The impact of extensive agriculture on groundwater chemistry in the eastern part of Sri Lanka

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Abstract

Ampara District is one of the biggest agricultural area of the eastern province of Sri Lanka. It contributes more than 20 % of the country's annual rice production. However, the excessive use of agrochemicals and fertilizers by the farmers has created an emerging threat on the water quality of groundwater in the area. The lands of Sammanthurai, Karathivu, Ninthavur, Addalachchena, Irrakkamam and Navithanveli DSD's are covered mostly with large paddy lands cultivated in both of Yala and Maha seasons. Therefore the vulnerability of groundwater contamination in these areas is enormously high and the agricultural drains have also affected on the groundwater in the downstream areas too. This problem should be highly concerned since the rural community of the area is entirely depend on the extraction of groundwater through dug wells. These shallower level groundwater aquifers are being contaminated rapidly and respond immediately upon the any bad agricultural or pollution activity at the surface level. Once the deeper groundwater aquifers in the hard rock are contaminated, the reversible process or the remedial measures are hard to overcome the situation. Up to now, none of the organization or responsive bodies has been acted to assess the present status and impact levels on the groundwater due to these improper agricultural practices. This study deals with the assessment of groundwater quality through systematic monitoring network in dry & wet periods to identify the impact levels due to the above mentioned reasons.

The monitoring points for sampling were selected based on the field inspections & available information of topography, geology, landuse, hydrology & hydrogeology, pollution pathways or agricultural drains. The sampling was carried out at sixty five (65) identified locations from the dug wells representing the shallower aquifer and fifteen (15) tube wells representing the deeper aquifer for both dry and wet season of the year 2011/2012. All the samples were analyzed under SL Standards at the Chemical laboratory of Water Resources Board.

Analysis results indicated, the Phosphate (PO_4) values of shallow groundwater exceed the permissible level (> 2mg/l) in most of the areas and especially at the locations of Samanthurai, Malwatte and Part of Karativu area. The highest level of 25 mg/l is observed in Karativu area. In general, the PO_4 varies from 0.6 mg/l to 25mg/l in dry season (August 2011) and indicating the very lower values of 0.2mg/l to 3.3mg/l during the wet period possibly attributed to dilution in the groundwater by recharge process and surface runoff removal before entering to the groundwater. The pattern of fertilizer application cannot be deemed out for this variation but requires careful survey. PO_4 contamination is not highly affected in deeper groundwater sources despite there are some anomalies could be identified within the permissible levels. In dry period (October 2011), 04 locations shows exceeded values of PO_4 out of 18 sampling location and analyzed results vary from 0.1mg/l to 2.6mg/l. In wet period (February 2012) it also shows 04 locations out of 15 sampling locations as exceeded values of PO_4 and almost all samples are reaching their permissible level of PO_4.

According heavy metal analysis, the Cd level is appeared to a considerable level (vary between 0.6ppb and 4.1ppb) in the shallow aquifer at dry season despite the permissible is 5 ppb. The Mn content of shallower groundwater is higher at four locations exceeding the permissible levels during the dry period. During the wet period, Mn content in groundwater declines to a level below desirable level in the shallow groundwater. However, there are no Mn values encountered in deeper groundwater exceeding the desirable level in both dry and wet periods. The Cd level is also within the standards even there is some indication of Cd encountered at considerable levels indicating a possibility of a contamination in deeper groundwater.

The other chemical parameters including EC, TDS, and Alkalinity etc. are within the acceptable levels in most of the monitoring locations and there are certain anomalies observed in some localities possibly due to site specific characteristics and not in regional scale. These are described in detail at the results section of this paper. In conclusion, the groundwater is obviously been contaminated in the area due to the impact of excessive applications of fertilizers and the impact level is at incipient to intermediate level and therefore immediate awareness of community, corrective measures and regulatory mechanism implementation is vitally important.

