GROUNDWATER AVAILABILITY AND USE IN THE DRY ZONE OF SRI LANKA

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Editor

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Groundwater availability and use in the dry zone of Sri Lanka

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Contents

Present status of groundwater quality and quantity related issues and need for a groundwater monitoring system for Sri Lanka

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ABSTRACT

Demand for groundwater has grown rapidly as a result of population increase and economic development of the country. A wide variety of users such as small-scale irrigators, households and housing development schemes, industries and industrial promotion zones, hotels, shrimp farms are now tapping groundwater in large quantities. The unlimited groundwater extraction cause depletion of the regional groundwater table and drying out surrounding wells located in the shallow aquifers. The groundwater pollution due to application of excess fertilizer and use of pesticides and other agrochemicals in agricultural areas and emission of wastes from the industries leads to contaminate groundwater sources considerably.

Recently, the environmental issues related to groundwater depletion and groundwater pollution is considerably increased in many parts of the country. These areas includes Kalpitiya, Jaffna Peninsula, CKDu prevailing areas in Anuradhapura, Polonnaruwa, Kurunegala, Monaragala, Badulla and Hambantota districts, areas where groundwater based water bottling schemes established and many other coastal areas. Water Resources Board has engaged with research work on groundwater quality and quantity related issues of the above areas and found interesting results. The occurrence of excess amounts of Nitrates, iron, fluorides, phosphates and High EC values in groundwater are the main issues identified in those areas.

The paper discuss the current status of groundwater in Sri Lanka with respect to those issues and propose to establish a groundwater monitoring network to manage this valuable resource of the country for future generations.

INTRODUCTION

Groundwater is a limited and strategic water resource, widely used for domestic, small-scale irrigation, industrial and commercial and other purposes. Groundwater conditions vary considerably throughout the country. In some areas there are shallow aquifers which are replenished quickly during rainy seasons or from nearby surface water sources. This form of groundwater can be easily tapped and is susceptible to over use by numerous small users.

Demand for groundwater has grown rapidly as a result of population increases and economic development. A wide variety of users such as small-scale irrigators, households and housing development schemes, industries and industrial promotion zones, hotels, shrimp farms are now tapping groundwater to an unprecedented extent. Subsidies have been introduced for shallow wells in some areas and groundwater exploitation is being actively promoted by some politicians, often without adequate knowledge of the availability of the resource. Well drilling and pumping technologies have spread, increasing the risk of over-extraction and groundwater contamination. Groundwater is also, by nature, a hidden resource. Users often have little or no understanding of its location or quantity and a few incentives exist to protect groundwater supply and quality.

Groundwater in most shallow aquifers is closely connected to surface water. It is replenished directly from rainfall and infiltration from surface water bodies such as rivers, streams, tanks and ponds. Groundwater is also the source of river flow and other surface water during the periods of low precipitation or drought. During these periods shallow groundwater is slowly released through springs and other seepage pathways, providing more stable surface water supply. Groundwater replenishment and flows are normally slow, relative to surface water. As a result, groundwater is often a more localized resource than surface water and in some cases is relatively slow to recover from depletion or contamination.

OBJECTIVES

The main objective of the study is to collect data regarding the groundwater pollution, and other groundwater related issues through studies conducted by the Water Resources Board (WRB) and data available with other stakeholder agencies. This information would enable the Water Resources Board to introduce a mechanism to address the groundwater issues and manage groundwater resources of the country.

METHODOLOGY

This study was conducted under the Dam Safety and Water Resources Planning Project of Sri Lanka to identify groundwater related issues in selected

Divisional Secretary Divisions (DSD's) of seven districts as listed in Table 1. After carrying out field activities in the pilot areas, groundwater monitoring networks for each pilot area were developed and the hydro geological and geochemical maps were prepared. The maps were analysed and the groundwater related issues were identified in each pilot area. In addition, studies were conducted to gather information whenever there were serious issues of groundwater related problems reported by the public.

Table 1. Districts and respective Divisional Secretariat Divisions selected for the study

District	Selected Divisional Secretariat Divisions
Jaffna	Jaffna, Nallur, Chavakachcheri, Pachchalipallai
Puttalam	Kalpitiya, Puttalam, Vanathawillu
Anuradhapura	MedawachchiyaNuwaragamPalatha (central), Padaviya, Kebithigollewa, Rambewa, Horowpathana, Kahatagasdigiliya, Galanbindunuwewa
Gampaha	Gampaha, Wattala, JaEla, Wattala, Biyagama, Katana
Ampara	Sammanthurai, Kalmunai, Ninthavur, Adallachchenai
Matale	Dambulla, Galewela, Laggala, Pallegama, Na Ula, Pallepola
Badulla	Mainly southern part of the district

(Source: Water Resources Board)

The information collected is presented in graphical forms for each of the pilot study under the results and discussion.

RESULTS

Groundwater monitoring results from pilot areas

Puttalam pilot area

In the Puttalam district pilot area, zones with excess Nitrate and high Salinity zones were identified (Figure 1 and Figure 2). The Nitrate map indicates that Nitrate concentration of the groundwater in Puttalam pilot area varies from 0.0 to 34 mg/l. A sizable proportion of Kalpitiya peninsula has *Nitrate* concentration exceeding 10 mg/l, which is the permissible level according to the Sri Lankan drinking water standards. The Electrical Conductivity (EC) of groundwater varies from 750 - 7200 µs/cm. According to the Sri Lankan drinking water standards the maximum permissible level for *EC* is 3500 µs/cm.

