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A PRELIMINARY STUDY ON THE CHEMICAL QUALITY OF GROUND WATER IN THE ANDELLA OYA BASIN OF SRI LANKA

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Abstract : A hydrogeological investigation was carried out within the area of Andella Oya basin of the eastern part of Sri Lanka. As a part of this survey, water samples were collected from the dug wells before the north east monsoon rainfall and were chemically analysed for major ions. The results of these analyses were plotted on PIPER's trilinear diagram and the results reveal that about 1/3rd of the samples fall into bicarbonate type while 2/3rd fall into chloride type. Comparative studies emphasized that all chloride type of water correlate with electrical conductivity (EC) values higher than 500 micromhos/cm and the rest are below the critical value. The pH values of all samples were above 7 and sodium and calcium are the major cations in high TDS water. According to the Piper's trilinear diagram and the result of dug well survey, the samples can be divided into four geochemical groups. The groundwater from higher lands show high bicarbonate water (Group A) and when it moves into the lower areas, the quality changes into the chloride type. Water in shallow weathered overburden areas also show the bicarbonate type (Group B). There are a few wells in the higher lands with higher chloride content (Group C) which may be due to the higher clay content of the area or stagnation of water in structurally controlled basins. Wells near the lagoon show higher chloride content due to sea water intrusion. However, some wells about 1-2 kms away from the lagoon towards land also show higher chloride content (Group D) caused perhaps by the mixture of recharging water and salt water and therefore it can be assumed that there are salt water or salt which have been deposited in the subsurface areas perhaps due to the percolation of sea water during the Quaternary period marine transgression. This is very good evidence for locating the boundary of old beaches. The general quality of water is good.

1. Introduction

Groundwater prospecting techniques and investigations are directed mainly at locating groundwater resources and also at understanding the formations of groundwater systems with respect to the environment in which it occurs. The groundwater located from deeper areas can be used for any purpose during the drought. Hence the investigations for exploiting groundwater has important applications.

Andella Oya basin lies within the area of the Gal Oya development project which was started in early 1950 (Figure 1). "Senanayaka Samudraya" at Inginiyagala which is the main reservoir in this project supplies water through its left bank main channel for agriculture and domestic requirements of the settlers. A geohydrological investigation was carried out in this area to evaluate the groundwater and surface water resources of the area. Chemical analysis of water collected from dug wells was carried out as a part of this research. The chemical quality of water is a valuable tool in water investigation.