Key Words: Groundwater, Heavy metal, Water quality, Ampara

Introduction

Ampara district is a one of the largest agricultural area in Sri Lanka and it is contribute 20% of annual rice requirement for the country. Despite the large agricultural areas, the excessive use of agrochemicals and fertilizers by the farmers has created an enormous impact on the water quality of groundwater. The lands of Sammanthurai, Karathivu, Ninthavur, Addalachchena, Irrakkamam and Navithanveli DSD's are covered mostly with large paddy lands cultivated in both of Yala and Maha seasons. Therefore the vulnerability of groundwater contamination in these areas is higher and the agricultural drains have also affected on the groundwater in the lowland areas too. This problem should be highly concerned since the rural community of the area entirely depend on the extraction of groundwater through dug wells. These shallower level groundwater aquifers are being contaminated rapidly and respond immediately upon the any bad agricultural or pollution activity at the surface level. Once the deeper groundwater aquifers in the hard rock are contaminated, the reversible process or the remedial measures are hard to overcome the situation. Up to now, none of the organization or responsive bodies has been acted to assess the present status and impact levels on the groundwater due to these improper agricultural practices.

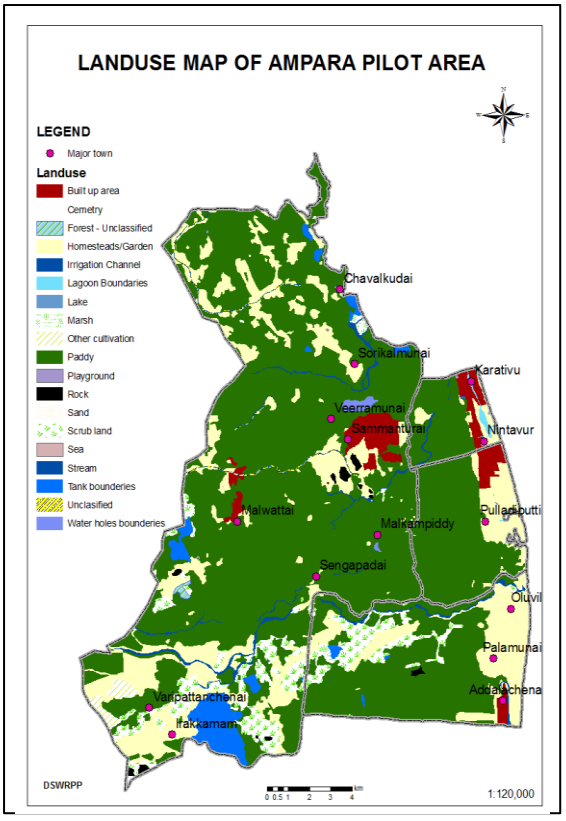


Figure 1: Landuse pattern of study area

Considering the necessity of the assessment of impact due to specified causes, this study was focused to deliver the present status of groundwater quality of the area including the follow up activity of implementing a long term surveillance based monitoring network under Dam Safety and Water Resources Planning Project(DSWRPP).

District is located at eastern part of the country and geomorphologicaly it is almost flat terrain. Study area is covered by 06 divisional secretariats of Karathivu, Ninthavur, Addalachchena, Irrakkamam, Navithanveli and Sammanthurai. Most of the selected area covered with paddy lands and other cultivated plants such as sugar cane and wheat. The area belongs to Gal Oya river basin and few numbers of tanks existed in study area. The approximate land area is 400 km^2 and area of surface water bodies are around 15 km^2.

Geological setup of the area

The study area belongs to Vijayan complex and the main lithology of the Vijayan and Vanni Complexes are amphibolite-facies metapelies, mafic to intermediate rocks, calc-silicates, granitic rocks and migmatites (Cooray, 1961, reprinted 1995 b, 1984). According to the drill litholog of existing tube wells, a thin soil layer is underlain by massive basement rock. Figure 02 is shown the general lithology of the study area.

