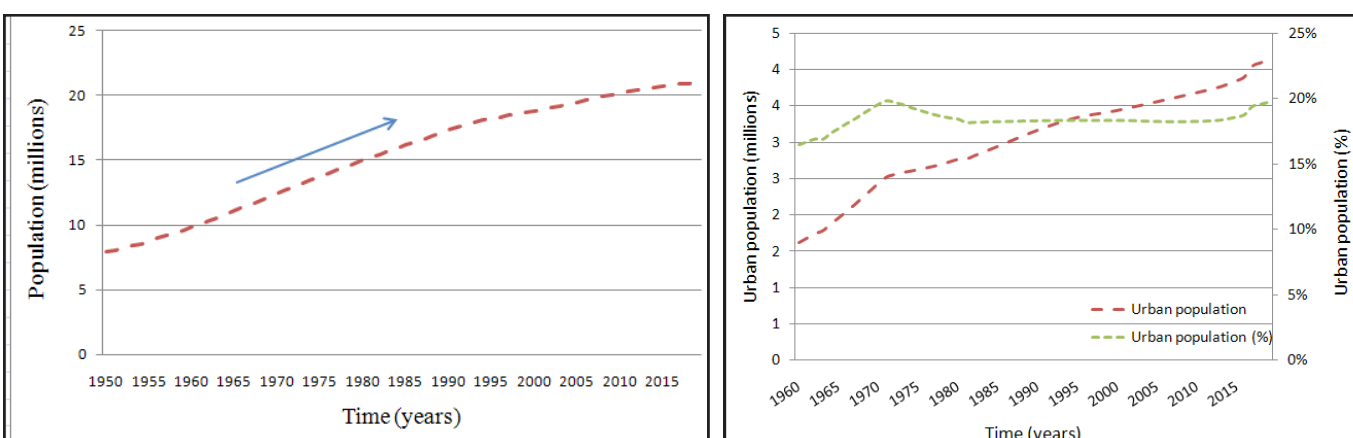
Impact of urbanization on earth resources in suburbs of Colombo, Sri Lanka

Dr Upaka Rathnayake

Sri Lanka is a moderately populated island (ranked 57th in the world) located in Indian Ocean. It is ranked 25th in the world in terms of population density. Sri Lanka as a country has faced several social issues since independence. Unplanned urbanization is one of the major issues experienced today. This unplanned urbanization has even indirectly led the society to have many social issues. These social issues include overpopulation, haphazard housing services, health burdens, urban poverty, crime, child labor, erratic education system, mismanagement of waste, deforestation, as well as air, water, sound and soil pollutions, carbon emission, environmental hazards, traffic jam, under employment and unemployment, improper drainage system inadequate entertainment facilities, drug abuse, vulnerable ecosystems, medley lifestyle and culture.

Colombo, the commercial capital of Sri Lanka, is continuously under pressure of urbanization. The land-use pattern in the Colombo District has changed dramatically over the last 50 years. Many migrants from the other districts have settled down in the Colombo city with the introduction of the open economy system in 1977. Many people have been under the belief that they could be economically wealthy, by moving into the capital city of the country. That is the current status of Colombo city, while the suburbs of Colombo began to urbanize during the early 1990s.

Figure 1(a) shows the population growth in Sri Lanka since the 1950's. The variation clearly shows the increasing trend of the total population in Sri Lanka. On the other hand, Figure 1(b) shows the urban population growth, and its percentage to the total population. Both figures show increasing trends as could be expected. However, since the land resources for the urban population are limited, while the growing urban population increases, the population density