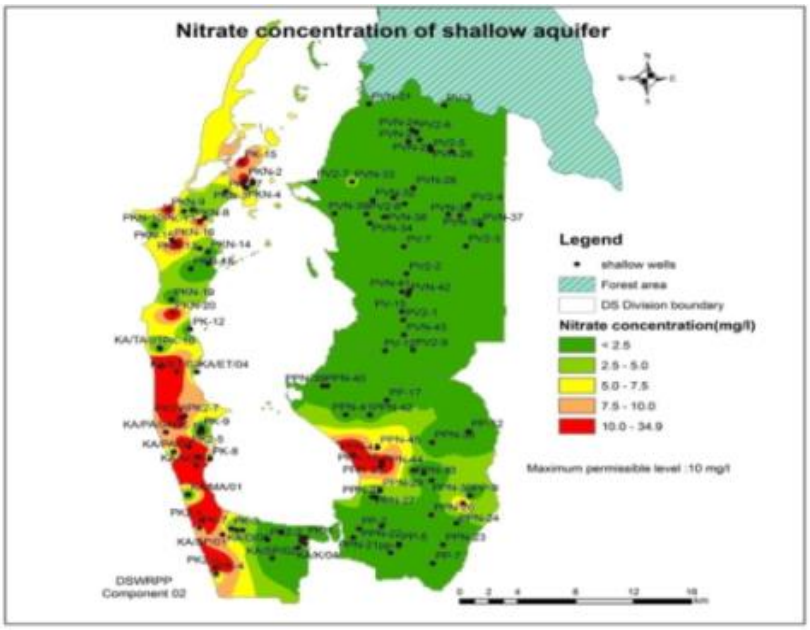

Figure 1. Nitrate map of Puttalam pilot area

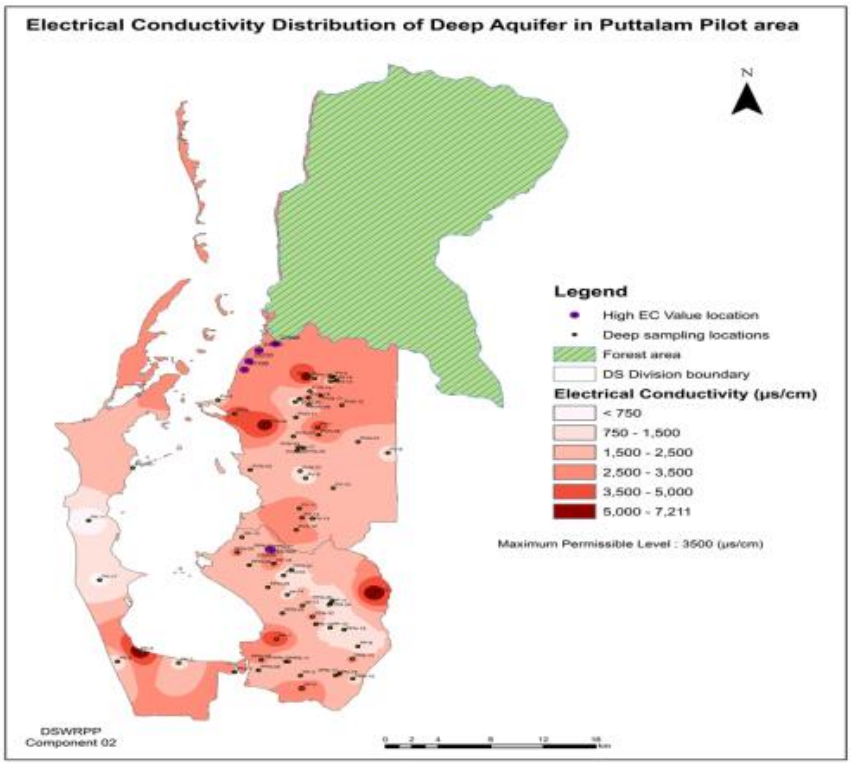

Figure 2. Electrical conductivity map of Puttalam pilot area

Jaffna pilot area

The data collected in Jaffna pilot area and rest of the peninsula were used to develop the water quality map for the entire peninsula. The maps clearly indicate the presence of zones with excess Nitrate and high salinity (Figure 3 and Figure 4). As in the case of Puttalam area, there are areas of more than 10 mg/l of *Nitrate* and 3500 µs/cm of Electrical Conductivity (EC) respectively.

Ampara pilot area

The *Phosphate* concentration of groundwater in Ampara pilot area varies from 0 – 6 mg/l as shown in Figure 5. According to the Sri Lankan drinking water standards the Phosphate concentration should be less than 2 mg/l. Therefore, zones with excess Phosphates were observed in eastern and central part of the pilot area which coincides with agricultural lands.

Anuradhapura pilot area

The zones with high concentration of Fluoride were observed in Anuradhapura pilot Area (Figure 6 and Figure 7). The Fluoride concentration of deep and shallow groundwater varies from 0 to 2.5 mg/l. According to the Sri Lankan drinking water standards the Fluoride level should be less than 1.5 mg/l. The occurrence of high fluorides is primarily connected to the geology of the area.

Figures 8 and 9 show the Arsenic concentration found in groundwater sources in Medawachchiya DSD. The values range from 2.6 ppb to 10.2 ppb. Only a small fraction of the area exceeds the permissible level of 10 ppb for drinking water.

Gampaha pilot area

The *pH* values of the groundwater in Gampaha pilot area varies from 3.8 – 8.5 as shown by Figure 10. In general, the groundwater appears to be more acidic.

Matale pilot area

The groundwater levels of the agro-wells in the selected DSD's of the *Matale* pilot area were monitored for two years. Figure 11 indicate groundwater flow map of the Matale Pilot area. The water level depletion was observed due to heavy pumping of groundwater for agriculture.

There was considerable fluctuation of the water levels both in wet and dry seasons. Figure 12 indicate the groundwater level fluctuation of the selected agro-wells in the pilot area, which shows different behaviour of the agro-wells. In some wells, the water level fluctuations were considerably high.

