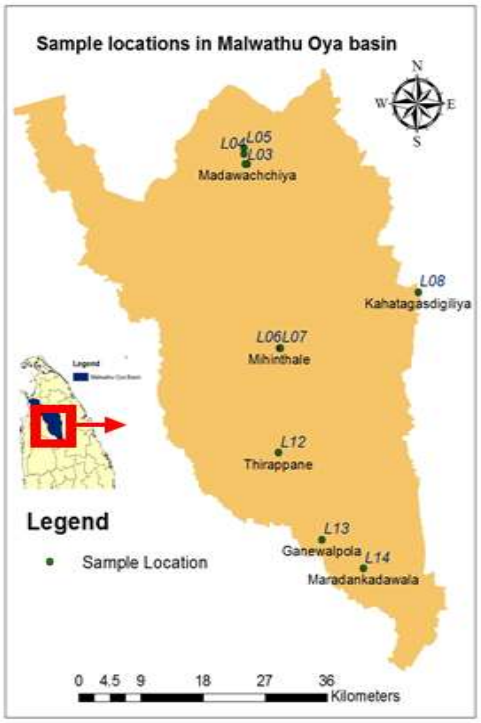


Figure 1- Sampling locations

The primary objectives of this research are to verify and understand the quantity and quality of the groundwater and effects of seasonal changes on them.

Water quality parameters were checked on the samples collected during the South-West Monsoon, Second Inter Monsoon and North-Eastern Monsoon seasons. Water samples were analysed for calcium, magnesium, pH, turbidity, conductivity, chlorides and fluoride content.

2. Methodology

The methodology of this research can be divided in to three steps.

2.1 Identification of sample locations

2.2 Sample collection and testing

2.3 Analysis of results

Initially at the desk study the basin area and the sampling locations for the research were identified and basic parameter testing and methodologies were discussed.

2.1 Identification of Sample Locations

The sampling locations were basically selected from the upstream of the Malwathu Oya river basin.

The exact locations for sampling throughout the duration of the research were selected according to the requirement of the research and the availability of groundwater wells. According to these parameters 11 sampling locations were marked covering upstream of the Malwathu Oya river basin.

2.2 Sample Collection and Testing

From every sampling location two sets of samples were taken for analysis. One is acidified to prevent any disturbance. Second set of the sample was kept without any additions to be used for measuring the pH values since the acidified samples will show false values as the pH reading. All the samples were transported in air tight bottles under controlled environment.

As soon as the samples were taken back to the laboratory the samples were analysed for selected water quality parameters like, pH, conductivity, turbidity, chlorides, fluorides, calcium and magnesium. All the analysis was carried out according to the standard procedures for water quality testing [5].

2.3 Analysis of Results

Results for the water quantity were taken as variation of depth of groundwater relative to the measurement made on 30/09/2016. Groundwater quality results taken from sample analysis were interpolated using Arc Map to plot the variation of different parameters throughout the basin for each season. The parameters were compared with the World Health Organization and Sri Lankan standards to verify the quality.

3. Results and Discussion

Figure 2 and 3 show the observed seasonal groundwater level variation in the study area. Initial observations were taken as the base level of the groundwater in the study area.

The highest groundwater level variation shows in the same area round Kahatagasdigiliya during study period. In South-West monsoon to Second Inter monsoon the relative groundwater level vary from 0.34-0.96m to 5.49-6.14m range and Second Inter monsoon to North-East monsoon the groundwater level vary from 0.36-1.10m to 6.30-7.04m range.

The seasonal variation of the groundwater quality the area was measured according to the selected parameters of drinking water quality standards of World Health Organization and Sri Lankan Standards.

Results of the analysed samples for all three seasons are shown in figure 4 to 10.