(a)Cumulative population

(b)Cumulative urban population

Fig 01 : Population statistics over the years for Sri Lanka

in urban

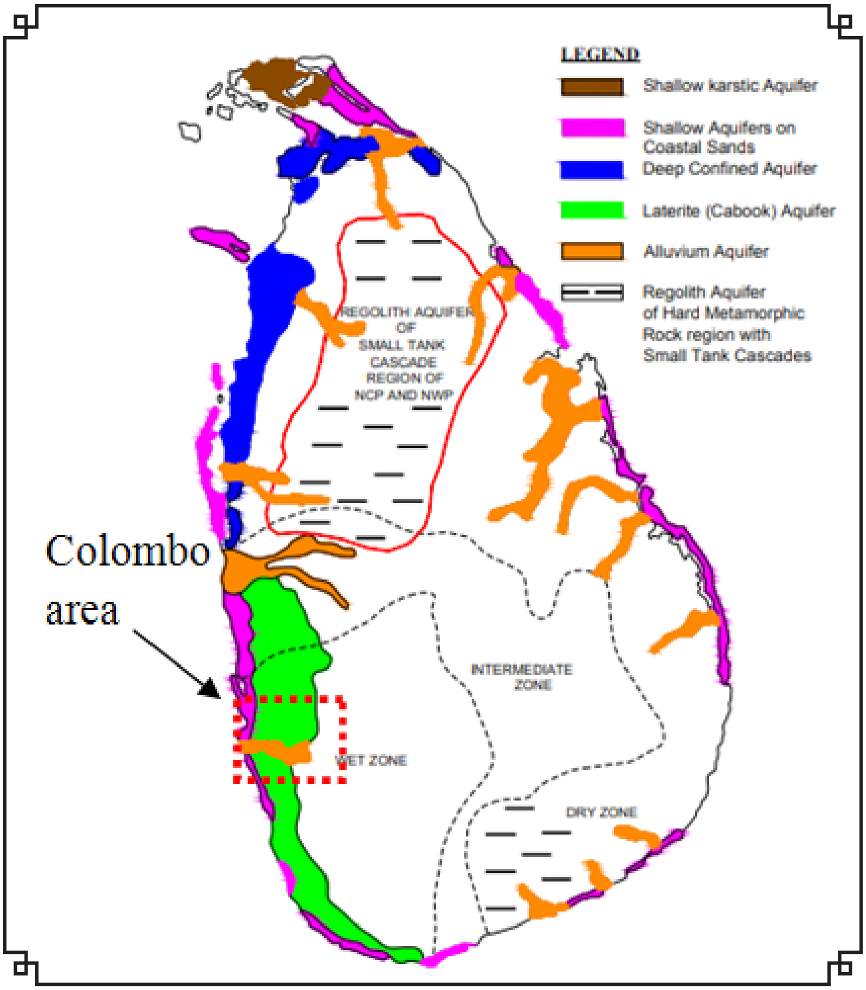
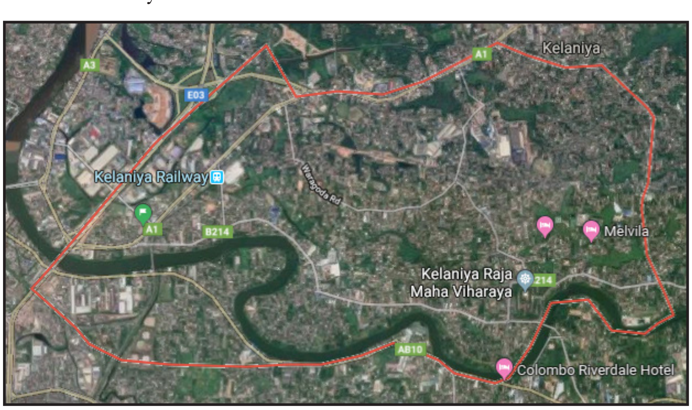


