Preliminary Groundwater Assessment and Water Quality Study in the Shallow Aquifer System in the Attanagalu Oya Basin

R. S. Wijesekara[1] and C. Kudahetty[2]
[1]Senior Hydro-geologist, Water Resources Board, Gregory's Avenue, Colombo - 7, Sri Lanka
[2] Geologist, Water Resources Board, Gregory's Avenue, Colombo - 7, Sri Lanka

Abstract

The 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. It contains four streams: Diyaeli Oya, Attanagalu Oya, Uruwala Oya and Kimbulapitiya Oya, which discharge into the Negombo Lagoon as Dandagamuwa Oya. A study was conducted in the Attanagalu Oya basin in order to assess the groundwater potential of the area and to identify the water quality of the shallow aquifer system of the basin.

The available qualitative and quantitative data on groundwater were collected and compiled, and a groundwater database was developed for the basin. The total basin area was divided into five major divisions and shallow groundwater monitoring networks were designed for each. Representative shallow dug wells were selected for the monitoring network and 100 water samples were collected from each division. Samples were analyzed for 17 physical and chemical parameters. In addition, 10 water samples were collected from surface and groundwater bodies in the paddy cultivated areas and analyzed for pesticides. Another 10 water samples from the industrialized area were analyzed for lead and 10 from urban areas were analyzed for bacteria. Based on the data collected, geochemical maps were prepared for the entire basin. These indicated that the pH values of the shallow groundwater in some parts of the Attanagalu Oya basin were very low, varying from 4 to 8.5. High electrical conductivity (EC) values were reported in the coastal area. Bacterial contamination was reported in groundwater sources in the urban areas. No pesticide contamination was detected in any of the water samples collected in paddy cultivated areas. The occurrence of lead in shallow groundwater was reported within the range of 0.01-0.02 ppm. The major aquifer types in the basin are river alluvium, coastal sand and fractured basement hard rocks. The existing northeast-southwest trending lineaments were identified as promising areas for groundwater development.

Introduction

Attanagalu Oya is considered to be a basin filled with resources. The important water uses of the Attanagalu Oya are the supply of drinking water and the maintenance of aquatic ecosystems.

Negombo Lagoon and Muturajawela Marsh are the two large aquatic ecosystems in the basin. The major environmental problems of the Attanagalu Oya basin are related to the deterioration of the water quality due to domestic, agricultural and industrial activities, specifically the uncontrolled disposal of industrial effluents (both solid and liquid) and use of agro-chemicals. Water pollution is expected in industrialized areas such as the Katunayake Industrial Processing Zone and Ekala Industrial Estate. The water quality of Negombo Lagoon has deteriorated over the past few decades, with algal growth resulting from the accumulation of nutrients.

Objectives of the Study

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

The Study Area

The 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), and has three streams, Diyaelli Oya, Attanagalu Oya and Uruwala Oya, which discharge into the Negombo Lagoon as Dandugam Oya and also through Ja-Ela. The dendritic drainage pattern can be seen in the study area. Two streams that originated from Gallanda and the Polgahagoda area join to form the Waharaka Oya. The Basnagoda Oya originated from Bewangama and flows in the southwest to northeast direction and joins Waharaka Oya to form the Attanagalu Oya. The Algama Oya joins the Attanagalu Oya close to Attanagalle Town.

The main geological formations in the basin area are: laterite, unconsolidated sand, alluvium, peat deposits and crystalline basement rocks.