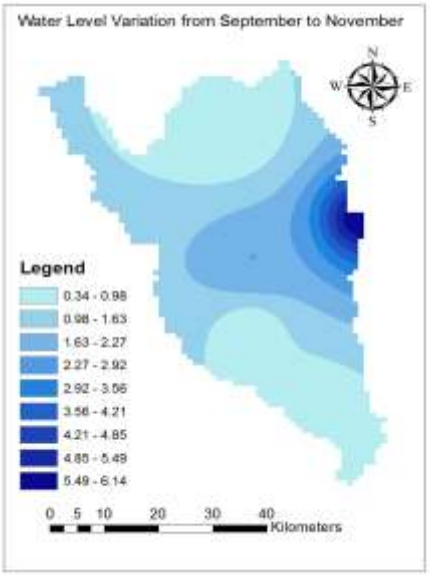


Figure 2 - Groundwater level (m) variation from 30/09/2016to 20/11/2016(South-West Monsoon to Second Inter monsoon)

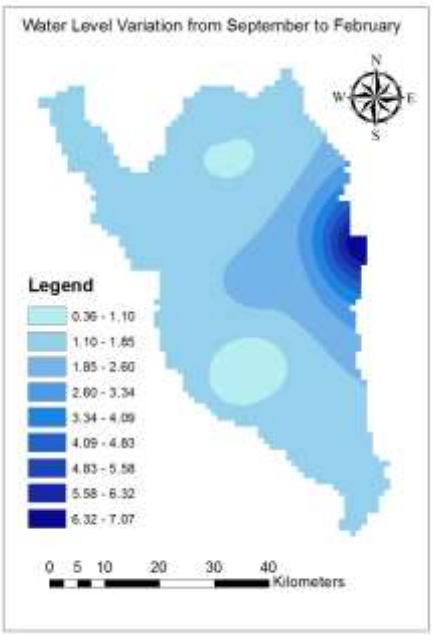
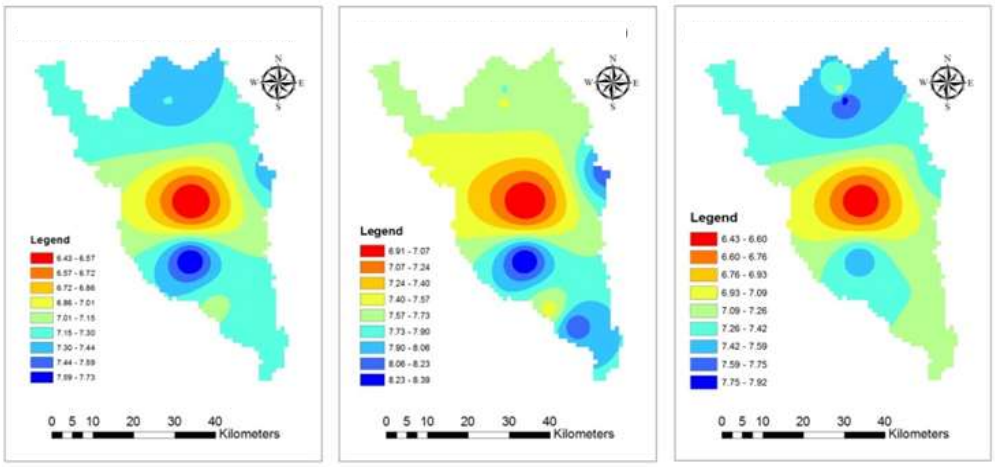


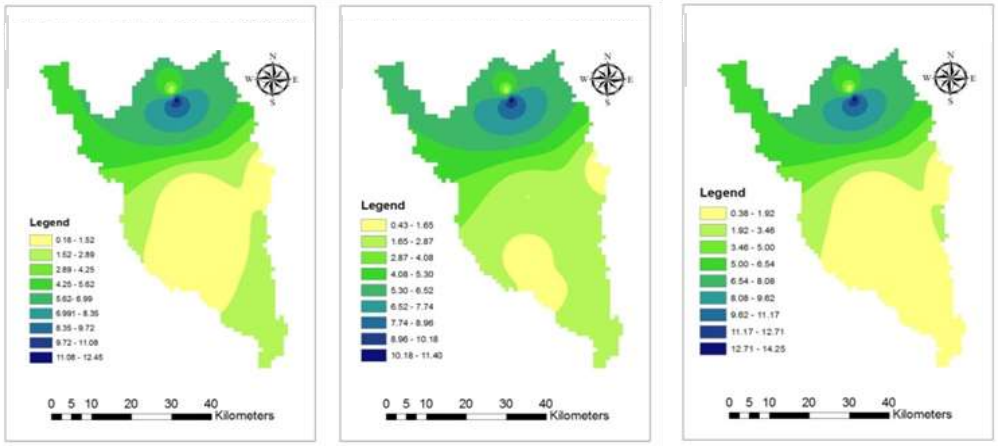
Figure 3 - Groundwater level (m) variation from 20/11/2016 to 22/02/20(South-West monsoon to North-East monsoon)