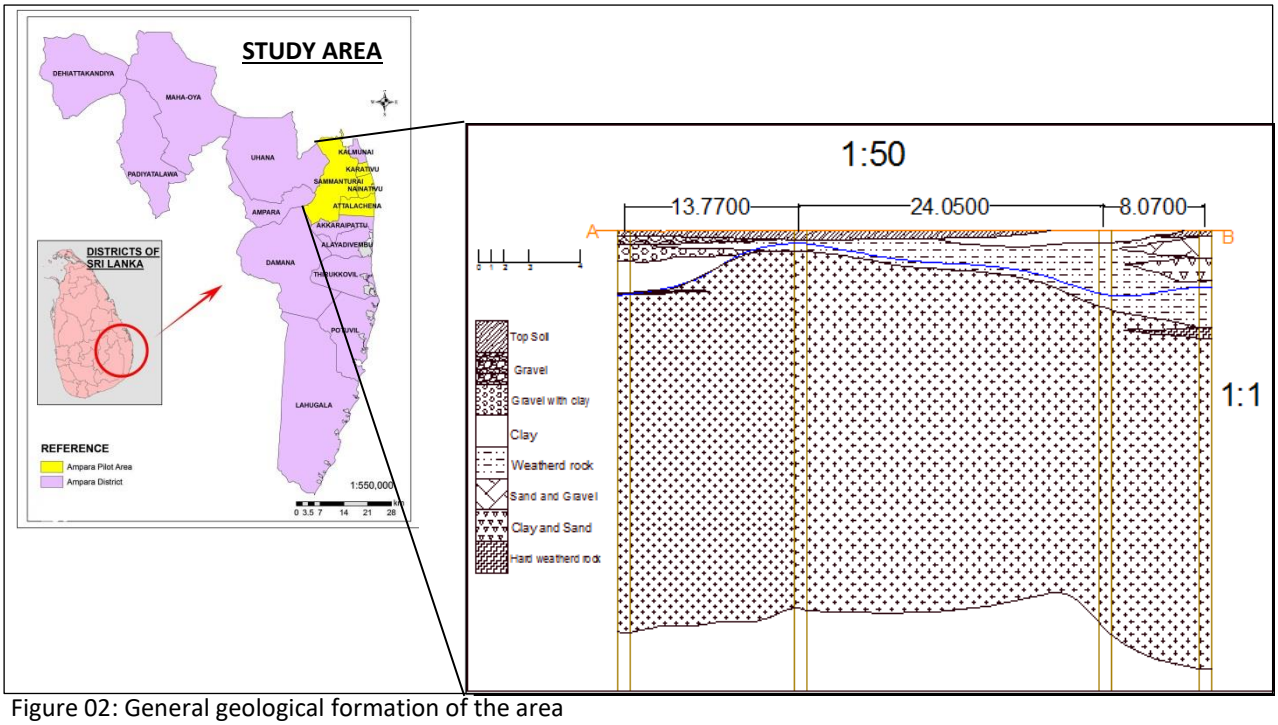


Figure 02: General geological formation of the area

METHODOLOGY

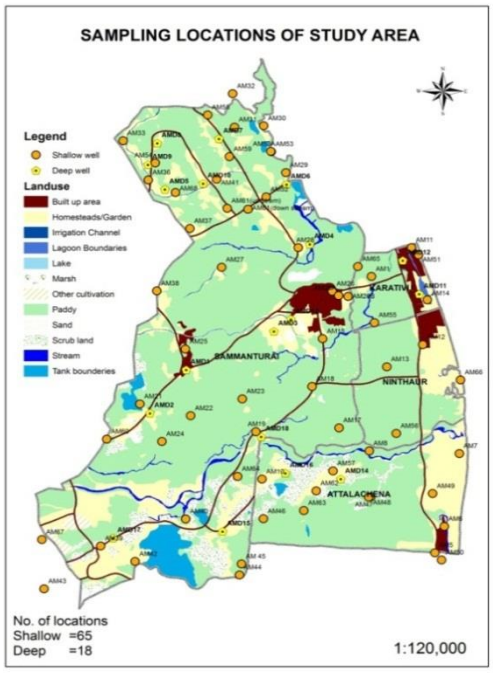


Fig. 03: Sampling locations of study area

The preliminary data and information of the area were collected from various organizations and studied for the selection of monitoring point. The sampling was performed on these selected points for the chemical analysis work to obtain the water chemistry spatially as well as temporally. Base maps of Landuse, Geology and DEM maps were prepared with the use of ArcGIS 10 software.

Initially, based on the field inspections & available information of topography, geology, landuse, hydrology & hydrogeology, pollution pathways or agricultural drains and chemical records of the previous studies and information on the issues identified in the area were

considered for the in-situ testing of Electrical Conductivity (EC), total Dissolved Solids (TDS), Salinity, NO3 and PO4. Once these basic parameter assessment in the field, the final monitoring point was identified for further full chemical analysis, heavy metal analysis (Mn, Cd, Pb and Cu) and bacteriological analysis if required.