Methodology

The broad set of activities in the study was to:

- Conduct a desk study to compile available data (geological, hydro-geological and geochemical), to present them on GIS maps and to identify the data gaps.
- Identify area-specific problems and undertake field visits to verify the issues and to 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 of 727 km^2 was divided into five units and 100 water samples were collected from each. Another 100 water samples were collected from the problematic areas such as industrialized and extensively cultivated areas. They were tested for 17 physical and chemical parameters: appearance, temperature, turbidity, pH, electrical conductivity (EC), total hardness, total alkalinity, total dissolved solids (TDS), sodium, calcium, potassium and magnesium ions, total iron, fluoride, sulphate, chloride, salinity and nitrate, and the results were compared with

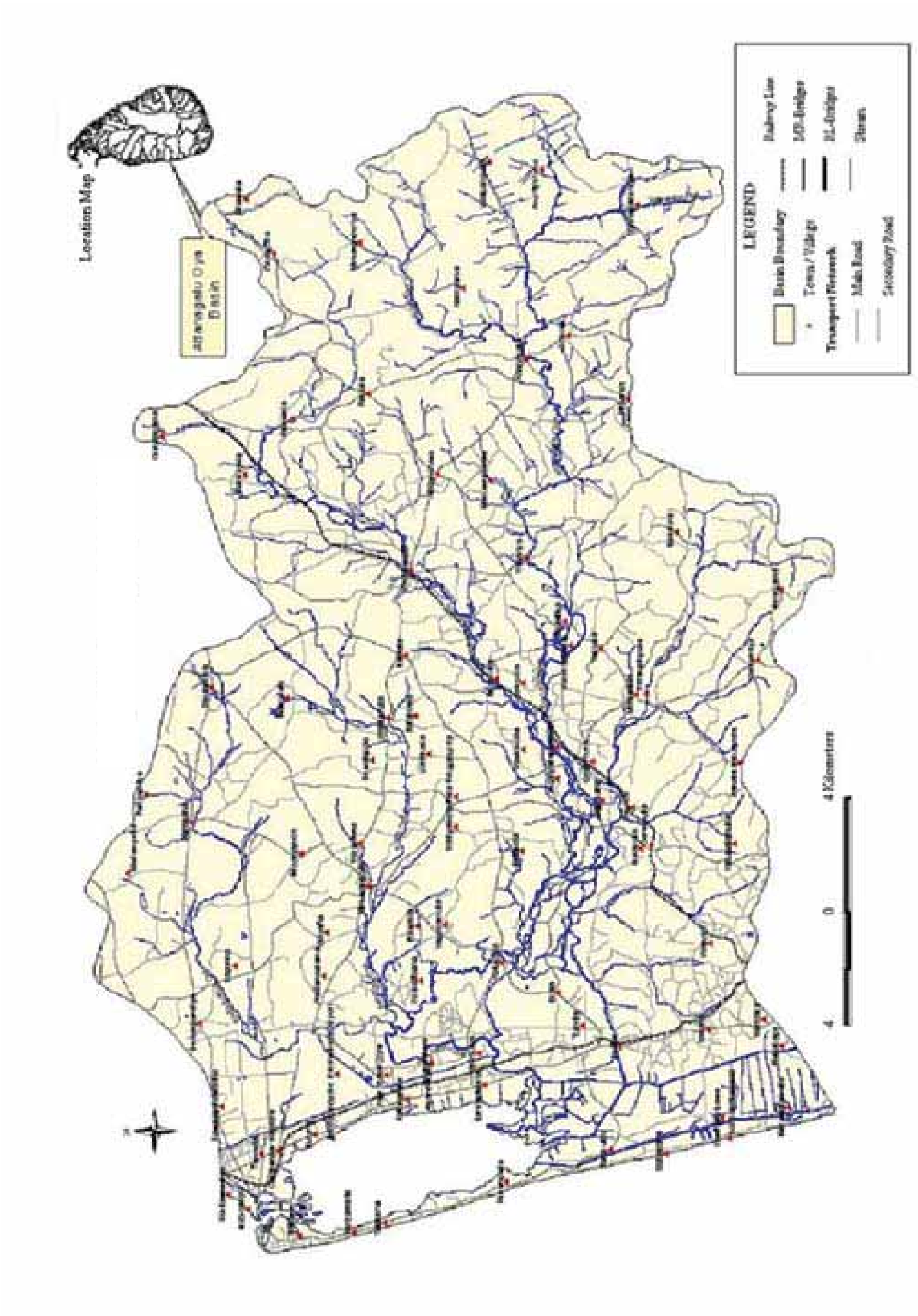

Figure 1. Map of the Attanagalu Oya Basin.

the Sri Lankan drinking water standards. In addition, 10 water samples were collected from extensively cultivated areas and analyzed for pesticides; 10 water samples were collected from industrialized areas and analyzed for lead; and 10 water samples were collected from the urban areas of the basin and analyzed for bacteria. The data were used to prepare geochemical maps.