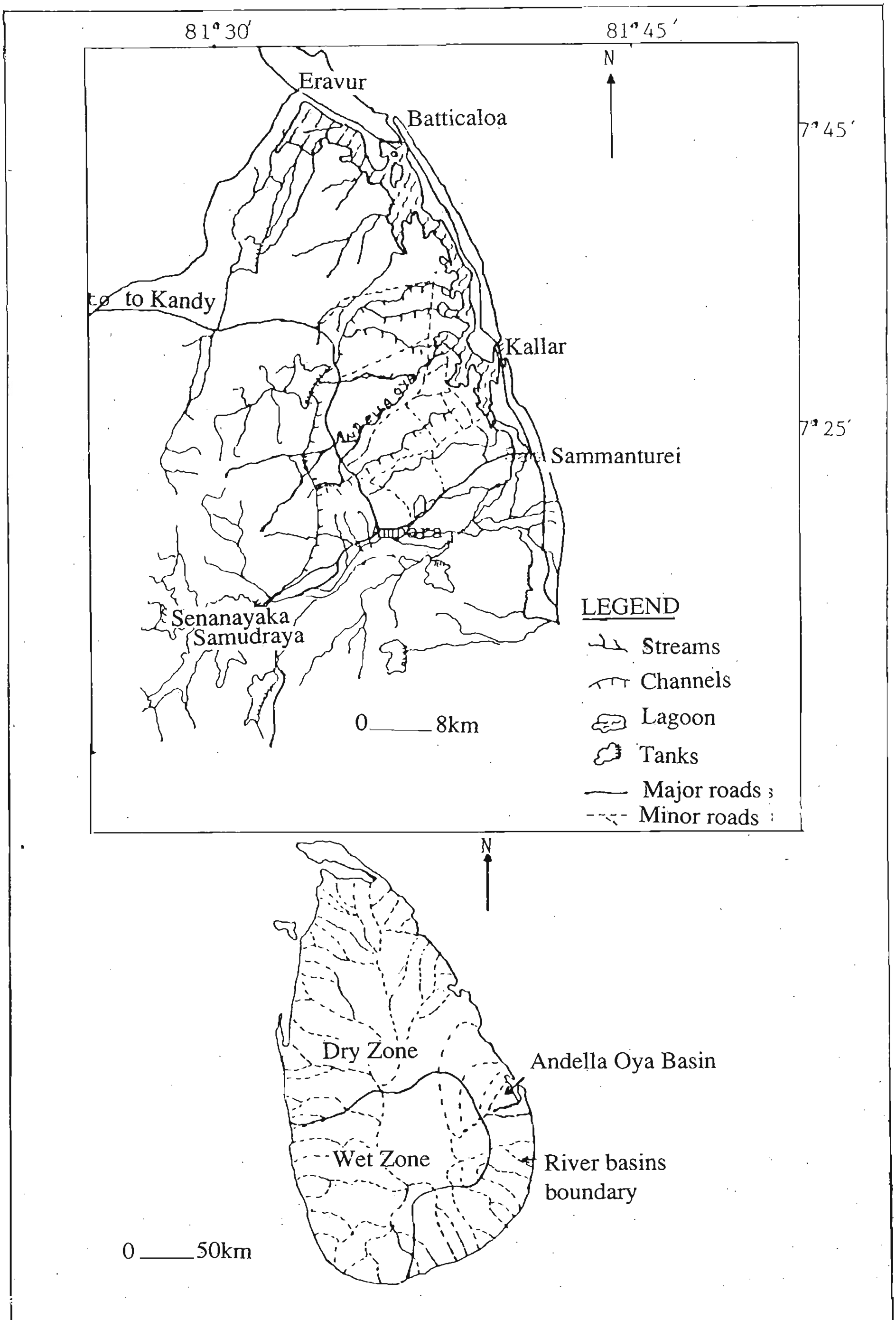

Figure 1: Andella Oya Basin of Sri Lanka

2. Location and Extent of The Area

The study area lying in the Andella Oya basin comes under Ampara and Batticaloa districts in the eastern province of Sri Lanka (Figure 1). This area is about 272 sq. kms and lies between 81 35' and 81 47' east and 7 20' and 7 34' north. The area under investigation is bounded by the Uhana main branch channel in the south and by the Sammanthurei-Batticaloa minor road which is close to the southern strip of lagoon in the east and by the left bank main channel in the west and north (Figure 3).

Andella Oya basin is situated in the Dry Zone of Sri Lanka (Figure 1). The rainfall isohytes show that the arithmatic mean in the hilly areas and lower areas are 2000 mm and 1735 mm respectively.[7] The temperature of the area varies between 26°C and 32°C.

