PRELIMINARY GROUNDWATER ASSESSMENT AND WATER QUALITY STUDY IN THE SHALLOW AQUIFER SYSTEM IN ATTANAGALU OYA BASIN

R.S. Wijesekara, Senior Hydrogeologist
and
C. Kudahetty, Geologist

Water Resources Board, Gregory's Avenue, Colombo 07

1. Abstract

Attanagalu Oya basin is situated between two major river basins, Kelani and Maha Oya in the Western Province of Sri Lanka with an extent of 727 km^2. Four streams; Diyaeli Oya, Attanagalu Oya, Uruwala Oya, Kimbulapitiya Oya which discharge into the Negambo Lagoon as Dandagamuwa Oya. A study was conducted at Attanagalu Oya basin in order to assess the groundwater potential of the area and to identify water quality of the shallow aquifer system of the basin.

The available qualitative and quantitative data on groundwater were collected and compiled. A groundwater database was developed for the basin. The total basin area was divided into five major divisions and shallow groundwater monitoring network was designed for each division. Representative shallow dug wells were selected for the monitoring network and 100 samples were collected from each division. Samples were analyzed for 17 physical and chemical parameters (appearance, temperature, turbidity, pH, EC, total hardness, total alkalinity, total dissolved solids, Na^+, Ca^{2+}, K^+, Mg^{2+}, total iron, fluoride, SO^{-2}_4, Cl^-, salinity, nitrate). Addition to that, 10 samples were collected from surface and groundwater bodies in the paddy cultivated areas and analyzed for pesticides. Another 10 samples from industrialized area to analyze for Pb. Another 10 samples from urban area to analyze for bacteria. Based on the data collected, geochemical maps (pH, EC, Na, K, F, Fe, salinity, TDS) were prepared for the entire basin.

The geo-chemical maps indicated that the pH value of the shallow groundwater in some parts of the Attanagalu Oya basin was very low. The pH value varied from 4 – 8.5 and high EC values were reported in the coastal area. Bacterial contamination was reported in groundwater sources in urban areas. No pesticide contamination was detected in any of the water samples collected in paddy cultivated areas. The occurrence of Pb in shallow

groundwater was reported within the range of 0.01 – 0.02 ppm. The major aquifer types exist in the basin are river alluvium, costal sand and fractured basement hard rocks. The existing NE – SW trending lineaments were identified as promising areas for groundwater development.

2. Introduction

Attanagalu Oya considered one of the resource full basins. The important water uses in Attanagalu Oya are the supply of drinking water and the maintenance of aquatic ecosystems. The Negambo lagoon and the Muturajawela marsh are the two large aquatic ecosystems in the basin. The major environmental problems of the Attanagalu Oya basin are related to deterioration of the water quality due to domestic, agricultural and industrial activities. Uncontrolled disposal of industrial effluents (both solid and liquid) and use of agro chemicals mainly affected to the deterioration of water quality in the basin area. The water pollution could be expected in industrialized areas such as Katunayake industrial Processing Zone and the Ekala Industrial Estate. The water quality of Negambo lagoon has deteriorated over the last few decades. The growth of algae in the lagoon is primarily the result of the accumulation of nutrients in the lagoon.

3. Objectives of the study

The main purpose of this study was to identify the water quality variation of the shallow groundwater and to make recommendations for further studies, including long term monitoring of groundwater quality variations and groundwater assessment.

4. Study Area

Attanagalu Oya basin is situated between two major river basins, Kelani and Maha Oya in the Western Province of Sri lanka with an extent of 727 km^2 (Figure 1). The three streams, Deyella Oya, Attanagalla Oya and Uruwal Oya which discharges into the Negambo lagoon as Dandugam Oya and also through Ja – Ela. The dendritic drainage pattern can be seen in the study area. Two streams originated from Gallanda and Polgahagoda area join to form Waharaka Oya. The Basnagoda Oya originated from Bewangama and flows SW – NE direction and joins Waharaka Oya to form Attanagalu Oya. The Algama Oya joins Attanagalu Oya close to Attanagalle town.