Aquifer Types in the Basin

The major aquifer types identified in the Attanagalu Oya basin are: lateritic, alluvial, coastal sand and fractured crystalline basement aquifers.

Lateritic Aquifer

The major lateritic formations can be identified in Ragama, Gampaha, Veyangoda, Andiambalama, Naiwela, Kimbulapitiya, Ganemulla and Katana. In Ragama, the formations indicate that part of the rainwater 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 of about 7 meters at the top of the hills and 3 meters on the slopes. The best sites for wells are, therefore, the valley edges in this particular area. The well-yields of the lateritic aquifer mainly depend on the permeability of the formation. In areas where the laterite fills with kaolin, the expected well-yields would be very poor. Wells in those areas may become dry during the dry period of the year.

Alluvial Aquifer

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

Beach Sand

The unconsolidated sand belt runs along the coastal belt, especially from Ja-Ela, Seeduwa and Katunayake up to Negombo. This sand belt is well developed in the Katunayake and Seeduwa areas. The Katunayake International Airport and the Katunayake Export Processing Zone fall within this sand belt and extract considerable amounts 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 the Dandugam Oya and the rest is supplied by groundwater from 44 shallow and deep tubewells. The quantity of water that was recommended to be extracted from these tubewells was estimated at 3,000 m^3 per day. The tourist hotels in the Katunayake area and most of the private establishments located along the coastal belt also extract groundwater from this aquifer. This aquifer was subjected to pollution due to domestic, industrial and agricultural activities. Katunayaka International Airport also extracts water from shallow tubewells constructed in this coastal sandy aquifer.

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 the 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 of the existence of a fracture in the basement rocks. The major lineaments in the Attanagalu Oya basin are directed to northeast-southwest (NE-SW), east norteast-west southwest (ENE-WSW), east-west (E-W) and northwest-southeast (NW-SE). The NW-SE lineaments are strike valleys running parallel to the strike of the basement rocks. A major lineament, striking WNW-ENE direction, runs through Makewita, Kalagedihena up to Attanagalla. A similar type of lineament system runs across Minuwangoda and Nittambuwa. The areas where major lineaments cross each other are considered to be promising areas for groundwater development.

Issues Identified within the Basin

The Divisional Secretariat (DS) Divisions, Pradeshiya Sabas and other relevant organizations in the basin area were contacted and the data related to water issues were collected.

The areas surrounded by Negombo Lagoon such as Talahena, Peruwa and another nine Grama Niladhari Divisions (GNDs) have insufficient water for drinking purposes. Pipe-borne water is available in the area but the supply is inadequate. Therefore, water scarcity exists in these areas. The total number of families that do not have sufficient water facilities in the area is 13,438 (Census 2004). The main water sources used by the people are dug wells, tubewells and their own tap lines.

The area of Meerigama Pradeshiya Sabha is 189 km^2 and the population is 1,43,741. Of these a total of 4,500 families do not have proper water facilities (Census 2004). Due to the over extraction of water, the people in the surrounding area are faced with water problems even when there is a slight dry spell. There is also considerable pollution in the natural stream due to the emission of effluents from rubber factories and coconut mills.

Water pollution in Negombo Lagoon is also a problem because the boat building industries dispose of their effluents into the lagoon, and sewage and other wastes from many houses in the area are also diverted there. Most of the drainage in Negombo Town is also diverted into the lagoon.