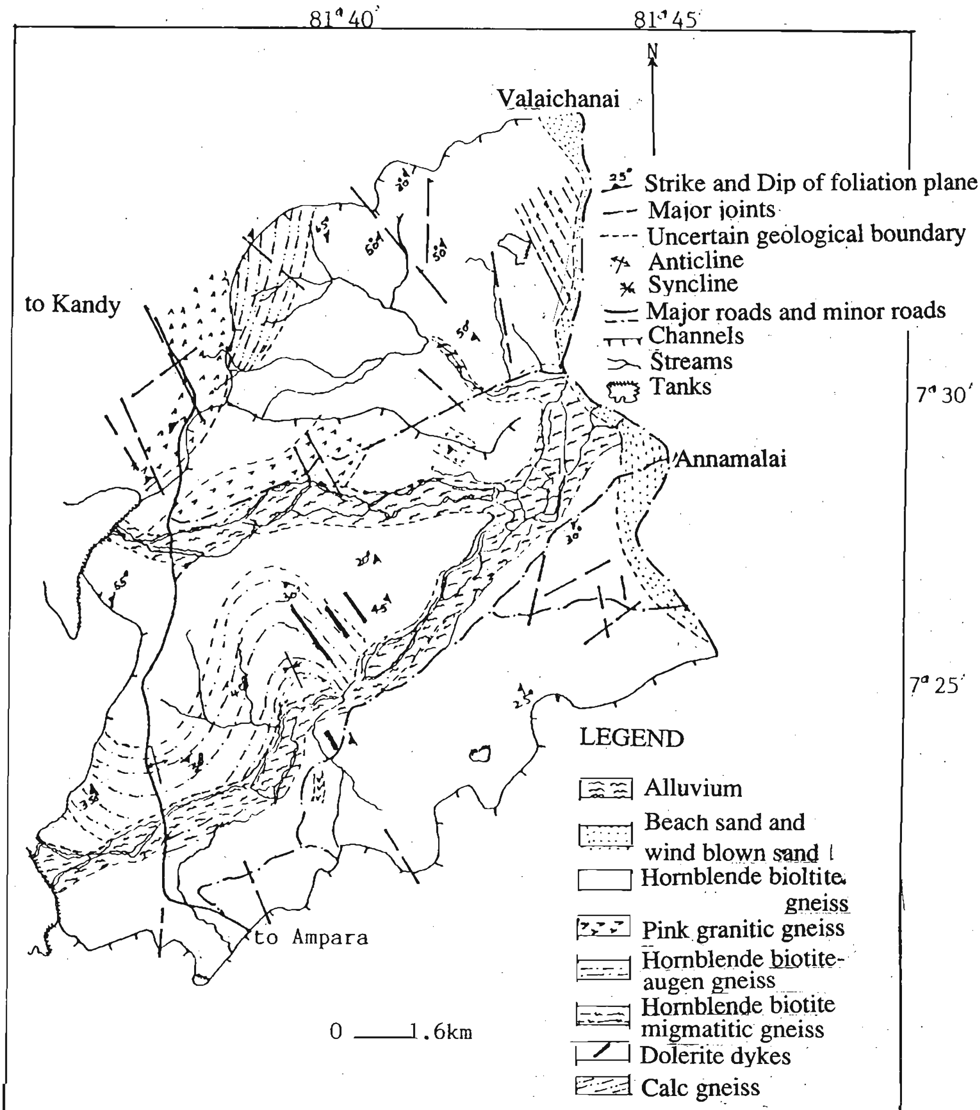

Figure 2: Geology of Andella Oya Basin.