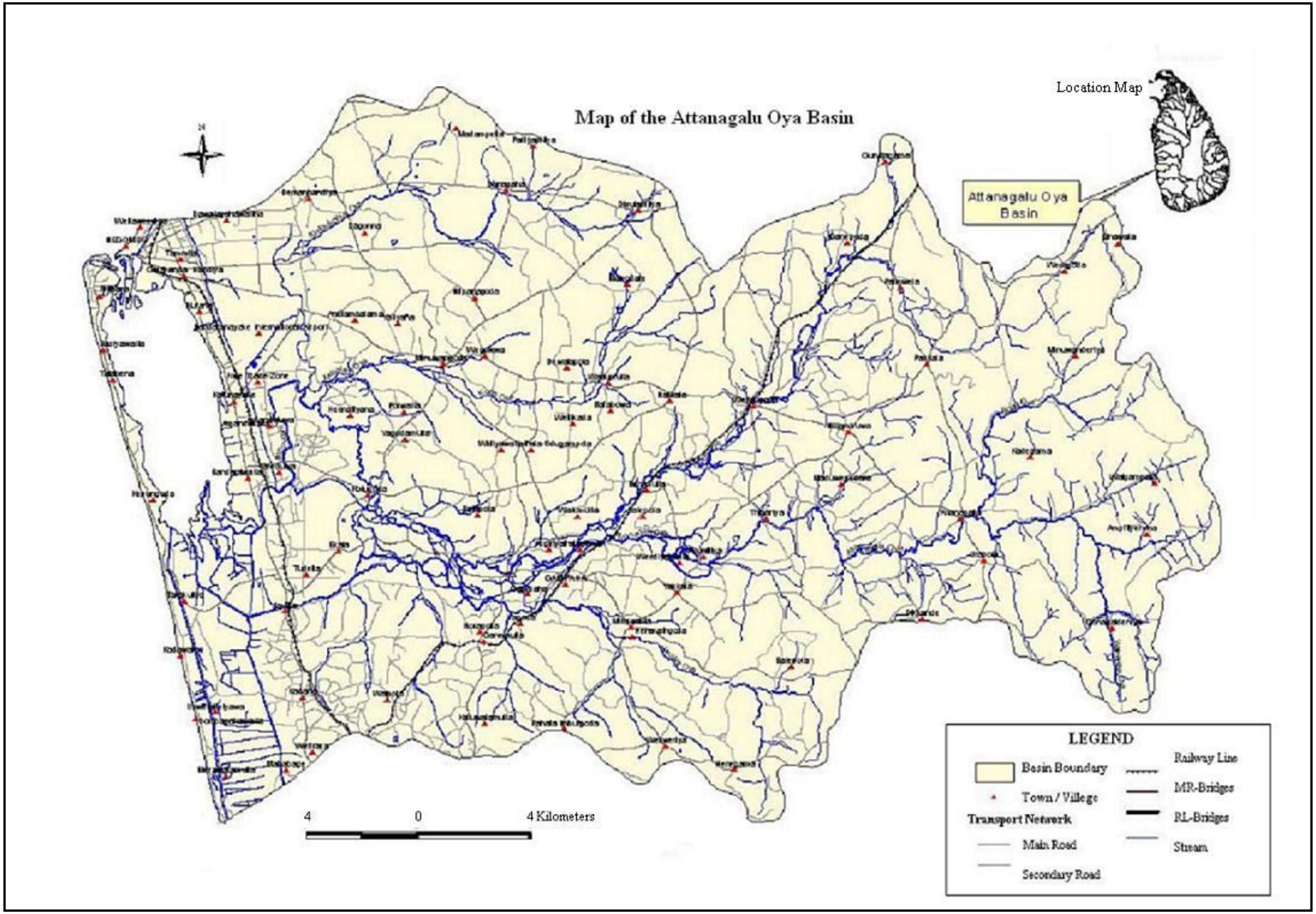

Figure 1: Map of the Attanagalu Oya Basin

The main geological formations in the basin area are Laterite, Unconsolidated Sand, Alluvium, Peat deposits and Crystalline basement rocks.

5. Methodology

The broad set of activities in the proposed study to achieve the objectives were

- Conduct a desk study and compile available data (geological, hydrogeological, geochemical etc.) and present them on GIS maps and identify the data gaps.
- Identify area specific problems and field visits to verify and confirmation of the issues. Collect data for filling the data gaps.