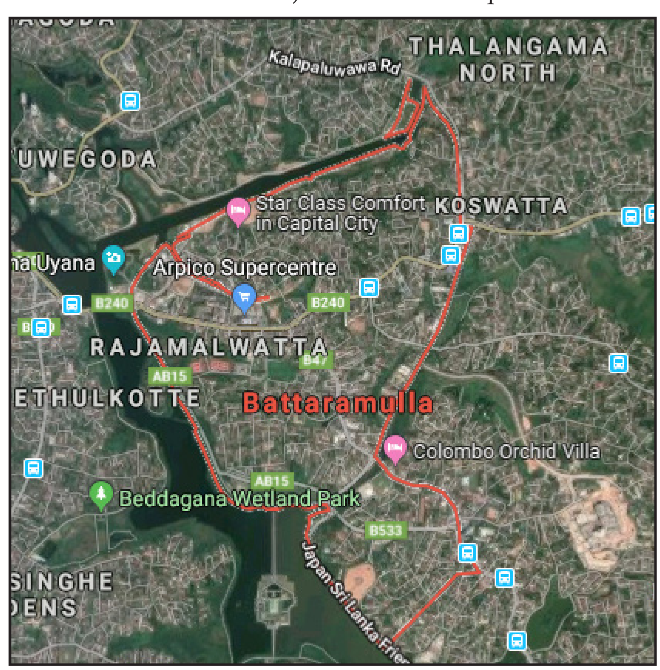
Fig 02 : Types of aquifers in Sri Lanka

areas continues to increase. In addition, new constructions (especially high-rise apartments) are being continuously introduced to the urban areas to cater to the growing population, and therefore the imperviousness of the land areas are at the increasing phase. This not only increases the urban runoff but also reduces the groundwater recharge.

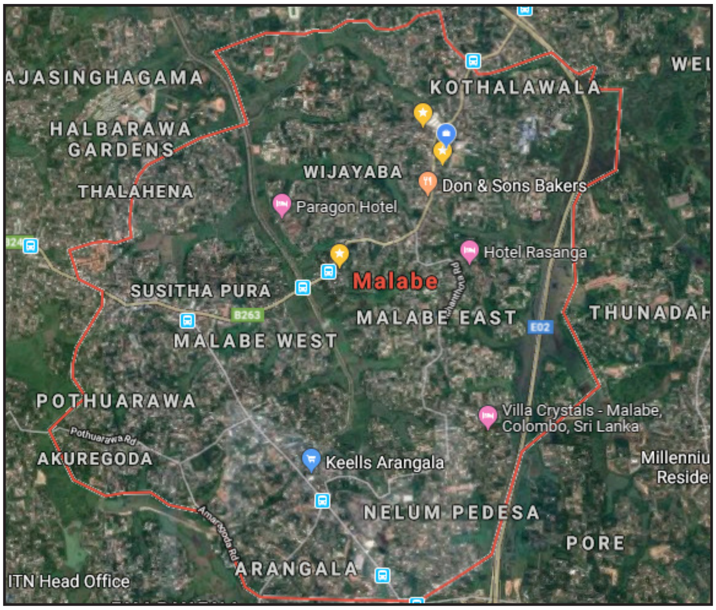
Let us now look at the groundwater resource in Sri Lanka. Groundwater is the largest reservoir of fresh water in the world. Groundwater can be found in aquifers (Wikipedia says; An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials like, gravel, sand, or silt) and probably treated as the most precious earth resource by many people. In addition, it is one of the highly demanding components of the water cycle. Therefore, the geology (or in other words the soil structure) is very important to keep steady the groundwater aquifers. The geology of Colombo is representative of the entire west coast of the Sri Lanka's geology. The geology can be seen by a borehole test. A borehole can be defined as a narrow shaft drilled (bore) in the ground. This can be either vertical or horizontal though the vertical boreholes are frequent. Borehole analysis showed that the Colombo area had been formed as an estuary of Kelani and Kalu rivers. The flood plains of Kelani River provided thick alluvial (loose and liquidous) profiles for unconfined aquifers (Institute for Global Environmental Strategies, 2007). Unconfined aquifers are