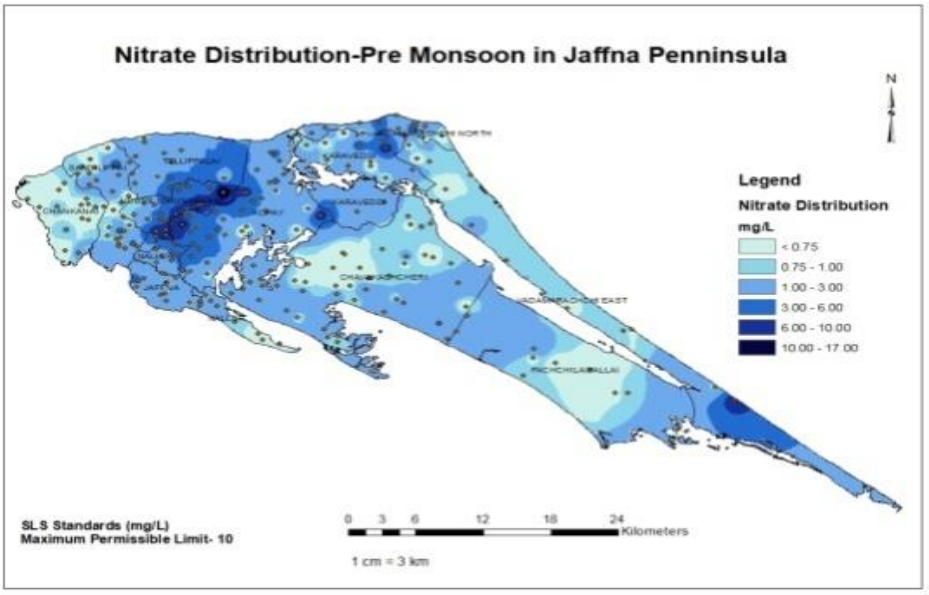

Figure 3. Nitrate map of Jaffna Peninsula

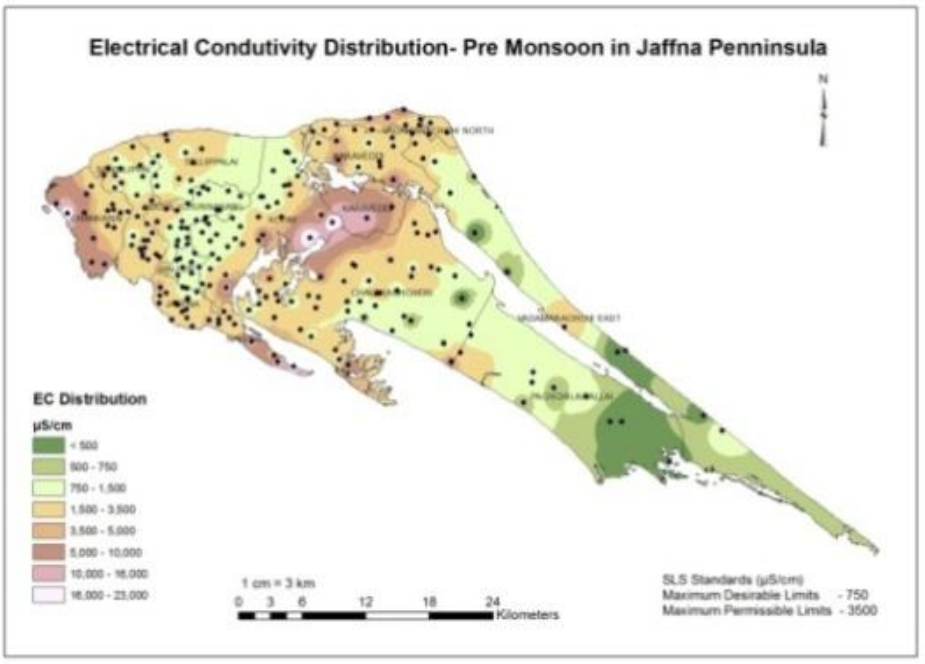

Figure 4. Electrical conductivity map of Jaffna Peninsula

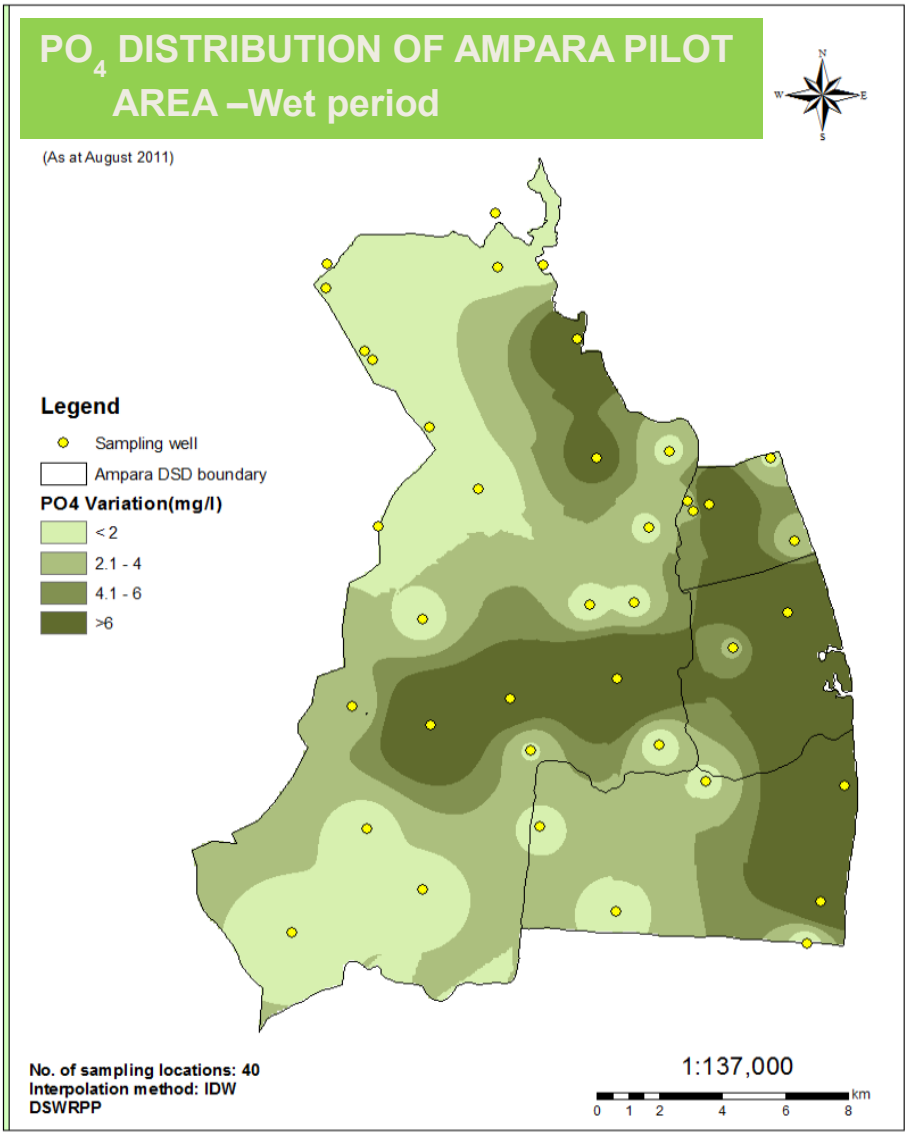

Figure 5. Phosphate map of Ampara pilot area

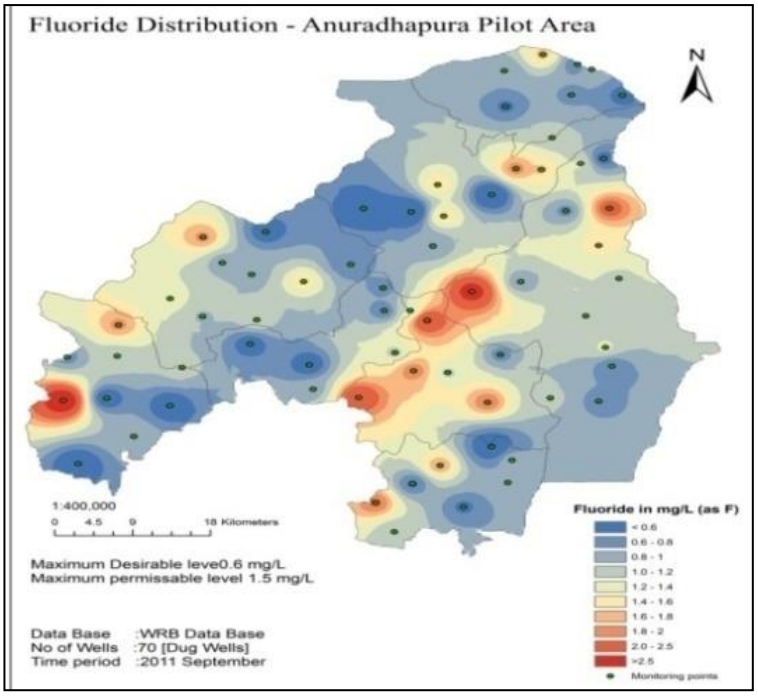

Figure 6. Fluoride in shallow groundwater of Anuradhapura pilot area