Field investigation was conducted in order to collect data to fill the data gaps. The total basin area 727 Km^2 was divided into five units and collect 100 water samples from each and every unit and another 100 samples were collected from the problematic areas such as industrialized and extensively cultivated areas. They were tested for 17 physical and chemical parameters and the results were compared with the Sri Lankan drinking water standards. Addition to that 10 water samples were collected from extensively cultivated areas of the basin and analyzed for pesticides. 10 water samples were collected from the industrialized areas of the basin and analyzed for Pb and another 10 water samples were collected from the urban areas of the basin and analyzed for bacteria. Analyzed data were used to prepare geochemical maps.

6. Aquifer types in the basin

The major aquifer types identified in the Attanagalu Oya basin are Lateritic aquifer, Alluvial aquifer, Coastal Sand aquifer and Fractured crystalline basement aquifer.

6.1. Lateritic aquifer

The major lateritic formations can be identified in Ragama, Gampaha, Veyangoda, Andiambalama, Naiwela, Kimbulapitiya, Ganemulla and Katana areas. Ragama indicate that part of the rain water falling on the area drains away rapidly along short–lived surface streams, gullies, foot paths and roads, but most of it percolates downwards, eventually seeping into the marshes and streams between the laterite hills. The water bearing lateritic formation behaves as a water table aquifer, oscillating the water table in a wide range, about 7 metres at the top of the hills and 3 metres on the slopes. The best sites for wells are, therefore, the valley edges in this particular areas. The well yields of the lateritic aquifer, mainly depend on the permeability of the formation. In areas where the laterite fill with kaolin, the expected well yields would be very poor. Well in those areas may undergone dry during the dry period of the year.

6.2. Alluvial aquifer

Alluviums are one of the largest carriers of groundwater among the sedimentary formations. Alluvium can be found in the major river valleys, may vary from 8 -10 metres in thickness and may extend laterally for several hundreds of meters on either side of the river beds. The alluvial beds may composed of sand, clay, gravels etc. forming high potential aquifers. The alluvium beds in the Attanagalu Oya and other rivers could be considered as water table aquifer system. The wells located in that aquifer type indicate very shallow groundwater table varies from 1.0 metres to 2.0 metres.

6.3. Beach Sand

The unconsolidated sand belt running long the coastal belt specially from Ja – Ela, Seeduwa, Katunayake up to Negambo. This sand belt is well developed in Katunayake and Seeduwa areas. The Katunayake airport and the Katunayake Export Processing Zone fall within this sand belt and extract considerable amount of water from this sandy aquifer system. In the Katunayake Export Processing Zone, 98 factories are established and part of their water requirement is supplied by the surface water from Dandugam Oya and the rest is supplied by groundwater from 44 shallow and deep tube wells. The Quantity of water that was recommended to extract from these tube wells was estimated as 3000 cubic metres per day. The tourist hotels in the Katunayake area and most of the private establishments located along the coastal belt are extracting groundwater from this aquifer. This aquifer was subjected to pollution due to the human activities, industrial activities and agricultural activities of the area. Katunayaka airport also extract water from shallow tube wells constructed in this coastal sandy aquifer.

6.4. Fractured crystalline basement aquifer

The unweathered crystalline rocks, by their nature are relatively impervious and non porous. Where joints and fissures are concentrated in zones, as in fault zones then permeability of the system is increased to important proportions. There is, therefore, no continuous body of groundwater with a single water table in these rocks. The presence of major lineaments is a good indication for existence of a fracture in the basement rocks. The major lineaments in the Attanagalu Oya basin are directed to NE – SW, ENE – WSW, EW and NW – SE direction. The NW – SE lineaments are strike valleys running parallel to the strike of the basement rocks. A major lineament striking WNW – ENE direction running through Makewita, Kalagedihena up to Attanagalla. Similar type of lineament system is running across Minuwangoda and Nittambuwa areas. The areas where major lineaments crosses each other are considered to be the promising areas for groundwater development.

7. Issues identified within the basin

The DSD's, Pradeshiya Sabas' and other relevant organizations in the basin area were contacted and the data related to water issues were collected.