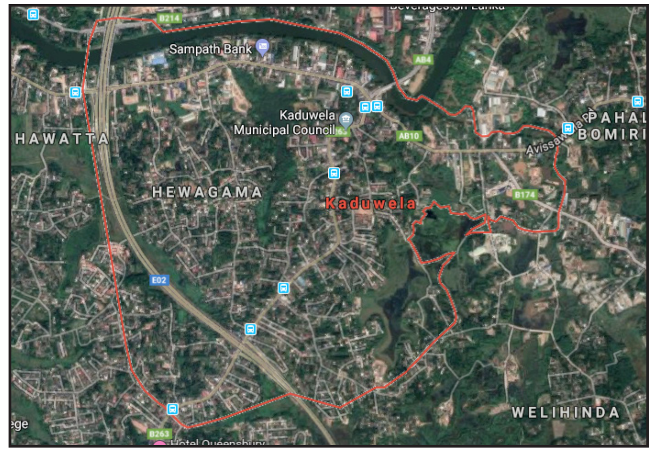
(a)Peliyagoda



(b)Battaramulla



(c) Malabe



(d)Kaduwela

Fig 3 : Google map images

those into which water seeps from the ground surface directly above the aquifer.
Six types of groundwater aquifers can be identified in Sri Lanka (Panabokke and Perera, 2005). They are shallow karstic aquifers, coastal sand aquifers, deep confined aquifers, lateritic aquifers, alluvial aquifers and shallow regolith aquifers. The distribution of aquiters presented by Panabokke and Perera (2005) can be seen in the Figure 2. However, they cited that many small groundwater pockets are distributed all over the country, indicating that Sri Lanka has rich groundwater resources.

As could be seen from Figure 2, Colombo area has three aquifer types including, shallow aquifers in coastal sand aquifers, lateritic aquifers and alluvial aquifers. Therefore, we can justifiably state that the area has a significant amount of groundwater resources. The geological structure also provides very good conditions to store groundwater in the area. Also since Colombo area is in the wet zone of the country, regular recharging of the aquifer through heavy rainfall can be observed.
Now let us look at groundwater usage in Colombo District. Sri Lankans since ancient times, believed that groundwater resources have the better quality compared to other water sources. People never tested the quality of the groundwater. However, they had

Fig 04 : processing details for Peliyagoda area

Fig 05 : Sample locations on Google Map

that belief. Even without treatment, they believed that the groundwater from wells can be used as drinking water. Many people used a cloth filter to screen small insects and floating particles from the well water, while some others boiled the water before drinking.

Nevertheless, Colombo does not have a groundwater supply system. The water distribution system in Colombo and its suburbs is through the pipe network that originates from surface water. However, a significant amount of residents in the suburbs of Colombo still use groundwater as their primary water supply source. Most of them use a small pump to lift the well water. The population that relies on groundwater in Colombo District is 34.8% (Institute for Global Environmental Strategies, 2007). This is a significant contribution from the earth resources. Malabe, Athurugiriya, Kaduwela, and Homagama are few of the suburbs that use more groundwater for domestic usages.

Now let us look at the impact of urbanization on well water in Colombo. As indicated earlier, Sri Lanka is a moderately dense island by population. However, few of the suburbs of Colombo have been extensively urbanized during the last decade. Peliyagoda, Battaramulla, Kaduwela and Malabe are few examples for such suburbs. The Google map images of these suburbs accessed on 13th of April, 2019 are given in Figures 3(a) to 3(d). These Figures clearly show that the green patches are at a minimum level. These suburbs are several kilometers away from Colombo city. However, they are highly packed. Nevertheless, a significant number of residents in these suburbs use groundwater for their domestic purposes (at least as the secondary water supply system). Several years ago, people used to utilize 10 perch (or more) land extent to build a regular house. However, it is now reduced to 6 perches. Rapid urbanization has reduced the land extent for the households. Within this 6 perch land area, people still use to have their water well and the toilet pit. There are many standard values for the minimum distance from a toilet pit to the water well (Graham and Polizzotto; 2013, Islam et al., 2016). However, as a norm, Sri Lankans use a 50 foot distance. Within the 6 perch land extent it is very unlikely to have such a distance in between the toilet pit and the water well.