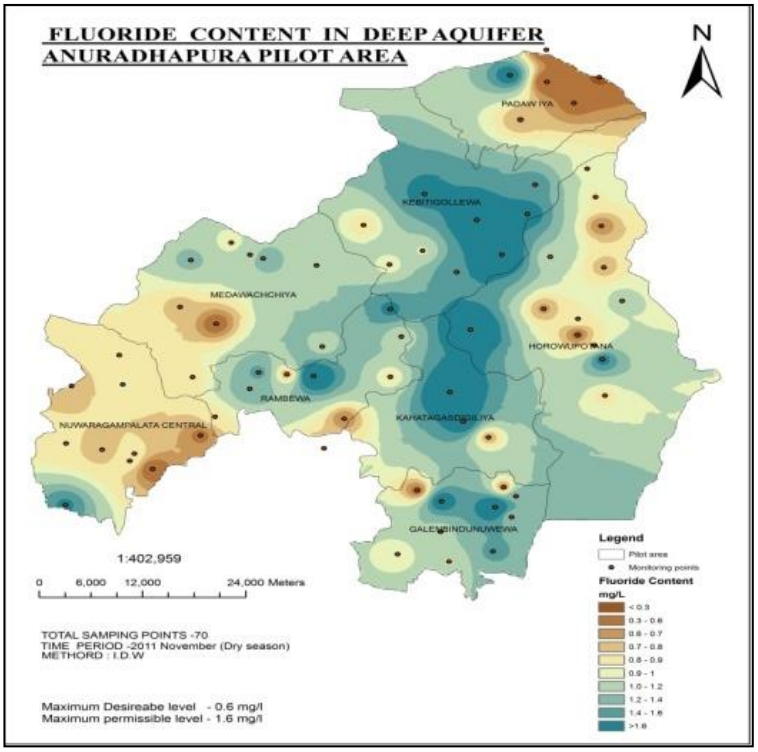

Figure 7. Fluoride in deep groundwater of Anuradhapura pilot area

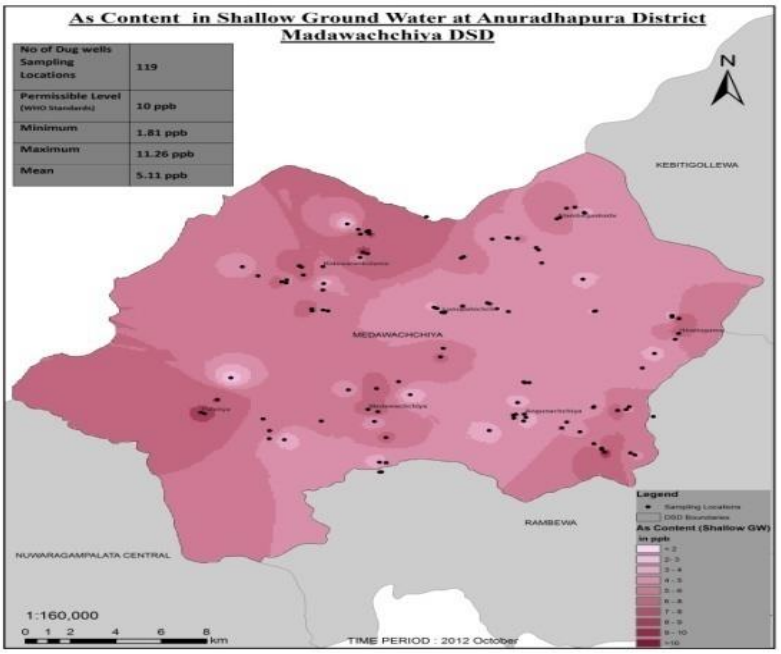

Figure 8. Arsenic in shallow groundwater of Medawachchiya DSD

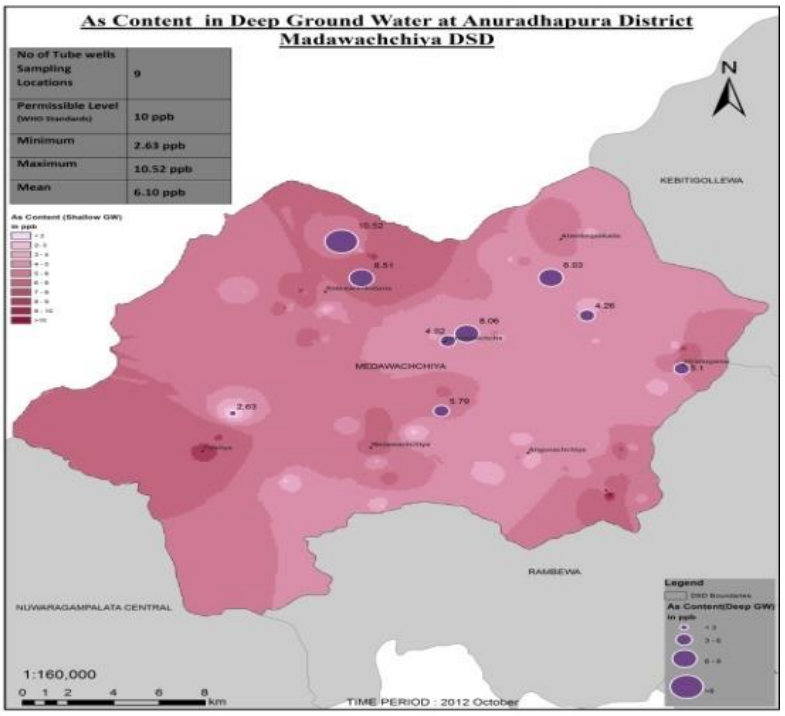

Figure 9. Arsenic in deep groundwater of Medawachchiya DSD

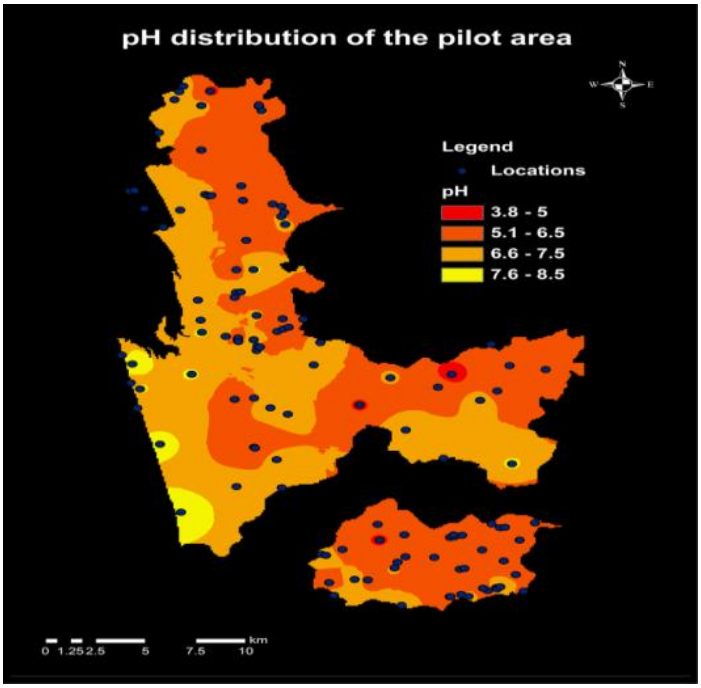

Figure 10. pH values of Gampaha pilot area.