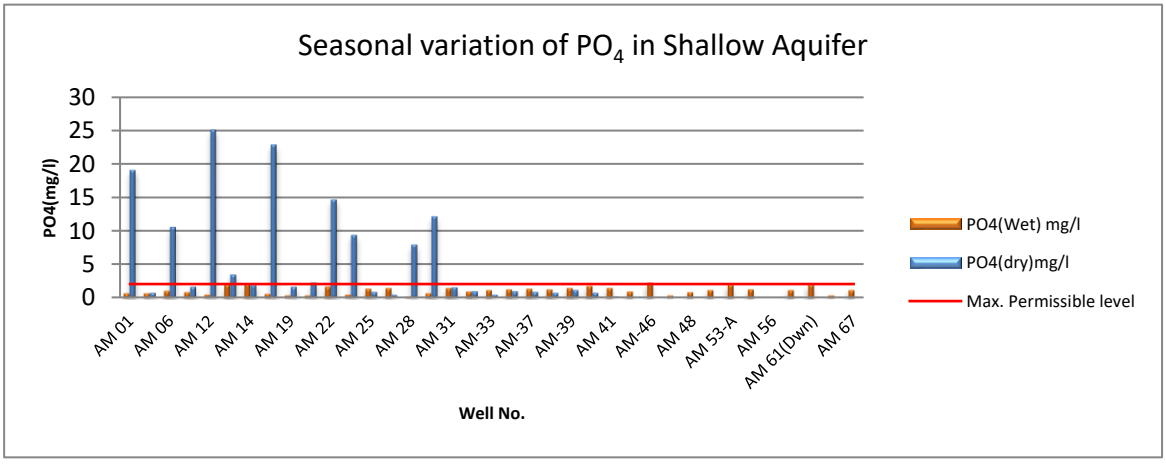
The sampling was carried out at sixty five (65) identified locations from the dug wells representing the shallower aquifer and fifteen (15) tube wells representing the deeper aquifer for both dry and wet season of the year 2011/2012. All the samples were analyzed under SL Standards at the Chemical laboratory of Water Resources Board.

Result and Discussion

According to the samples analysis result of shallow and deep aquifers during dry and wet periods, there are some anomalies detected in several chemical parameters such as EC, salinity, PO_4, F, and Mn. In certain urbanized areas of the study area indicated high values of Nitrate (Sammanthurai town and Central camp town).

It is reported that that excessive application pesticides and weedicides on the cultivation lands is a general practice adopted by the farmers. This may directly affect on shallow water sources and deeper groundwater bodies as well. Except the areas having pipe born water facility, the other remote community still totally relies on the shallower water sources “open dug wells”. The area is in semi-arid climatic condition thus low rainfall distribution and high evapotranspiration resulting enrichment of mineral content in groundwater and other chemical substitutes as well.

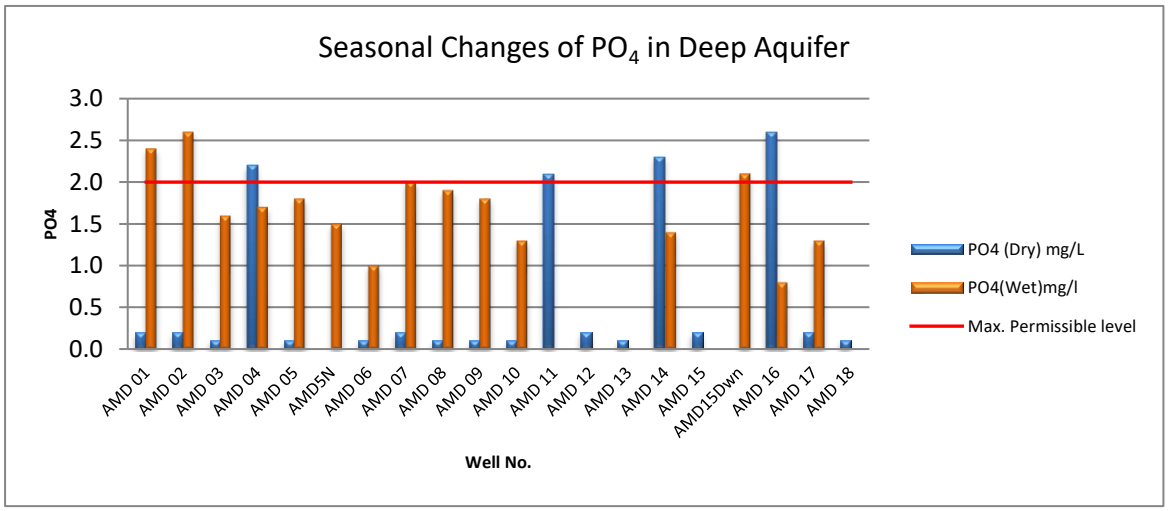
The PO_4 is the one of major issue identified in the pilot area from the analysis results. Almost all over the area of monitoring locations indicates high PO_4 in groundwater both during dry and wet periods. The Graph 01 shows the seasonal variation of PO_4.