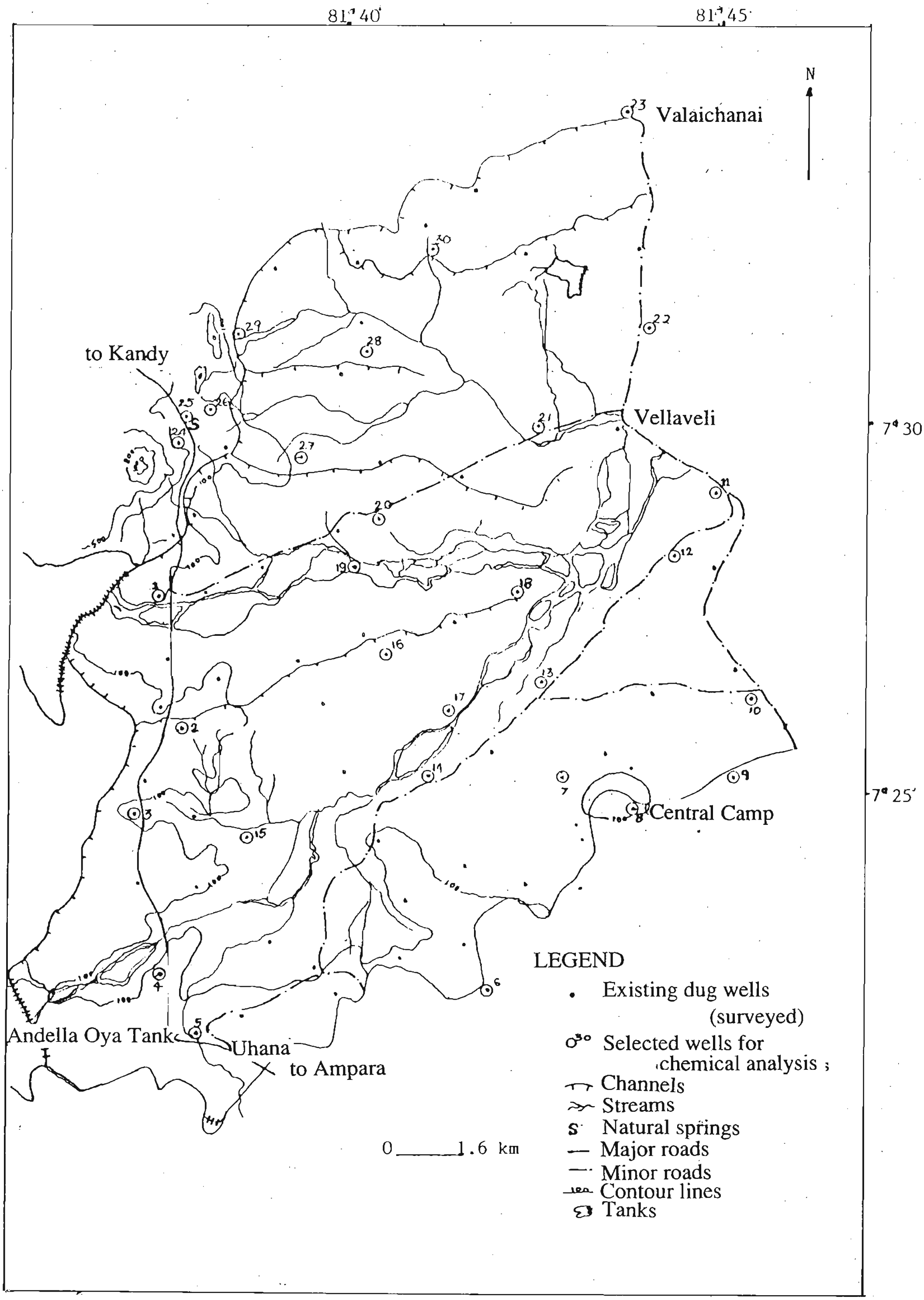

Figure 3: Locations of Dug Wells in The Andella Oya Basin

3. Geomorphology and Geology

The groundwater basin under study is situated in the lowest peneplain[6] which is continuous over most of the north-eastern and coastal parts of Sri Lanka. The land surface is of the gently undulating type with more resistant rock types standing out as ridges, isolated hills and turtle back shaped outcrops. The general elevation varies from sea level in the east to about 48 m. in the west. The hilly area in the north-western side rises steeply from 48 meters to about 316 meters.

Geologically the land can be divided into the following zones;

(a) beach sands, dune sands and salt marshes

(b) alluvium such as flood plains and braided stream deposits

(c) rocky area with Precambrian basement outcrops.[2]

Major rock types throughout the area are hornblende biotite gneiss, hornblende biotite rich augen gneiss, migmatitic gneiss, pink feldspar granitic gneiss and granite, calc gneiss, basic dykes and pegmatites (Figure 2). All joints in the outcrops are closed and very tight. Well developed flood plains and other alluvial deposits occur on both sides of Andella Oya and other tributaries. Medium to coarse grained well graded sand deposits which is subangular to subrounded in texture occur in the homestead areas along the eastern boundary of the area. The dug well survey indicated that the weathered overburden varies from place to place significantly. It was also found that except at a few places, the entire area consists of shallow weathered overburden. The maximum range of the weathered overburden lies between 5m to 10m with a few locations showing the formation of lateritic soils.