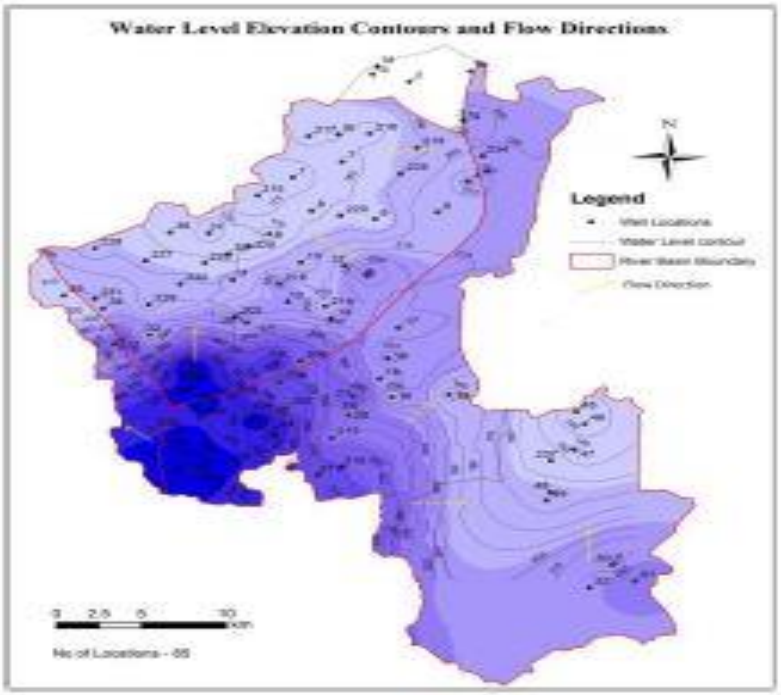

Figure 11. Groundwater flow map of Matale pilot area

Badulla pilot area

As shown in Figure 13, there is only localized Nitrate concentrations, which exceed the permissible limit of 10 mg/l in Badulla pilot area.

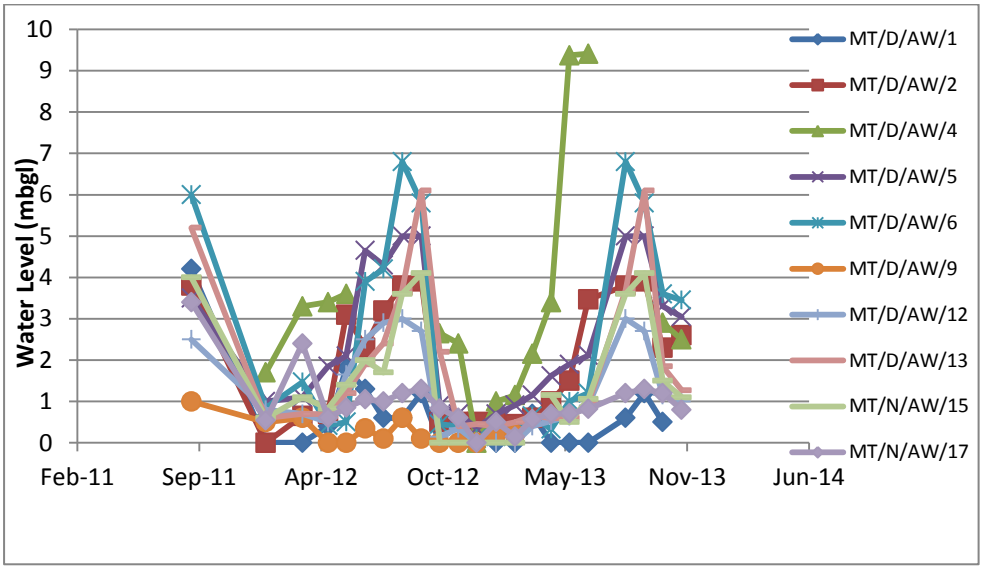

Figure 12. Water level fluctuation in selected agro-wells of Matale pilot area (2011 –2014)