Graph 01: Seasonal changes of PO_4 in shallow aquifer

The Phosphate (PO_4) values of shallow groundwater exceed the permissible level (> 2 mg/l) in most of the areas and especially at the locations of Samanthurai, Malwatte and Part of Karativu area. The highest level of 25 mg/l is observed in Karativu area. In general, the PO_4 varies from 0.6 mg/l to 25mg/l in dry season (August 2011) and indicating the very lower values of 0.2mg/l to 3.3mg/l during the wet period possibly attributed to dilution in the groundwater by recharge process and surface runoff removal before entering to the groundwater. The pattern of fertilizer application cannot be deemed out for this variation but requires careful survey. PO_4 contamination is not highly affected in deeper groundwater sources despite there are some anomalies could be identified within the permissible levels. In dry period (October 2011), 04 locations shows exceeded values of PO_4 out of 18 sampling location and analyzed results vary from 0.1mg/l to 2.6mg/l. In wet period (February 2012) it also shows 04 locations out of 15 sampling locations as exceeded values of PO_4 and almost all samples are reaching their permissible level of PO_4.

The area was covered by 70-80 % of paddy land and farmers used various pesticides and weedicides (Nomini, Solito, He-Coper, M-08, and Bandi pohora, etc.) for their cultivations. These pesticides may have a strong impact on the increase of PO_4 in groundwater. PO_4 directly impact to human health such as Urolithasis (Urine stones), skeletal etc.