Dumping of solid wastes such as silage, plastics, metal cuttings and tailings are common practices and have become a growing problem in Sri Lanka. This is further aggravated by the absence of a proper waste management system. The 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. These can impact on surface waters and on groundwater, which is often a source of drinking water. In the solid waste dumping areas of Katana and Negombo DS Divisions, the concentrations of heavy metals (lead, chromium and copper) in shallow groundwater in dumping areas are reported to be high (Water Resources Research in Sri Lanka 2004).

Results and Discussion: Hydro-geochemical Maps

Using the analytical data of 600 water samples of the Attanagalu Oya basin, geochemical maps were prepared for pH, iron, salinity, total hardness, sodium, potassium and EC, and results were compared to Sri Lankan drinking water standards. Different zones were identified based on these maps.

In most natural waters the pH value is dependent on the carbon dioxide-carbonate-bicarbonate equilibrium, and the presence of phosphates, silicates, fluorides and other salts in dissociated form may affect the pH. Chemical changes such as reduction and oxidation and decomposition of organic matter may also change the pH in groundwater. The shallow groundwater in zones 1 and 2 is acidic (Figure 2), which could be a serious problem. The zones with very low pH values (pH 4-5) are located in the central and southern part of the basin. However, the pH values of shallow groundwater in the western part of the basin fall into the zones 3 and 4, with pH values of 6-8.5, which is acceptable for drinking water.

For EC, the majority of the area falls into zone 1 with an EC of 5-250 μS/cm but high concentrations were detected in the western coastal zone area (Figure 3). This area also has the highest salinity values and hardness. The map of sodium concentration of shallow groundwater in the basin area was based on eight zones. The majority of the areas fall into zones 1 and 2 (1-20 mg/l and 20-40 mg/l), but high values were recorded in the western part of the basin. For potassium, the majority of the area falls into zone 1 (0.3-5.0 mg/l) indicating a low level of potassium contamination in the groundwater. The southern and eastern part of the basin area falls into fluoride zone 1 (0-0.2 mg/l), while the western, northern and some of the central areas fall into zone 2 (0.2-0.4 mg/l). Patches of zone 4 (0.6-0.7 mg/l) can be seen in the central and western part of the basin. For iron, most of the area of the basin falls on the range 0.0-0.3 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. For lead, values ranged from 0.01 to 0.02 ppm, which indicates that lead pollution of groundwater is not a problem in the basin.

Considering all the hydro-geochemical maps, the promising areas for groundwater development were identified as indicated in Figure 4.