In addition, radially this 50-feet distance cannot be maintained in relation to the neighboring toilet pits and the wells. This is almost impossible with the on-going rapid urbanization. Therefore, the contamination of well water through toilet waste is not preventable, and thus the quality of well water is in great danger.

The impact of urbanization on groundwater resources can be understood using mathematics. Research (project) work has been done to understand what is happening using simple mathematics. For this purpose the 4 above stated suburbs (Peliyagoda, Battaramulla, Malabe and Kaduwela) were selected. Then, an analysis was done on these suburbs to find the impervious and pervious ratio using image processing techniques. To compare the rate of urbanization, the years 2004 and 2016 were selected. Google Earth was used to locate the land-use maps for the suburbs for an early time period. Therefore, the analysis was used for a comparison of a 12 year period. The Google Earth images Autodesk AutoCAD 2014 software was digitized to find out the pervious and impervious areas. Figure 4 illustrates an example for identification of pervious and impervious land extents in the Peliyagoda area.

Similar studies were carried out for other three suburbs for the years 2004 and 2016. In addition, as an initial step, groundwater quality was measured for a set of wells in Malabe and Kaduwela areas. Several basic water quality parameters (colour, pH, turbidity, conductivity, nitrate concentration, nitrite concentration, sulphate concentration, phosphate concentration, coliform availability and E-coli availability) were measured to understand the quality of the well water in the Malabe and Kaduwela areas. Due to various limitations, it was possible to analyze only few wells in Malabe area for coliform availability and E-coli availability. Figure 5 shows the locations where quality tests in water wells were carried out. The wells were intensively used by the community as the primary sources of their water supply.