4. Method of Survey

Dug Well Survey

This survey was carried out in order to obtain preliminary information on annual water level fluctuations, consumption of water, recharge of water into the well, taste of water, formation of the well sites and weathering condition of the rocks, effect of the seepage condition from the channels, temperature and conductivity of the well water and possible effects of water pollution. The wells near the channels were not selected for this survey. Wells which were generally more than 100 meters away from the channels were selected randomly (Figure 3).

During this survey, several water samples were collected before the north-east monsoon rainfall from the selected wells for the analysis of major ions. The following factors were considered in the selection of wells for chemical analysis.

1. Topographically higher and lower lands.

2. Largely extracting wells.
3. Deep weathered rocks and deep hard rocks.
4. Highly rechargable wells and less rechargable wells.
5. Streams and springs.

Samples were collected from the top of the water column using a bucket used by the people for collecting water and filled into 500 ml capacity pre-cleaned plastic bottles. All water samples were collected within a day and handed over for chemical analysis to the chemical laboratory of the Water Resources Board, the following day. The temperature was measured in Centrigrade using a thermometer.

5. Results and Discussion

Very tight joints in the hard rocks, less decomposed rocks and thin in-situ chemically weathered products (lateritic types) indicate that the general groundwater circulation is limited in this studied area.

About half of the samples show low total dissolved solids value (TDS) and generally range from 45 to 465 ppm. The high total dissolved solids range from 790 to 4572 ppm. The variations of the electrical conductivity with the TDS were plotted and the best relationship on these two properties can be expressed as

$$TDS = 0.77\ EC + 38.46.\ \text{(Figure 4)}$$

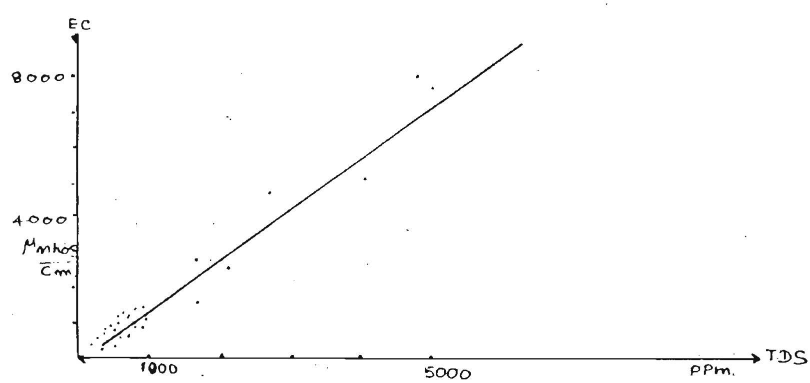

Figure 4: Relationship of Electrical Conductivity with Total Dissolved Solids.

The chloride content is very high in lower ground and in a few locations of higher lands. Comparative studies showed that all chloride types of water have EC values higher than 500 micromhos/cm and that the rest are below the critical value of 500 micromhos/cm.

The results of these analysis (Table 1) plotted on PIPER's trilinear diagram (Figure 5), reveals that about 1/3 of the samples fall into the bicarbonate type while 2/3rd falls into chloride type. Most of the water from the western higher areas show high bicarbonate concentrations and when it moves into the lower areas, the quality changes into the chloride type.