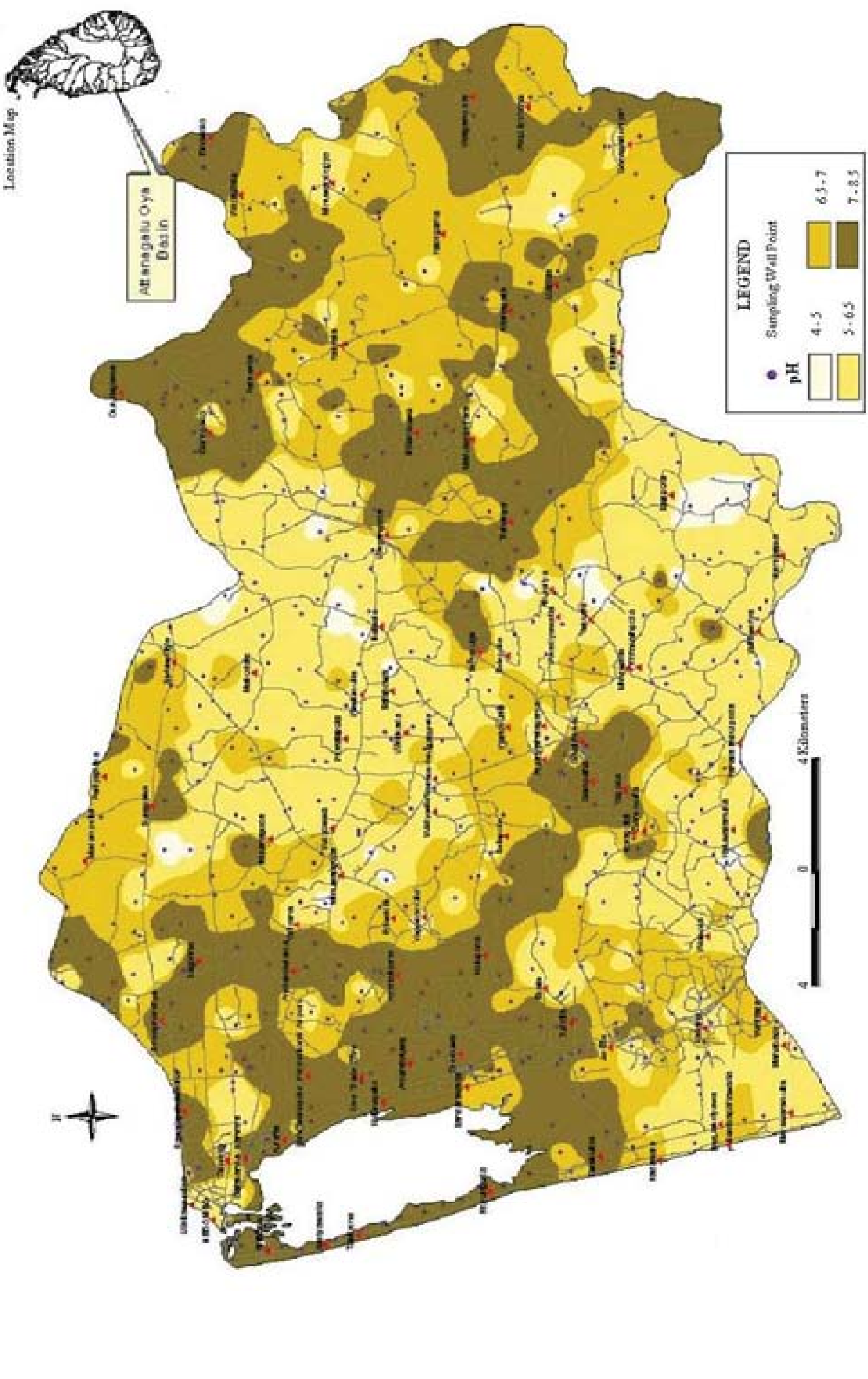

Figure 2. Map of pH variation.