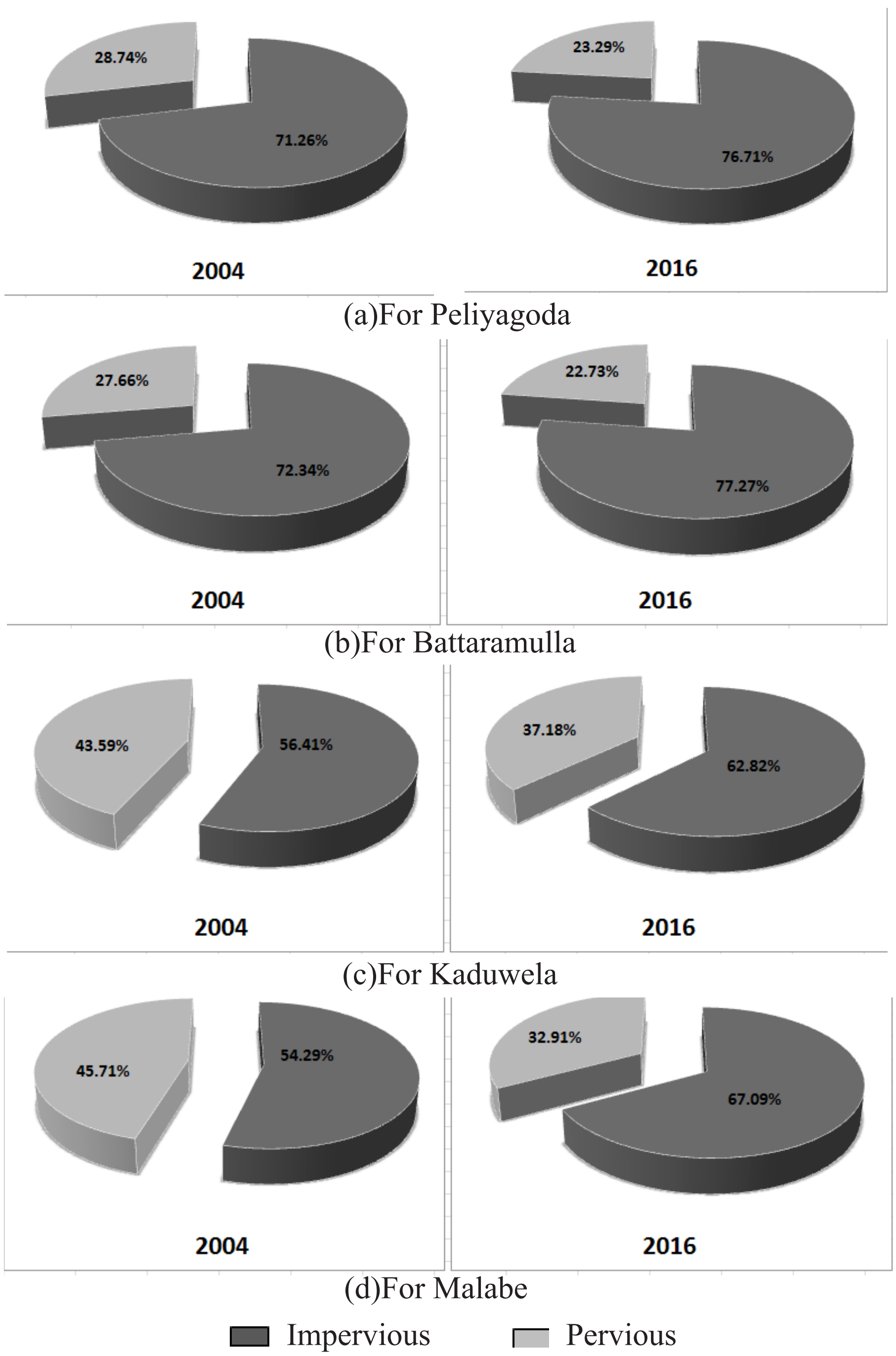
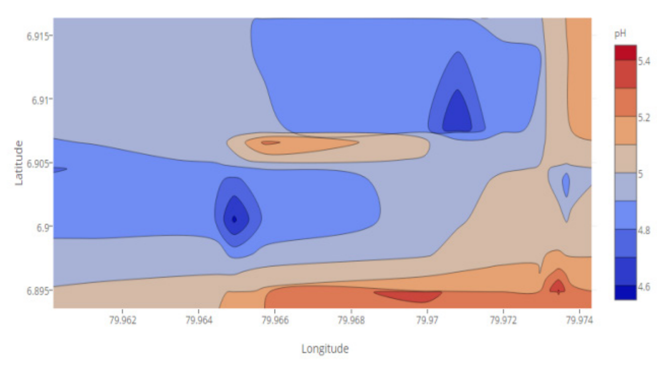
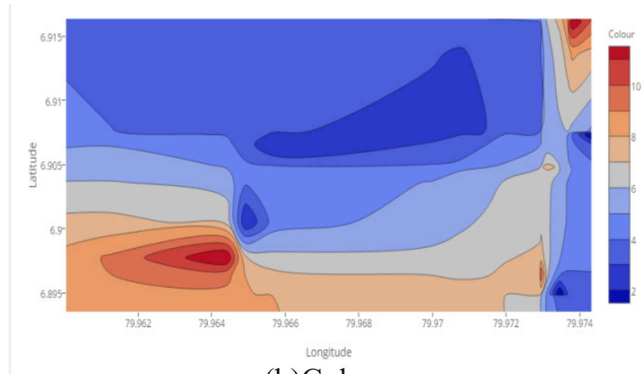