4-a 4-b 4-c

Figure 4 - Map 4-a, 4-b, 4-c shows the pH variation of the area during South-West monsoon, Second Inter monsoon and North-East monsoon respectively

Madawachchi area shows considerable pH variation with the seasons as shown in map 4-a pH level range is 7.33-7.44, in map 4-b pH level range is 7.01-7.15 and in map 4-c pH Level range is 7.44-7.59. Mihintale area has low acidic water and Thirappane and Maradankadawala areas show basic water. Overall result seems to be within permissible [6] limit.

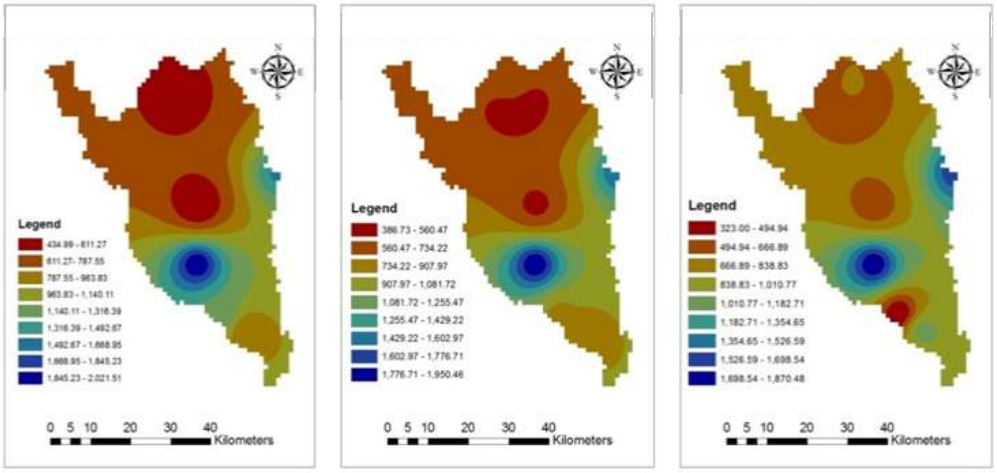


5-a 5-b 5-c

Figure 5 - Map 5-a, 5-b, 5-c shows the Turbidity (NTU) variation of the area during South-West monsoon, Second Inter monsoon and North-East monsoon respectively

Turbidity has shown very less variation throughout the study period of the research. The highest turbidity shows in same area but values were varied with the seasons. In map 5-a it's 11.06-12.45NTU range, in map 5-b it's 10.10-11.42NTU range and map 5-c it's 12.17-14.25NTU range.

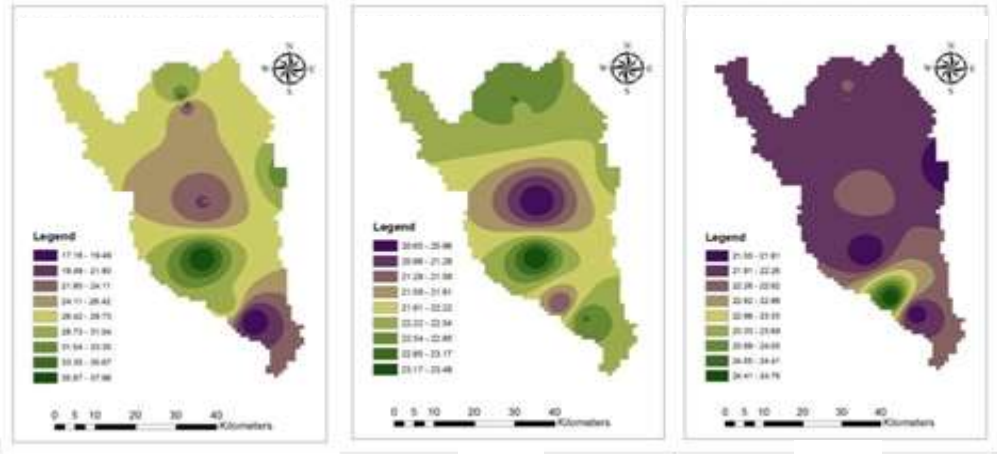
In general turbidity can be removed from filtration and hence has less health effects.