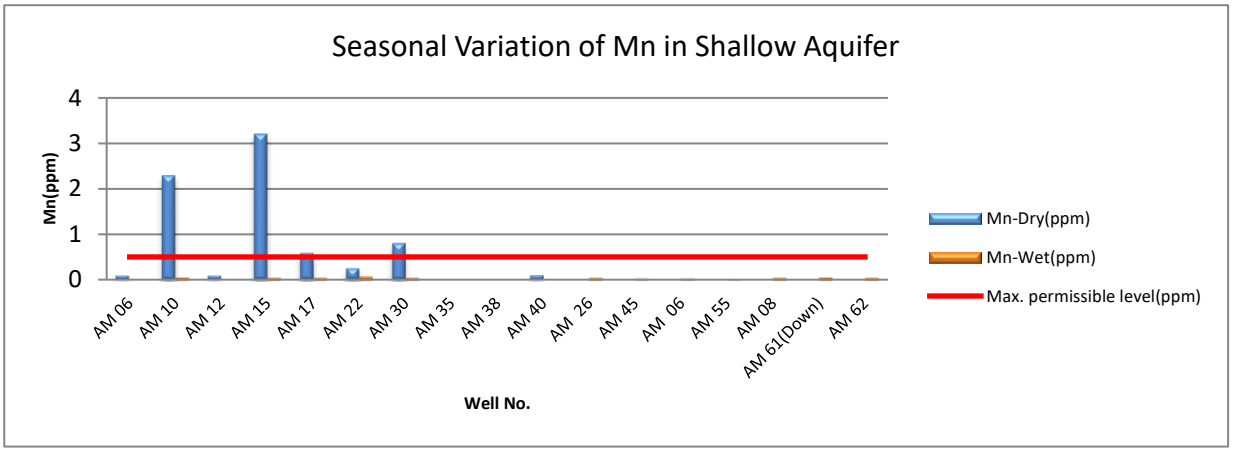


Graph 02: Seasonal changes of PO_4 in deep aquifer

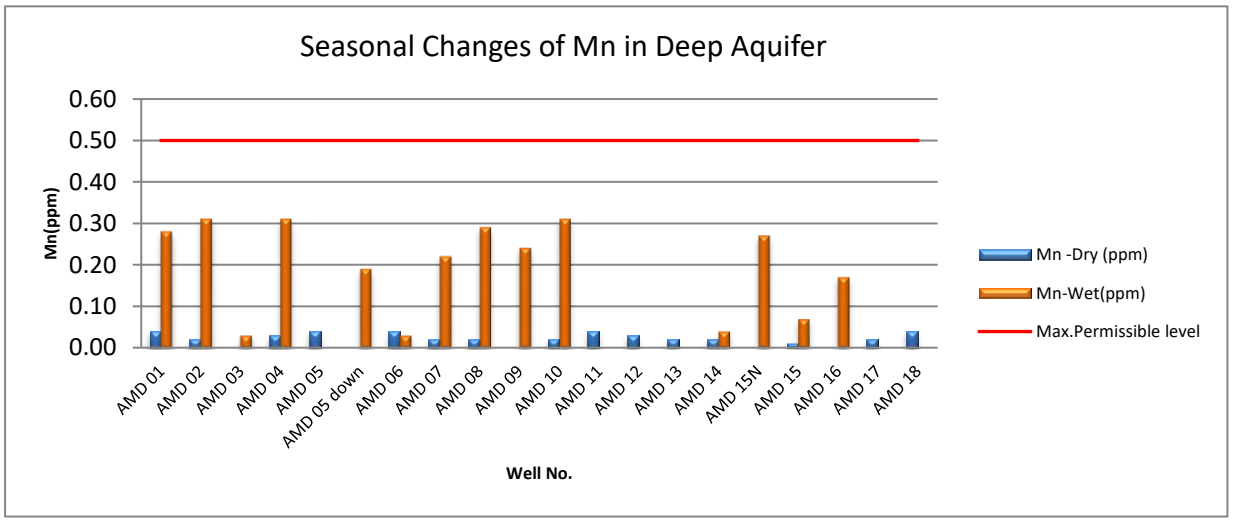
Mn, Cu, Pb, Cd and As were analyzed under heavy metal analysis. The result indicates high Mn and Cd values in shallow aquifer water sources during dry season. These anomalies may occur due to Mn rich parent rock weathering or due to pesticides / weedicides. In dry season, 10 samples selected for heavy metal analysis in shallow aquifer. The result reveals that 40% of samples exceeding maximum permissible level of Mn (0.5ppm). But in wet season, samples show slightly low values of Mn than dry season.

When considering deep aquifer samples, it is shown some different behaviors compare to the shallower aquifer. In wet season, samples were shown quit high values than dry season. Similar variation could be seen for PO_4 amount in groundwater of the area. This may result due to leaching and percolation of high Mn and PO4 enriched shallower water to the deeper aquifer with the rainfall recharge during wet period. In contrary, the shallower aquifer may indicate low Mn and PO4 during wet season due to flushing off enriched and accumulated substitutes in dry period. The graphs 03 and Graph 04 are illustrated Mn variation of shallow and deep aquifer in both dry and wet season.

However, these Mn values in deep groundwater aquifer are still within the tolerable levels (not exceeding the desirable level) in both dry and wet periods.



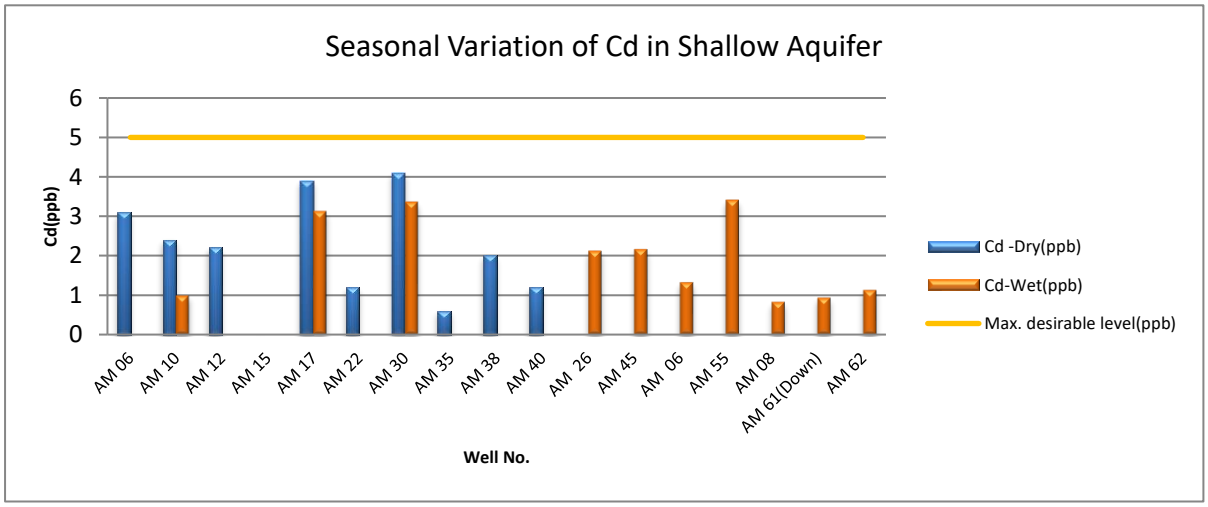
Graph 03: Seasonal changes of Mn in Shallow aquifer