Fig 06 : Impervious and pervious ratios in suburbs of Colombo

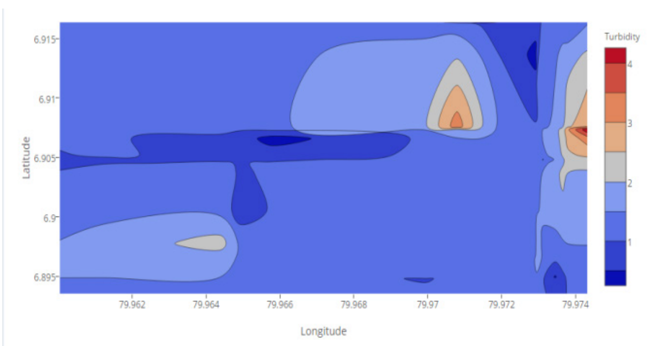
Very encouraging results were obtained from this work. The Figures 6(a) to 6(d) show the impervious and pervious ratios of soil layers in 2004 and 2016 for Peliyagoda, Battaramulla, Kaduwela and Malabe suburbs, respectively. These clearly show the temporal variation of the imperviousness and perviousness ratios over the 12 year span. Peliyagoda (5.45%), Battaramulla (4.93%) and Kaduwela (6.41%) areas showed a moderate impervious land ratio increase over the 12 years. Therefore, on an average, 5-7% of pervious lands had been converted to impervious lands. However, Malabe has a much heavier impact. The increased ratio of impervious lands in Malabe area was around 12.8%. It is a significant loss of pervious area for the earth system in that area. Malabe has been treated as an educational hub as well as an information technology hub for some years, and therefore the area has been heavily urbanized.