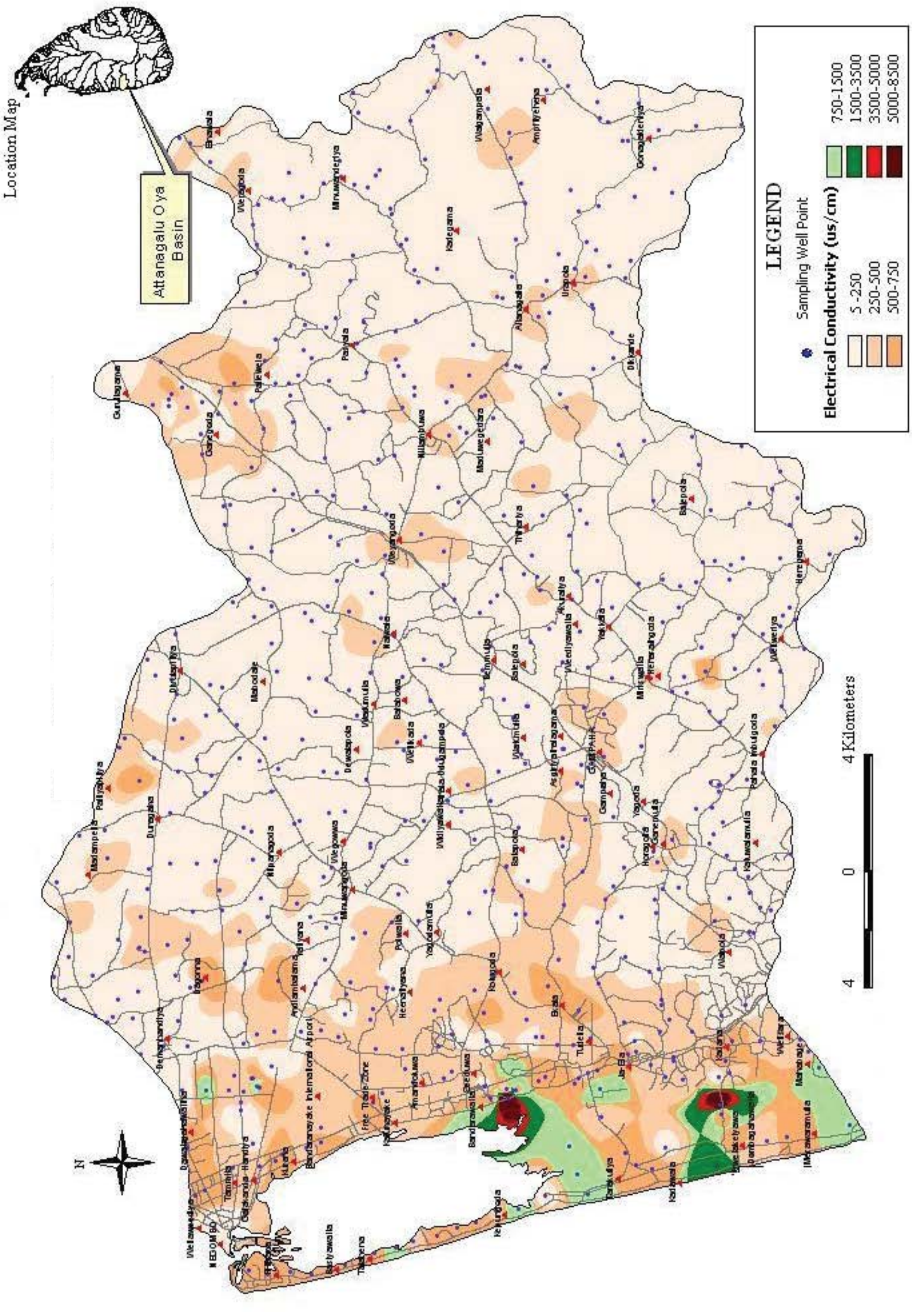

Figure 3. Map of electrical conductivity variation.