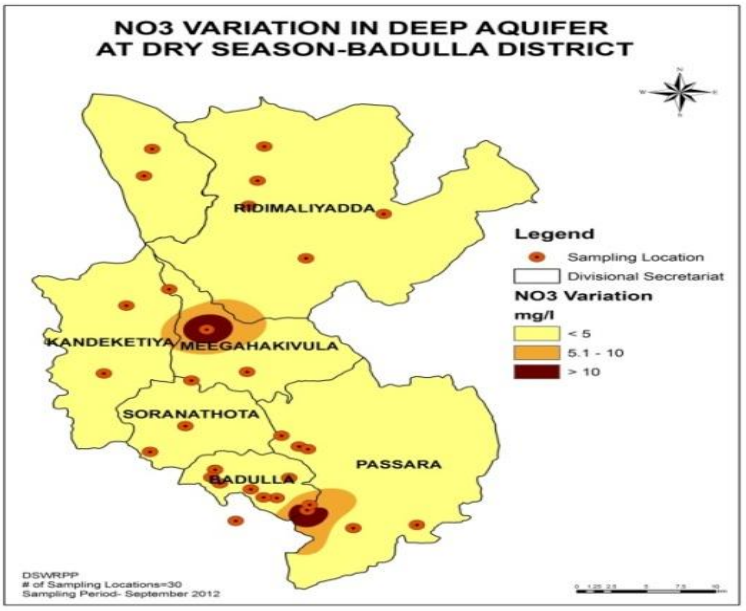

Figure 13. Nitrate map of Badulla pilot area

Results from significant groundwater issues reported in Sri Lanka

Low pH problem in Rathupaswela

In 2013, a serious problem was reported in Ratupaswela in Gampaha district due to low pH in the well water around Rathupaswela area. It was suspected that the emission of effluents from a nearby factory could be the reason for the incident. A study was conducted by the Water Resources Board through a groundwater monitoring network covering the entire area. The groundwater flow maps were prepared and analyzed to determine the pattern of groundwater contamination. In addition to the low pH, Nitrate and Sulphate contamination was also noted in close by dug wells in the area. Figure 14 indicates the groundwater flow map and the pH distribution of the study area indicating a possible connection.

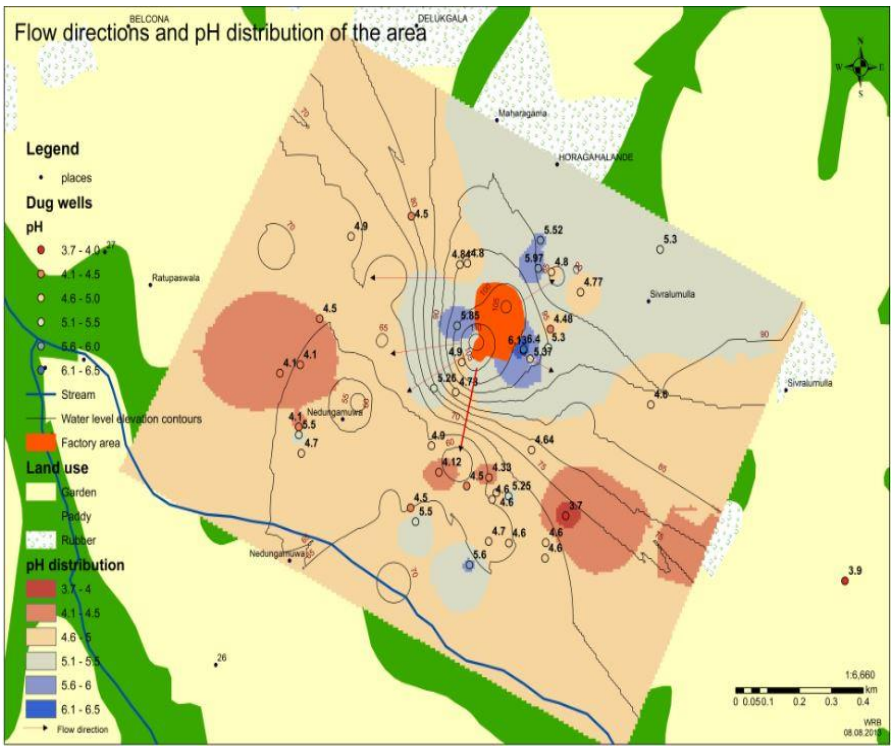

Figure 14. Groundwater flow direction and pH distribution in the well water, Rathupaswela

Contamination of groundwater due to dumping of oil and grease at Chunnakkam, Jaffna.

Groundwater contamination was reported in Chunnakkam, Jaffna due to dumping of oil and grease into the ground in an unprotected manner. Location of the site is indicated in Figure 15. The photographs in Figure 16 show the oil and grease contamination in surrounding areas of the Chunnakkam site.

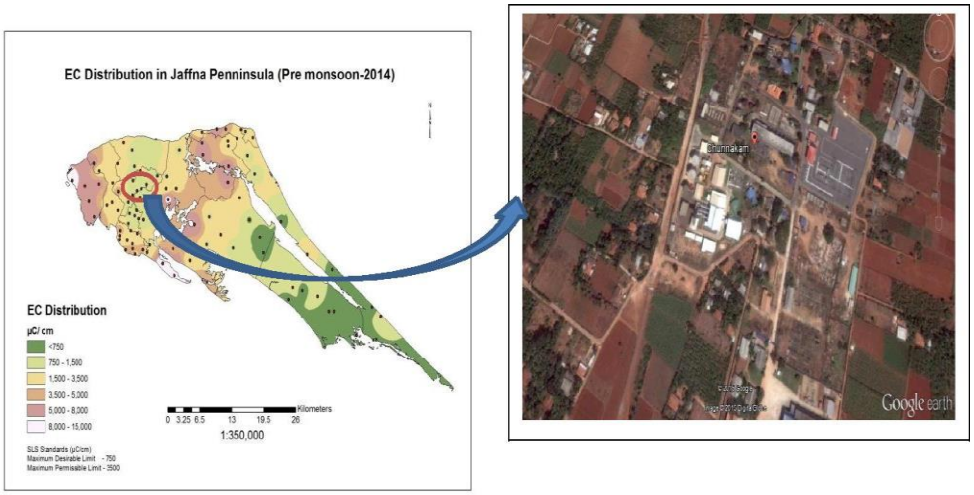

Figure 15. Location of the Chunnakkam site

Figure 16. Oil and grease Contamination in Chunnakkam area (Source: National Water Supply and Drainage Board)

E- coli contamination in Baduwatta, Katana

The residents of Baduwatta area complained to the Central Environmental Authority regarding the contamination of their wells due to the activity of a mill located close by to their village. The officers of the Central Environmental Authority checked three representative water samples from the wells in the village area. Their results are indicated in table 2. Comparison of these observed values with the Sri Lankan Standards, given in Table 3 shows that the water in this area is contaminated with E-Coli whilst the pH is also below the accepted standards.

Table 2. The analytical results of the well water, Baduwatta –Katana
(Source: Central Environmental Authority)

Sample	pH	Colour (NTU)	Chloride (mg/l)	Tcoli MPN/100 ml	Ecoli MPN/100 ml
Sample no 839/14/LS	5	7	271	800	130
Sample no 840/14/LS	4.5	4	187	1100	170
Sample no 841/14/LS	5.8	12	21	170	60

Table 3. Sri Lankan Standards

	pH	Colour (NTU)	Chloride (mg/l)	Tcoli MPN/100ml	Ecoli MPN/100ml
Standard values	6.5 – 8.5	2	250	10	0

DISCUSSION

The results presented above clearly indicate that the groundwater contamination and the groundwater depletion are happening in many parts of the country due to various human activities, incorrect agricultural and industrial activities. In addition to the cases reported above, data on many other groundwater related issues are available in the data bank of the Water Resources Board. If a proper groundwater monitoring system is established in the country, it would be possible to issue a warning before the incident happened. The availability and the accuracy of monitoring data would enable the authorities to manage groundwater system of the country in a sustainable manner. The management always depends on monitoring and the availability of reliable real time data. The diagram shown in Figure 17 clearly indicates the role of monitoring data in the water management.