7.1. Divisional Secretariat Division – Negambo (Source – DS, Negambo)

- Water Scarcity - The areas surrounded by the Negambo lagoon such as Talahena - Peruwa and other 9 GND's have no water for drinking purposes. The pipe born water is available in the area but the supply is insufficient. Therefore, water scarcity exists in these areas. The total number of families do not have sufficient water facility in the area is 13,438 (Censes, 2004). The main water sources used by the people are dug wells, tube wells, own tap lines.
- Water pollution due to industries - The industries established for production of boats, emits their effluents to the Negambo lagoon polluting the lagoon considerably. The sewage systems of the many houses in the area are diverted to the Negambo Lagoon. Similarly the wastes of the houses are diverted into the canal Hamilton, causing water pollution. Most of the drainage in the Negambo town diverted into the Negambo Lagoon.

7.2. Pradeshiya Saba – Mirigama (source – Pradeshiya Saba Mirigama)

The area belongs to Meerigama Pradesiya Saba is 189 km^2. Population of this respective area is 143741: Total number of families in the area with no proper water facility is 4500 families (Census, 2004).

- Water Scarcity - The water scarcity is reported in the following areas. Kal Eliya, Nambuluwa, Koshena, 20 acre, Ehala Thawalampitiya, Botale, Galge Kanda, Thawalampitiya, Keenadeni Kanda, Danowita – Harankahawa, Ilukpathana, Weveldeniya – Pothawalakanda, Karagahatennakanda, Botale – Sonduruwatta, Botale – Ihalagama Andagala Kanda, Makkakeegoda Kanda, Botala – Mottewatta, Keenadeniya town, Danovita kalukanda, Horagasmankada, Pasyala – Embillapitiya watta, Mawahena, Kosetadeniya – Deegalakanda, Maladeniya kapuhenakanda, Metihakka watta, Pasyala town, Kotakanda

- Major environmental problems - Due to the over extraction of water, the people in the surrounding area face water problems even in a slight dry spell (Ex. Water spring at Botale). Pollution of water in the natural stream due to the emission of effluents of the Rubber factories and coconut mills.

7.3. Solid wastes

Dumping of solid wastes such as silages, plastics, metal cuttings and tailings is a common practice. Solid waste is a growing problem in Sri Lanka, aggravated by the absence of proper management system. Inevitable consequences of the practice of solid waste disposal in landfills are gas and leachate generation due primarily to microbiological composition, climatic conditions, refuse characteristics and land filling operations. Source of drinking water in the project area from pipe born water, protected and unprotected wells and sources such as tanks and streams. So that the quality of inland water resources including groundwater is important, as these waters are sources of drinking water. The concentration of heavy metals (Pb, Cr, Cu) in shallow groundwater in dumping areas (Katana and Negambo DSD) reported with higher values (Water Resources Research in Sri Lanka, 2004).

8. Results and Discussion

600 water samples were collected and analyzed for 17 physical and chemical parameters. The well network was designed with 600 wells covering the entire basin. The number of wells were adequate to gather the chemical data of well water in the basin area. 10 samples were collected from intensively cultivated areas and analysed for Pb. 10 samples were collected from industrialized areas and analyzed for pesticides. 10 samples were collected from urban areas of the basin for microbiological analysis.

8.1.Hydrogeochemical maps

Using the analytical data 600 water samples of the Attanagalu Oya basin geochemical maps were prepared for pH, Iron, Salinity, Total hardness, Sodium, Pottasium considering Sri Lankan drinking water standards.

- pH concentration - The pH variation map of shallow groundwater in the basin was prepared and different zones were identified (Figure 2). The pH value of the zone 1 & 2 indicates the shallow groundwater in those areas are acidic. This could be a serious problem in the basin water. The zones with very low pH values (4 -5) are clearly seen in central and southern part of the basin. Most natural waters the pH value is dependent on the carbon dioxide – carbonate – bicarbonate equilibrium. Presence of phosphates, silicates, fluorides and other salts in dissociated form may affect the pH. Chemical changes such as reduction and oxidation, decomposition of organic matter, and many other causes may also change the pH in groundwater. However, the pH values of shallow groundwater in western part of the basin fall into the zone 3 and 4 indicating the values from 6 – 8.5.