6-a 6-b 6-c

Figure 6 - Map 6-a, 6-b, 6-c shows the conductivity (µS/cm) variation of the area South-West monsoon, Second Inter monsoon and North-East monsoon respectively

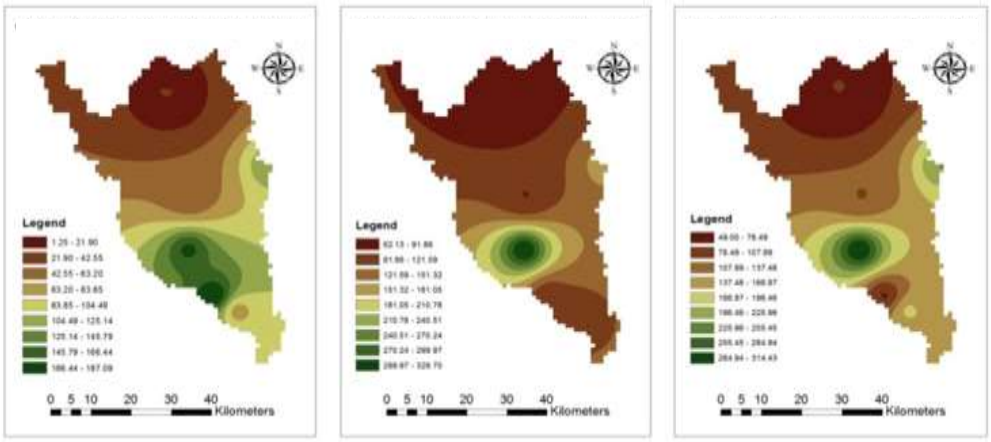
Conductivity of the water does not show a high variation throughout the seasons. Thirappane area shows highest conductivity. In map 6-a highest value range is 1845.22-2021.51µS/cm, in map 6-b it is 1766.71-1950.46µS/cm and map 6-c it's 1695.54-1870.48µS/cm. Overall the conductivity does not have high impact as a drinking water quality parameters however it is a direct measurement of the ion content.



7-a 7-b 7-c

Figure 7 - Map 7-a, 7-b, 7-c shows the Calcium variation (ppm) of the area during South-West monsoon, Second Inter monsoon and North-East monsoon respectively

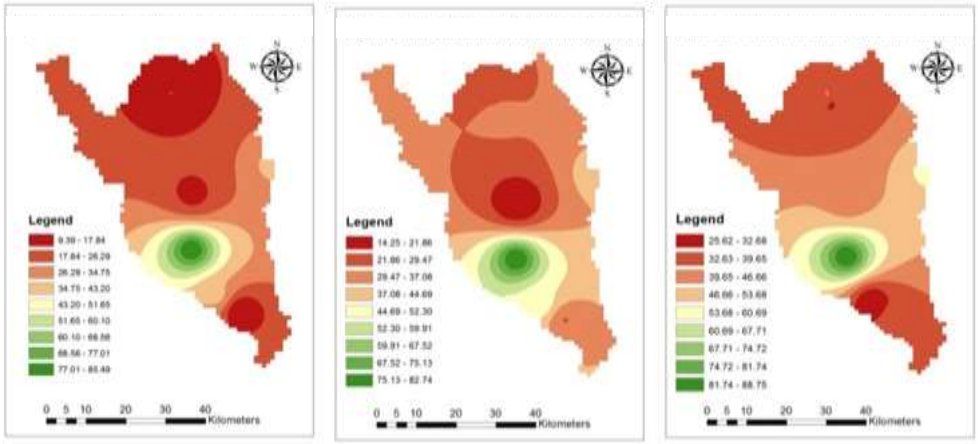
During the rainy season (North-East monsoon) the calcium levels of the area have been decreased significantly compared to the condition in the dry season. According to map 7-a, maximum Calcium level in the groundwater of the area is around 40ppm which is much less than the standard requirement. [7] However map 7-b and 7-c show maximum Calcium level approximates to 25ppm.