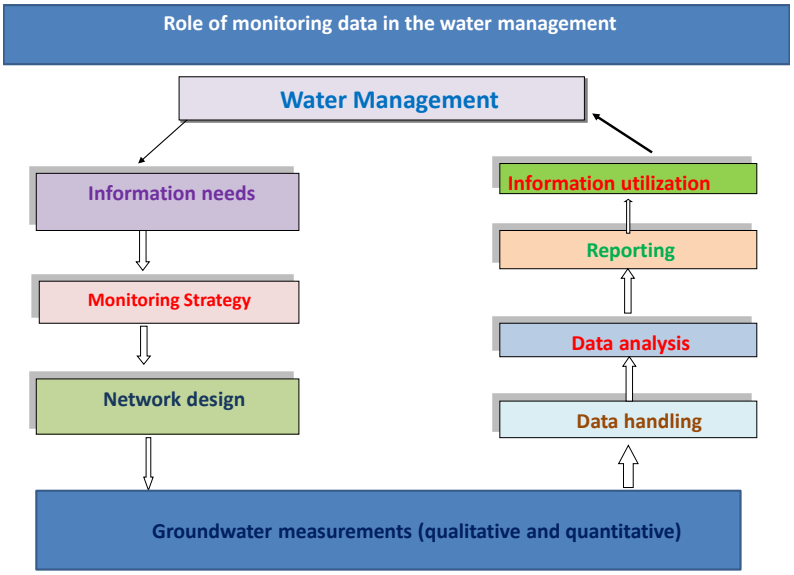

Figure 17. The role of monitoring data in the water management

There are many areas which require special attention due to the characteristics of aquifers and the type of groundwater use. A brief introduction of those identified areas is given below.

Community water supply schemes

There are many community based water supply schemes in Sri Lanka, especially in the dry zone. For an example the majority of community water supply schemes in Anuradhapura district use shallow or deep groundwater as their source. Figure 18 indicates the community water supply schemes in *Anuradhapura.* It is very important to monitor the groundwater quality of these wells in view of the prevailing CKDu problem in the area.

Groundwater in Jaffna peninsula

Groundwater is the main available source of water for the people in Jaffna Peninsula. Studies conducted in the peninsula indicate that the Nitrate concentration of groundwater in some of the water supply wells is above the recommended levels.

A case is point with regard to high concentration of *Nitrate* in groundwater comes from the water supply well at Kondavil, Jaffna. Figure 19 indicate the Nitrate concentration of this particular well. Water Resources Board continuously monitored the *Nitrate* concentration of this particular well during the last 4 years and observed that from January to December of each year the *Nitrate* levels are changing from 7 mg/l – 25mg/l. This well is located in the

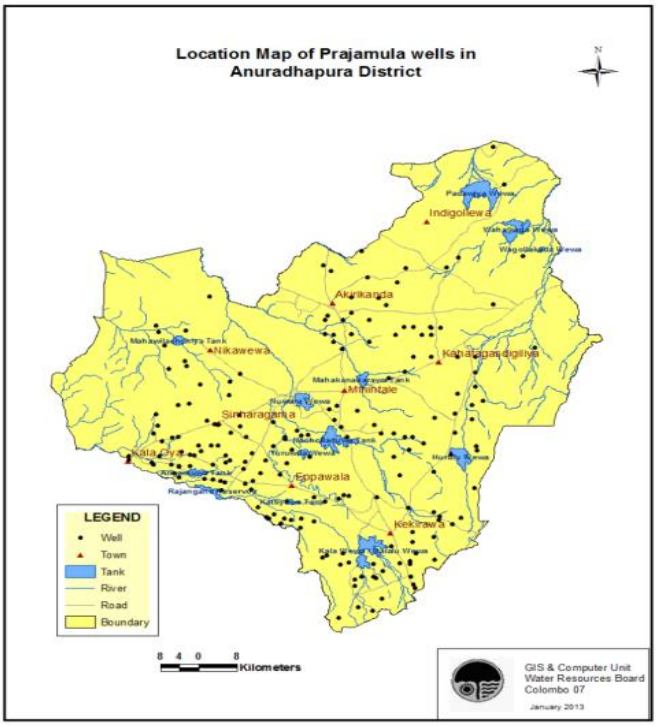

Figure 18.Cummunity based water supply schemes in Anuradhapura district (Data collected from NWSDB, Anuradhapura)

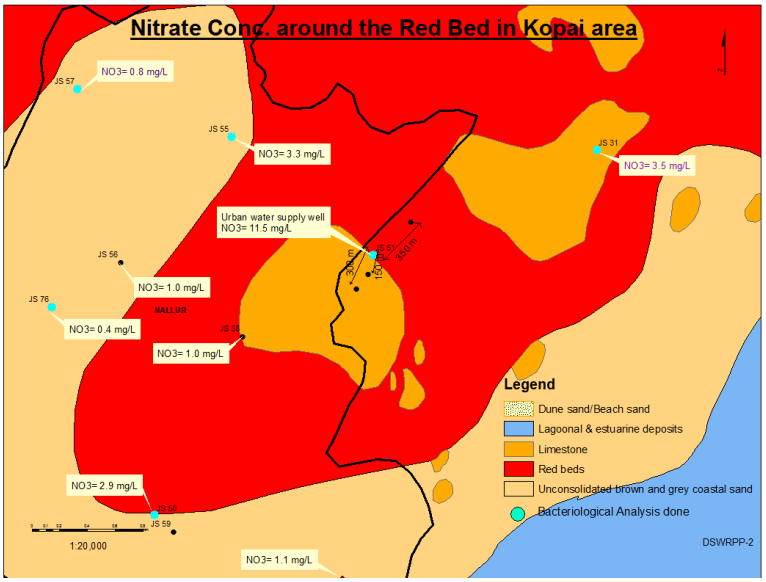

Figure 19. Nitrate map of Kondavil area

agricultural area and Nitrates may come from inorganic fertilizers applied for various crops by the farmers.