- Electrical Conductivity- The map of electrical conductivity of shallow groundwater was prepared by using the data collected from the basin (Figure 3). The zones with different values were demarcated according to the following criteria.

Zone	Concentration µs/ cm
1	5 – 250
2	250 – 500
3	500 – 750
4	750 – 1500
5	1500 -3500
6	3500 – 5000
7	5000- 8500

The majority of the basin area falls on zone 1. The high concentration of EC was reported in western coastal area.

- Sodium Concentration - Map of sodium concentration of shallow groundwater in the basin area was prepared. The following criteria were used to demarcate the different zones.

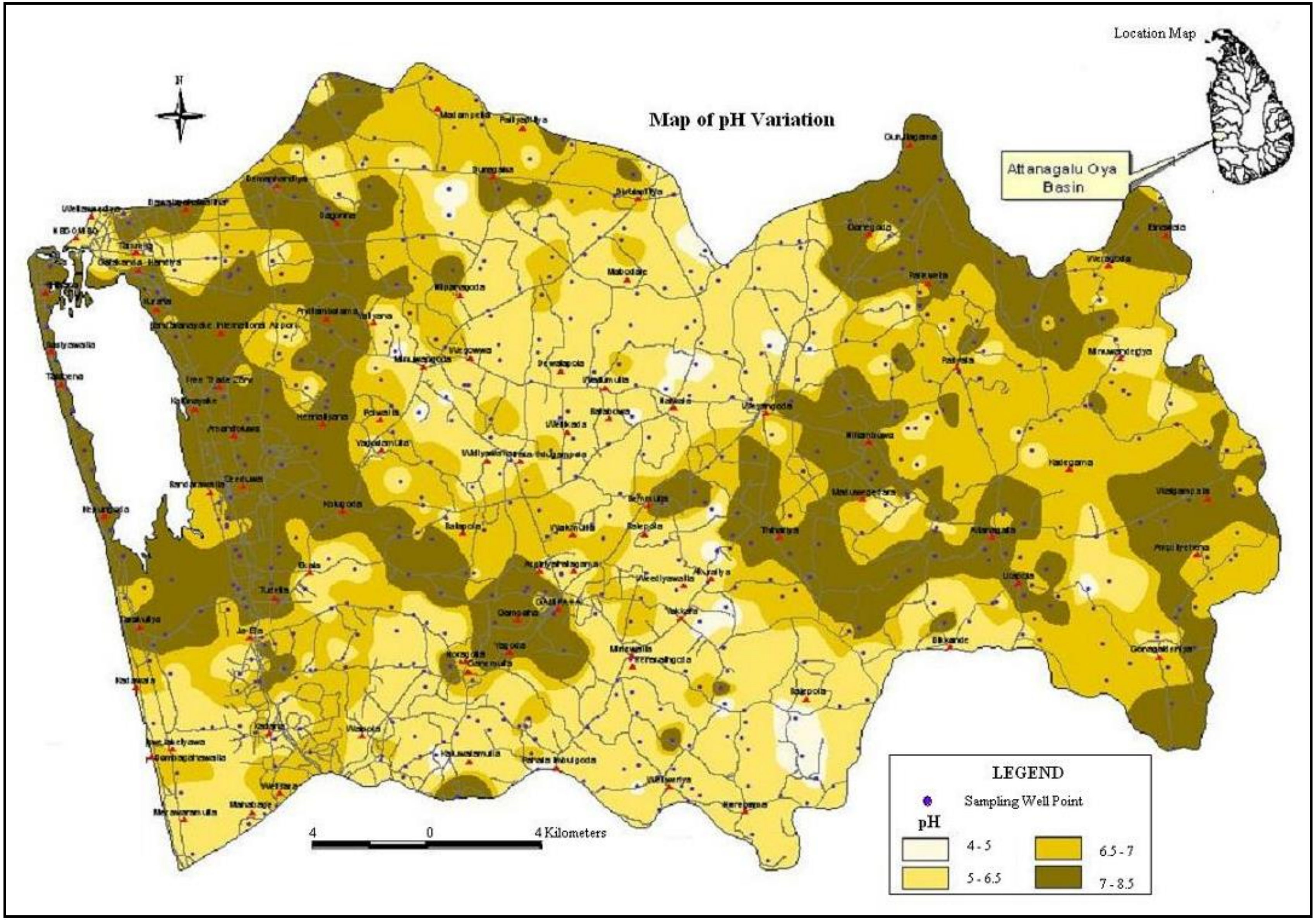

Figure 2: Map of pH Variation

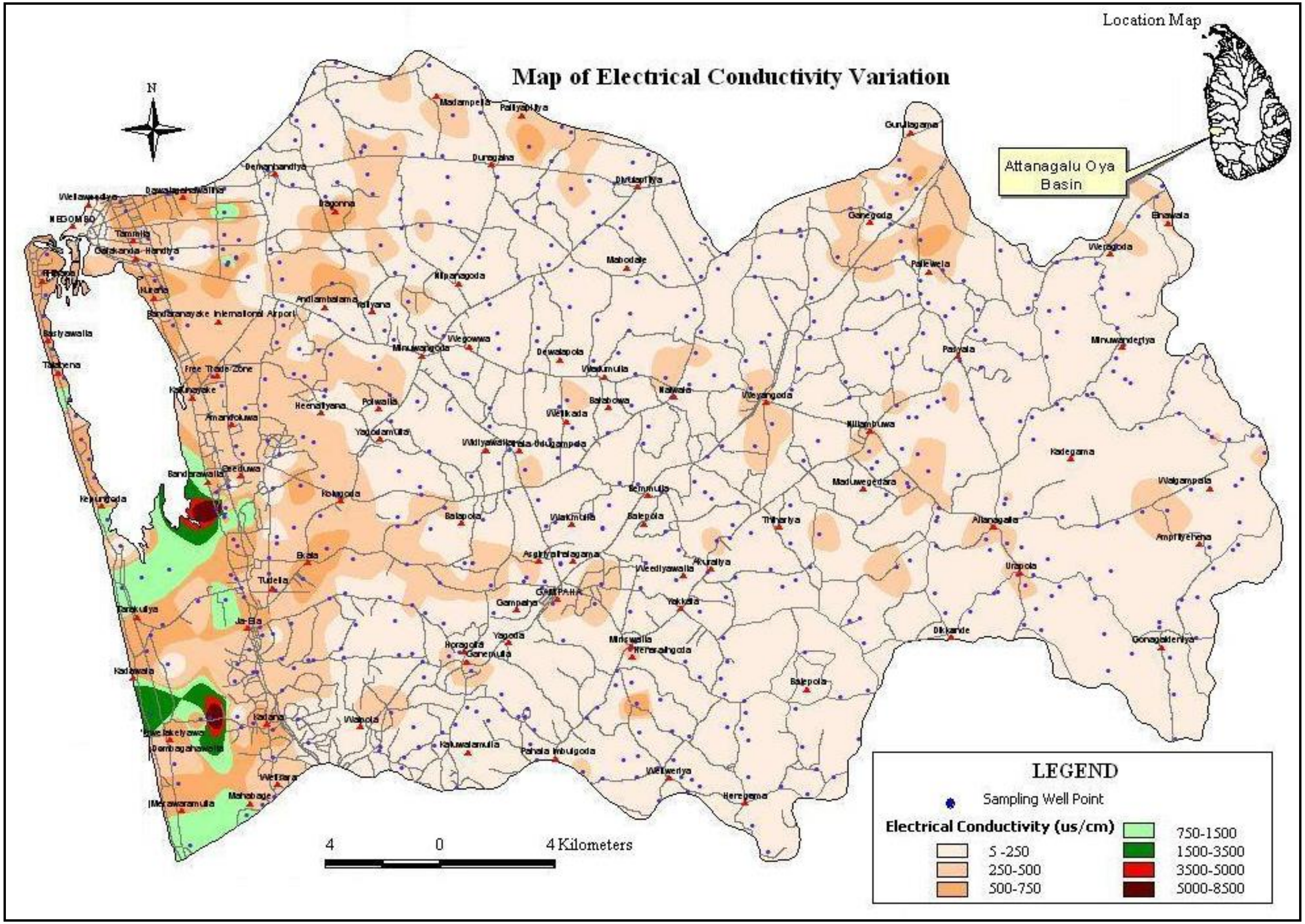

Figure 3: Map of Electrical Conductivity Variation

Zone	Concentration (mg/l)
1	1 – 20
2	20 -40
3	40 – 60
4	60 – 80
5	80 – 100
6	100 – 120
7	200 - 800
8	800 – 1400

Majority of the area falls on the zone 1 & 2. High values can be seen in the western part of the basin.