8-a 8-b 8-c

Figure 8 - Map 8-a, 8-b, 8-c shows the Cl^{-1} (ppm) variation of the area during South-West monsoon, Second Inter monsoon and North-East monsoon respectively

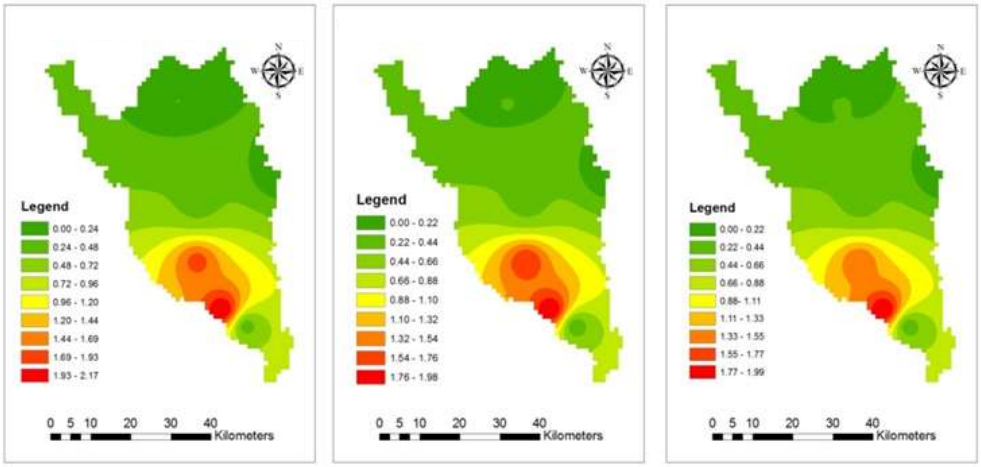
Chloride content in the study area has decreased during the South-West monsoon compared to the North-East monsoon period and the Second Inter monsoon period as shown in map 8-a, 8-c and 8-b respectively. Chloride variation shows a direct relation to the quantity variation of the groundwater during the study period. In the rainy seasons (map 8-b and 8-c) some areas in the study area seems to have chloride content higher than the permissible 250 ppm level [7].



9 - a 9 - b 9 - c

Figure 9 - Map 9-a, 9-b, 9-c shows the Magnesium variation (ppm) of the area during South-West monsoon, Second Inter monsoon and North-East monsoon respectively

The Mg variation seems almost identical for all three seasons and the Mg level never has gone over the permissible limit. Mg has very less effect to the human health directly, Magnesium level in the groundwater of the area is mostly around 25 – 35 ppm; however in Thirappane area this value is exceeding the permissible level of 30 ppm [7] during all three season as shown in maps 9-a, 9-b and 9-c.



10-a 10-b 10-c

Figure 10- Map 10-a, 10-b, 10-c shows the Fluoride variation (ppm) of the area during South-West monsoon, Second Inter monsoon and North-East monsoon respectively

Fluoride variation shows a little difference throughout the duration and most of the locations have an acceptable limit of Fluoride but Fluoride content can affect health problems mainly the fluorosis can cause dental and bone related problems. Location 12 and location 13 water samples has the values above the permissible limit [7] during all three seasons. Although map 10-a shows maximum fluoride range as 1.93 - 2.17 ppm range in Ganewalpola area.

4. Conclusions

It is clear that the groundwater quantity and quality parameters change with seasonal variations. According to the results the maximum groundwater level difference shows in the North-East monsoon, relative to the South-West monsoon for the upstream of the Malwathu Oya basin. The water level has increased about 7m of maximum in Kahatagasdigiliya area during North-East monsoon period compared to the end of South-West monsoon period. This is due to increasing the rate of recharging during the North-East monsoon period.

There are few wells which show higher amount of Fluoride and Chloride content compared to the permissible limits [4] during Second Inter monsoon period and North-East monsoon period. The quality may seem so to have a variation with the quantity as well during the monsoon period where high water capacity is available.

The quality of the groundwater seems to improve rather than in the South-West monsoon period and the Second Inter monsoon period where water quantity is much low. However turbidity has increased in the North-East monsoon season compared to other two seasons.

For this study the groundwater model proposed by Kazama [8] can be used as a further development.

Acknowledgements

We would like to acknowledge and extend our heartfelt gratitude to the following personnel who helped us in various ways to complete this research project;

Dr. H.M.R. Premasiri, Head of the Department of Earth Resources Engineering and, Dr. G.V.I. Samaradivakara the final year research project coordinator for their guidance.

Also we like to acknowledge all the members of academic and non-academic staff for their support in various activities.

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