Mannar limestone aquifer

Mannar Limestone aquifer has very high groundwater potential and a large amount of groundwater is used for irrigation purposes. These wells are also threatened with the increase of chemical contents in water and hence needs to be monitored.

Coastal sandy aquifer

Many hotels and industries use groundwater from coastal aquifers. For instance, Industries in the Board of Investment zone of Katunayake use 3000 cubic meters of water on daily basis from 33wells constructed in the coastal aquifer extending from Colombo to Negombo. Therefore, this aquifer should be closely monitored qualitatively and quantitatively.

Alluvial aquifers

The alluvial deposits along major rivers are considered to be very good shallow aquifers. The main beverage companies like Coca Cola, Ceylon Cold Stores and other water bottling industries are situated along the river terrace of Kelani and they use considerable amounts of groundwater from shallow wells. As a result of these heavy groundwater extractions, the groundwater level fluctuation and water quality changes could be expected in this aquifer system. This aquifer system also needs more attention in future.

Laterite aquifer

This is the main aquifer in western and south western part of the county. The groundwater in this particular aquifer shows low pH values within the range of 4 – 6. Many people use this water for their day to day activities. Many industries are located within this area and activities of these industries may be affecting water quality of the wells (e.g. Rathupaswela). Therefore, attention must be focused on this aquifer system too.

As stated earlier the development activities of the county with the population increase would increase the demand for groundwater considerably in future. Therefore, a groundwater management system through a proper groundwater monitoring network is essential for the country.

GROUNDWATER MONITORING SYSTEM

The paper contain only very limited issues identified or reported to the Water Resources Board. There are some court cases regarding the groundwater issues. Therefore, it is recommended to establish a proper groundwater monitoring

system for the country covering all the aquifer systems and the sensitive areas already identified by the Water Resources Board, as shown in Figure 20.

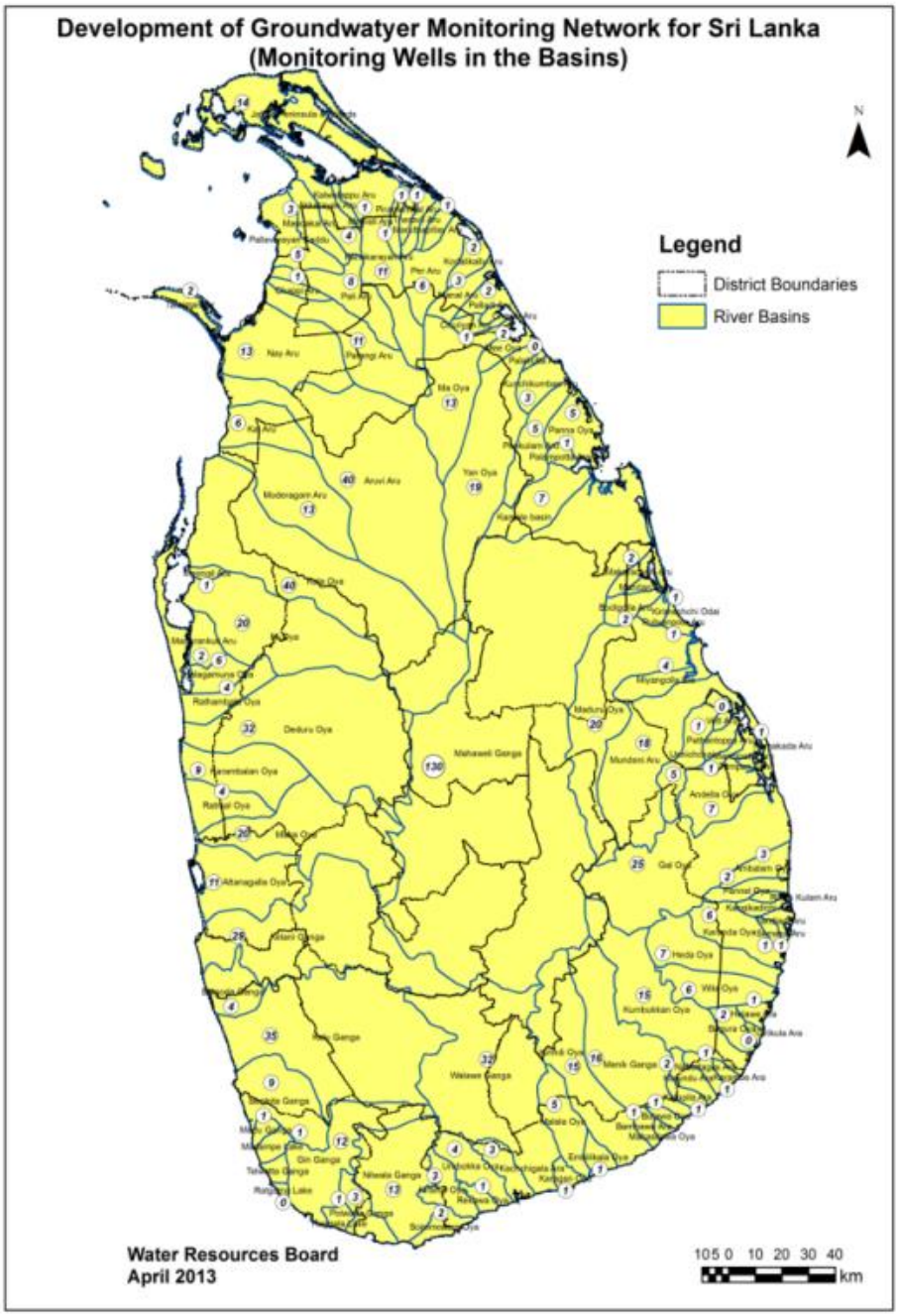

Figure 20. The groundwater monitoring network already designed by the Water Resources Board

The well monitoring system should be designed as follows:

a) The system should have at least 1030 observation wells.
b) Install the wells with data loggers to monitor Water levels, Electrical conductivity, *pH* and Chemical parameters (*Nitrate*)
c) Collect real time data
d) Data analysis

The following benefits could be accrued from a groundwater monitoring network.

- Develop real time groundwater data base for Sri Lanka.
- Maintain a proper groundwater management system for the country.
- The possibility of taking quick action to the groundwater related issues.
- Ability to forecast groundwater related issues.
- Share data with decision makers, researches, stakeholder agencies and general public.
- Periodical evaluation to examine the changing trends to assess the improvement of water quality.
- Conducting awareness programmes on mitigation.

CONCLUSION

The government of Sri Lanka should pay more attention to the protection of groundwater resources of the country by implementing groundwater monitoring system with immediate effect.

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Water Resources Board. Water Quality study at low pH areas of Gampaha district (Unpublished). Water Resources Board, Colombo, Sri Lanka.