- Potassium Concentration - The potassium in the shallow groundwater in the basin was prepared. The zones with different values were demarcated according to the following criteria.

Zone	Concentration (mg/l)
1	0.3 – 5
2	5 -10
3	10 -20
4	20 -30
5	30 – 40

Majority of the area falls on the zone 1 indicate low level of Potassium concentration. The potassium concentration in groundwater is very important factor in irrigation water.

- Fluoride Concentration - The map of fluoride in shallow groundwater was prepared. The zones with different values were demarcated according to the following criteria.

Zone	Concentration mg/l
1	0 – 0.2
2	0.2 – 0.4
3	0.4 -0.6
4	0.6 -0.7
5	0.7 -0.8
6	0.8 – 0.9

The southern and eastern part of the basin area falls on zone 1. Western, northern and some of the central areas fall on zone 2. The patches of zone 4 can be seen in the central and western part of the basin.

- Iron Concentration - The iron concentration of shallow groundwater was evaluated and the map was prepared. Most of the area of the basin falls on the range 0 – 0.3 mg/l (zone 1) and 0.3 – 1.0 mg/l (zone 2). Higher values are reported in the south western part of the basin.

- Salinity - The salinity levels of shallow groundwater was evaluated. The salinity of shallow groundwater in the Western coastal belt reported with the higher values. The rest of the area salinity values falls within the range of 0 – 0.2 mg/l.

- Total Hardness - Hardness of the shallow groundwater in the basin was evaluated. Different zones were marked using the following criteria.

Zone	**Concentration (mg/l)**
1	5 -100
2	100 -250
3	250 – 400
4	400 – 600
5	600 – 800
6	800 – 1050

  The majority of the basin area falls on zone 1. The higher values were reported in the western part of the basin.

- Lead - The analytical results of the water samples tested for Pb indicated that the values varied from 0.01 ppm to 0.02 ppm. All the samples were reported within the permissible range indicating no Pb pollution in the area concerned.

- Bacteriological pollution was reported in urban areas.

Considering all the hydrogeochemical maps promising areas for groundwater development were identified as indicated in Figure 4.