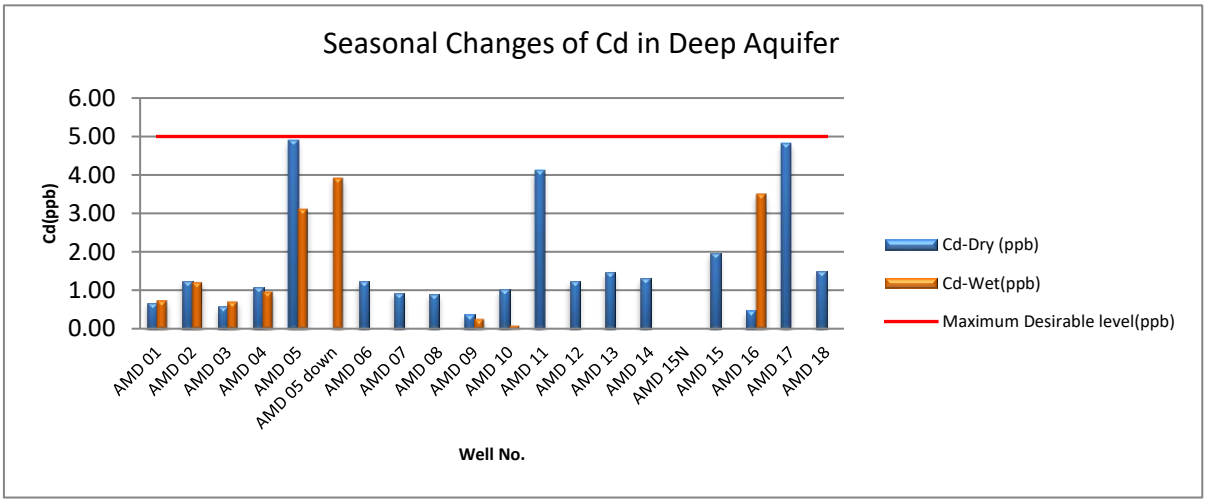
Graph 04: Seasonal changes of Mn in deep aquifer

In wet season, samples are shown lower Cd levels than dry season in both deep and shallow aquifers. Cd level is appeared to a considerable level (vary between 0.6ppb and 4.1ppb) in the shallow aquifer at dry season despite the permissible is 5 ppb. The Cd level is also within the standards even there is some indication of Cd encountered at considerable levels indicating a possibility of a contamination in deeper groundwater.

Groundwater can be contaminated by Cd due to parent rock weathering or usage of pesticides and weedicides as mentioned above. When it considers deep aquifer, Cd increase could occur due to both of above mentioned reasons. But in shallow aquifer, it may be largely affected by agricultural practices in general. The graphs 05 and Graph 06 are shown the seasonal changes of Cd in deep and shallow aquifer in the area



Graph 05: Seasonal changes of Cd in Shallow aquifer



Graph 06: Seasonal changes of Cd in Deep aquifer

Conclusion

This was a pilot study to identify the effect of extensive agriculture for the groundwater chemistry in eastern part of Sri Lanka. According to the results of water samples, groundwater of the study area is polluted due to heavy agricultural practices. Mainly in shallow aquifer groundwater is highly affected by PO_4, especially in alluvial deposits of Gal Oya river zone. Mn and Cd are also showing somewhat high values in study area.

It is obvious that the groundwater is being contaminated in the area due to the impact of excessive applications of fertilizers and the impact level is at incipient to intermediate level. Therefore immediate awareness of community, corrective measures and regulatory mechanism implementation is vitally important.

Based on the output of this study, the final long term monitoring network is to be established as a follow up activity under Dam Safety and Water Resources Planning Project (DSWRPP).

ACKNOWLEDGMENTS

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