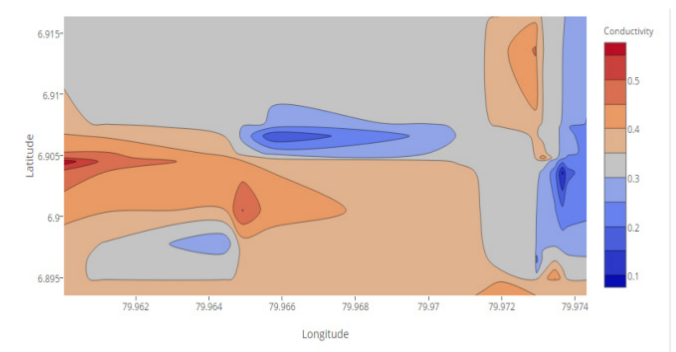
(a)pH



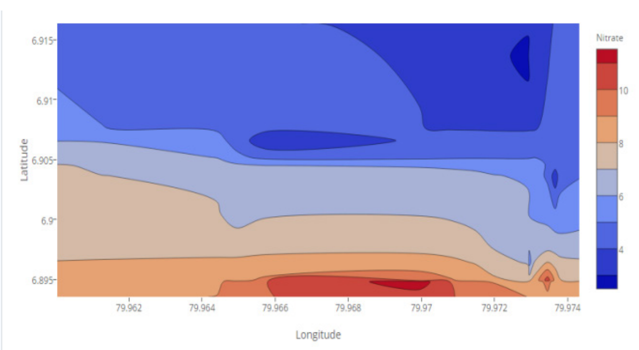
(b)Colour



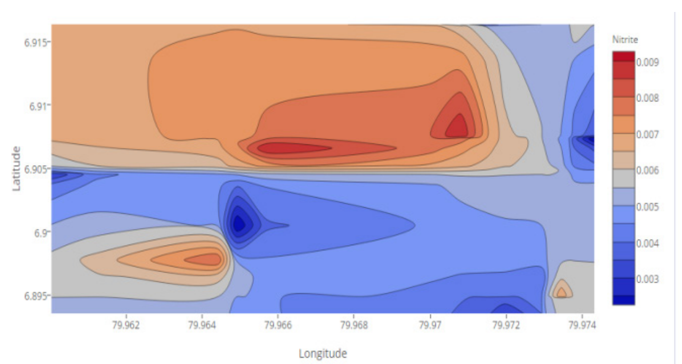
(c)Turbidity



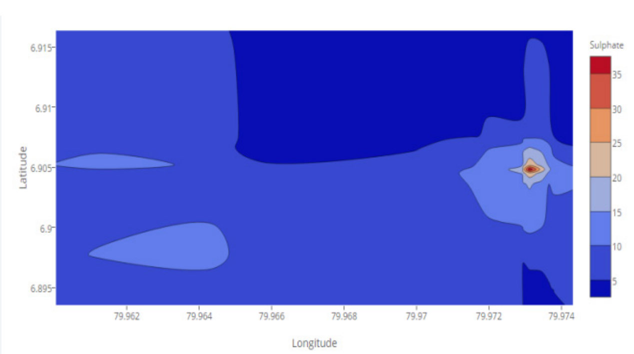
(d)Conductivity



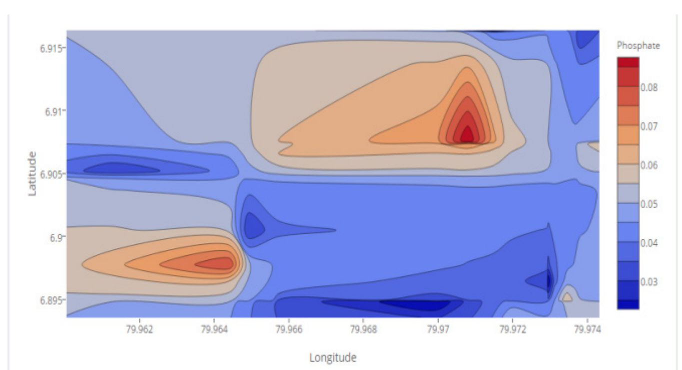
(e)Nitrate



(f)Nitrite



(g)Sulphate



(h)Phosphate

Fig 07 : Developed water quality contours

Table 1 : E-coli and coliform levels

Sample	E-coli (per 100ml)	Presumptive Coliform Count (per 100ml)
MN1	Nil	200
ME1	Nil	200
MW1	33	120
MW2	8	200
Desirable level	**Nil**	**Nil**
Maximum permissible level	**Nil**	**10**

It is well known that Malabe has been highly urbanized during the last decade. Non-state higher education institutes, technological parks, and treating it as one of the best residential areas, have increasingly affected the pervious lands. Since Malabe has an increased level of impervious lands over the years, Malabe and its surroundings were considered for groundwater quality checks.
The water quality tests were carried out at the Environmental and Water Quality Laboratory in SLIIT-Malabe. The required standards and protocols were carried out in measuring water qualities.
The water quality contours were plotted using the measurements taken. Figures 7(a) to 7(h) show the water quality contours for the area. These figures show the pH values of groundwater, colour, electrical conductivity, turbidity, conductivity, nitrates, nitrites, sulphates and phosphates contours in groundwater around the Malabe area.

Figure 7(a) gives the pH variation of the groundwater in the Malabe area. Blue patches in the figure indicates the areas with lowered pH values. Low pH values for drinking water may create some health issues. However, these results can be used to screen-out the areas, and to identify future well water extraction places. Similarly, other contour maps provide various essential water quality details of the groundwater in the area. However, there is concern over some other important test results. These include the coliform and E-Coli levels of groundwater. Initially, four intensively used wells were tested for these parameters and the results are given in the Table 1.

It is important to note that all four well water samples exceeded the safety level of presumptive coliform levels for drinking water (10/100 ml). These test results conclude that the groundwater in these four wells are at a bacteriologically unsatisfactory level for drinking water. More importantly, two wells were found to be contaminated with faecal bacteria. This is clear evidence to conclude the contamination by toilet waste of the groundwater in these wells. These two wells are located in a densely populated area with residential houses. There is thus a clear link between the urbanization and groundwater quality.

However, the water quality tests should be carried out for other wells as well to see the spatial variation of coliforms and E-Coli. In addition, tests should be carried out frequently to see the temporal variation, because the groundwater tables in the concerned areas are at shallow depths.

In summary, based on the studies carried out, it can be concluded that there is a clear link between urbanization and groundwater qualities. This can lead to a new health crisis in the area if timely safety precautions are not taken. Groundwater has to be treated as the most important earth resource. Hence this research is timely, and is necessary to understand the importance of unplanned urbanization on the Earth Resources.

Dr Upaka Rathnayake
Department of Civil Engineering,
Faculty of Engineering,
Sri Lanka Institute of Information Technology,
New Kandy Road,
Malabe,
Sri Lanka
upakasanjeewa@gmail.com /
upaka.r@sliit.lk