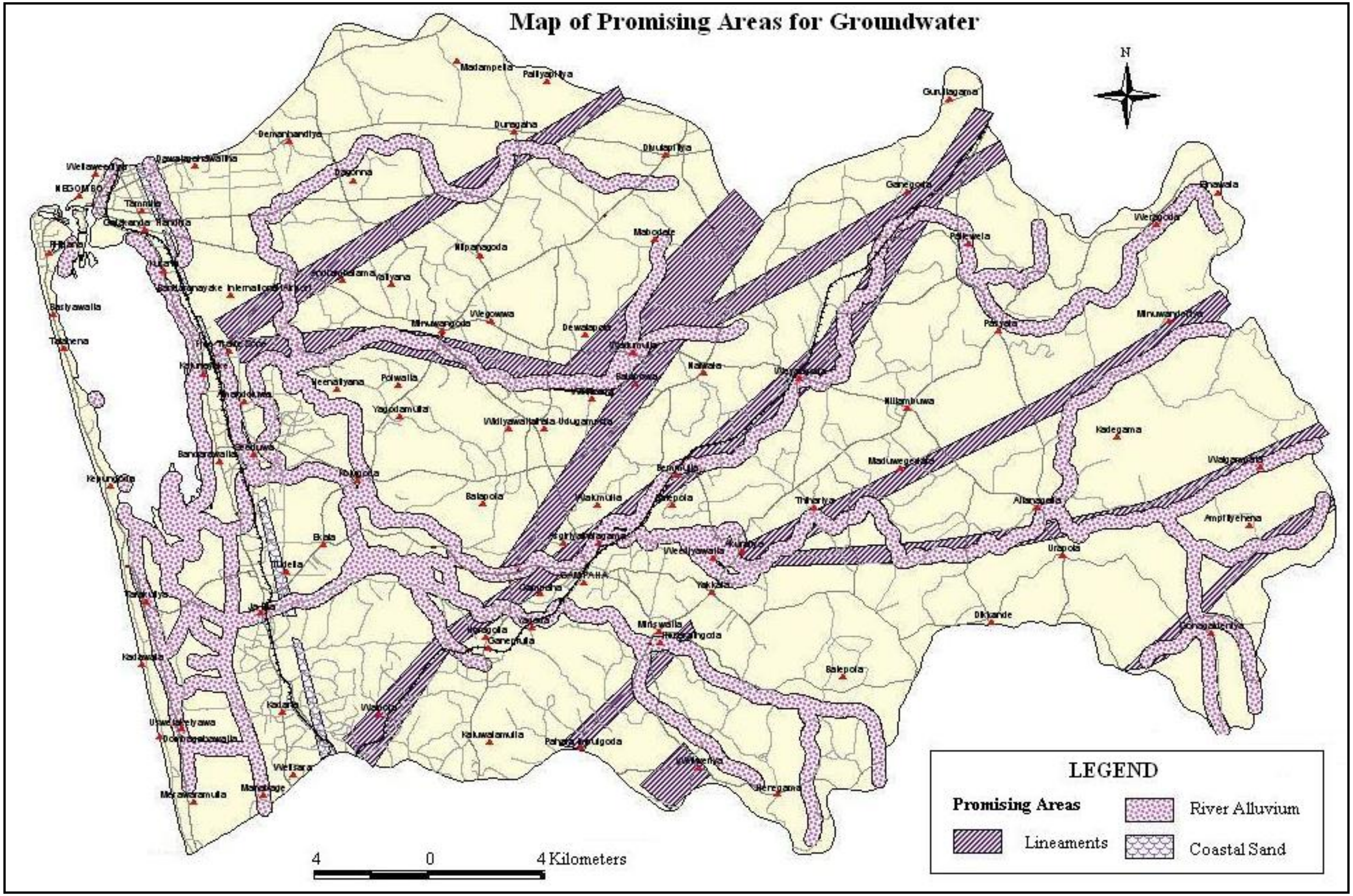

Figure 4: Map of Promising areas for Groundwater

9. Conclusion

- Pollution of groundwater and surface water was mainly due to human, industrial and agricultural activities. The wells in many urban areas lead to cause bacteriological pollution. This was clearly observed in the urban areas of Ekala, Ja Ela, Negambo, Wattala and Gampaha.

- The data collected from DSD's, Pradeshiya Sabas and other relevant agencies indicated that the dug wells are the main water source of the families in the basin area and considerable number of families have no proper water sources for drinking purposes. This was reported in the DSD Meerigama, DSD Attanagalla, DSD Gampaha, DSD Negambo and Pradeshiya Saba Areas of Mirigama and Katana.

- Heavy erosion along the river banks and the extensive sand mining in some areas of the basin was identified as a serious environmental issue. This was reported in the DSD areas of Attanagalla, Gampaha, Mirigama.

- As the pH values of shallow groundwater in the basin shows uneven distribution throughout the basin. Shallow water become acedic in some parts of Naiwala, Minuwangoda, Ekala, Walpola, Henegama, Weliweriya, Pahala Imbulgoda, Weediyawatta, Henarathgoda. Rest of the area pH values fall within the drinking water standards.

- It is recommended to design a proper monitoring net work including these areas and monitor pH variation of groundwater for a long period of time covering the dry and wet period of the year. High salinity and iron concentrations were reported in the shallow groundwater along the coastal strip. Water quality of shallow groundwater in rest of the area is suitable for drinking purposes.

- Using the existing aquifer systems additional amount of water could be supplied to the water supply schemes in Gampaha, Veyangoda, Raddoluwa, Bataleeya, Minuwangoda, Ja –Ela and Divulapitiya.

- Conjunctive use of groundwater and surface water and recycling of water in the Industries would be one of the major water conservation methods in industrial sector.

10. References

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