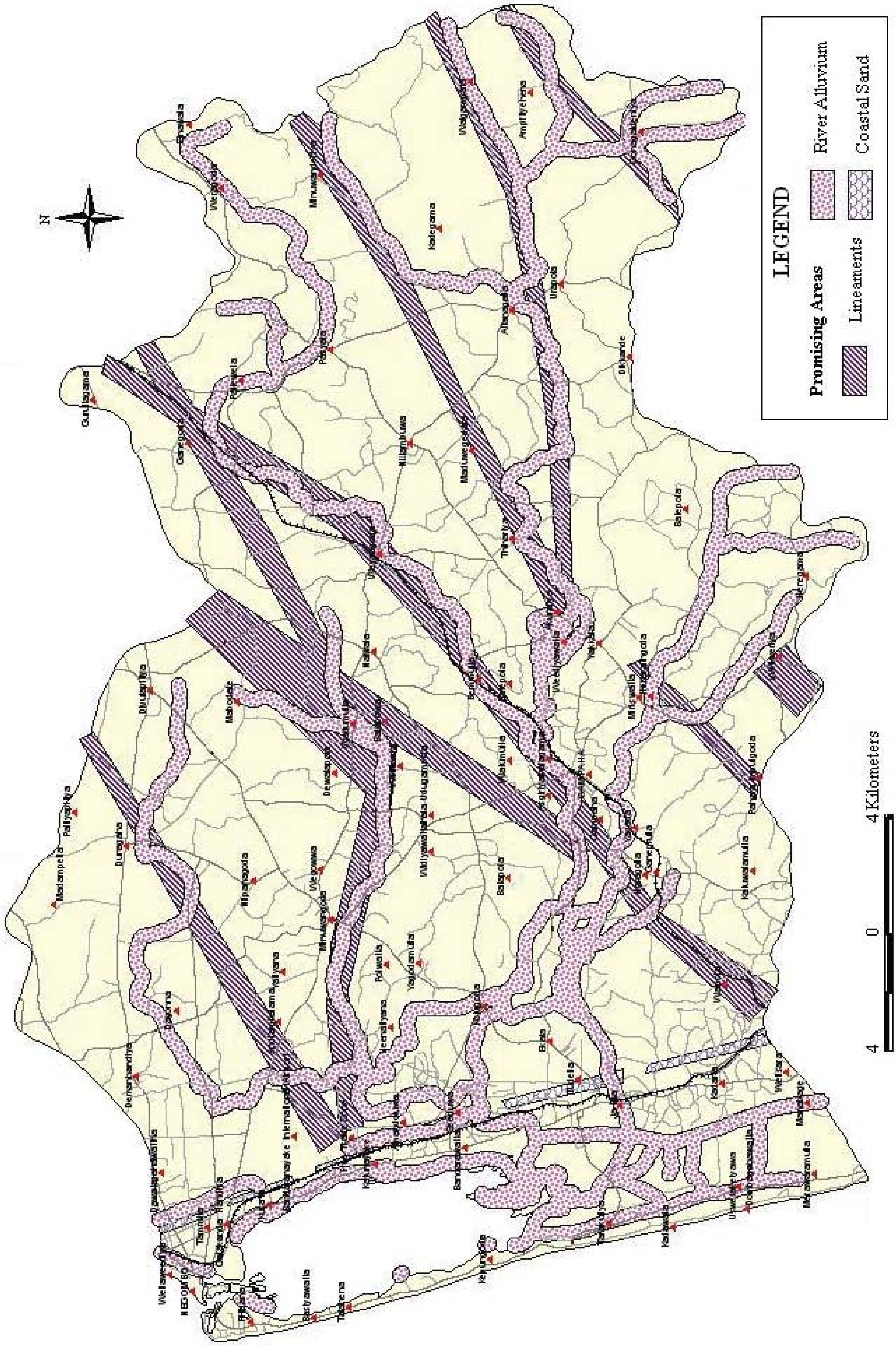

Figure 4. Map of promising areas for groundwater.

Conclusion

Pollution of groundwater and surface water was found to be mainly due to domestic, industrial and agricultural activities. The wells in many urban areas suffered from bacteriological pollution, which was clearly observed in the urban areas of Ekala, Ja Ela, Negombo, Wattala and Gampaha.

The data collected from DS Divisions, Pradeshiya Sabhas and other relevant agencies indicated that the dug wells are the main source of water for households in the basin and a considerable number of families have no proper water sources for drinking purposes. This was reported in the Meerigama, Attanagalla, Gampaha and Negombo DS Divisions and the Pradeshiya Sabha Areas of Meerigama and Katana.

The pH values of shallow groundwater in the basin show uneven distribution throughout the basin. Shallow water becomes acidic in some parts of Naiwala, Minuwangoda, Ekala, Walpola, Henegama, Weliweriya, Pahala Imbulgoda, Weediyawatta and Henarathgoda, but in the rest of the area the pH values are within the drinking water standards. It is recommended to design a proper monitoring network to monitor pH variation of groundwater over a long period including both dry and wet seasons.

High salinity and iron concentrations were reported in the shallow groundwater along the coastal strip. Water quality of shallow groundwater in the rest of the area is suitable for drinking purposes.

Using the existing aquifer systems an 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 the industrial sector.

References

Central Environmental Authority. 1995. ‘Man and Environment.’

Cooray, P. G. 1984. ‘Geology of Ceylon.’

Population and Housing Census, Gampaha. 2004.

Water Resources Research in Sri Lanka. 2004. Symposium Proceeding of the Water Professional’s Day.

Wijesekara, R. S.; Perera, A. P. G. R. L.; Wijekoon, D. V. K.; Kudahetty, C. 2005. ‘Preliminary Groundwater Assessment Attanagalu Oya Basin’. Sri Lanka: Water Resources Board.