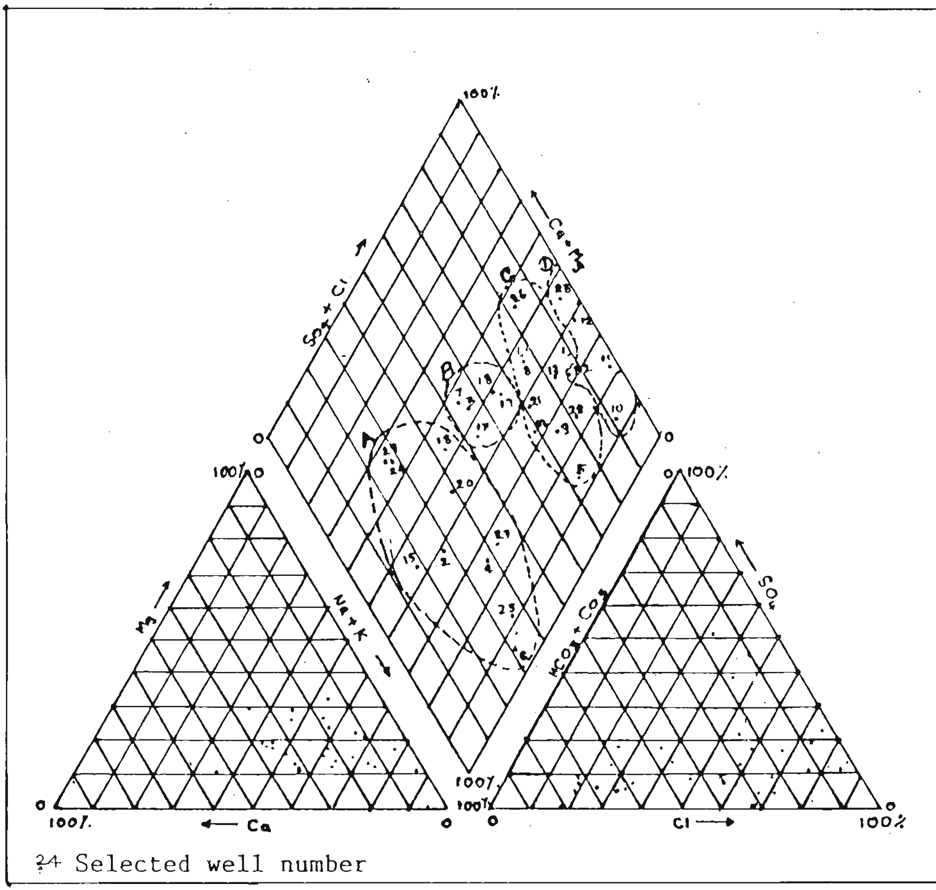

Figure 5: Trilinear Diagram (PIPER) Illustrating the Distribution of Major Ions (meq/l)

Sodium, calcium, bicarbonate and chloride are the major ions in high TDS water. The pH values of all samples were above 7, and hence the bicarbonates in the recharging water should be secondary formations.

Some wells in areas of higher elevation show the chloride type water. The reasons for the existence of chloride type water in higher lands or rechargable areas is explained using PIPER's trilinear diagram and the results of the dug wells survey. Accordingly, the author categorized the samples into four geochemical groups which shows a relationship with the surrounding geomorphological conditions of the groundwater existing areas. The following geochemical groups show the relevant geomorphological conditions of the

SL	EC mhos/cm	Hd $CaCO_3$	TDS	pH	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}	F^{-}
1	5180	1198	4385	7.5	15	200	1000	5	459	1047	1400	0.3
2	130	19	108	7.2	4	2	12	1	66	9	4	0.1
3	300	91	205	7.2	25	7	35	80	49	11	5	0.1
4	455	122	305	7.1	41	5	40	4	148	5	23	0.1
5	525	16	355	7.9	3	2	45	2	64	101	6	0.1
6	90	3	80	7.6	1	nil	18	1	40	10	nil	0.1
7	250	68	170	7.1	19	5	25	2	70	36	14	0.3
8	700	153	465	7.4	20	25	80	3	61	97	15	0.2
9	1280	204	1055	7.8	42	24	240	18	198	242	130	0.3
10	8400	669	4620	7.8	70	120	1500	2	468	1966	680	0.2
11	7525	943	5025	7.4	88	176	1440	56	554	2574	130	0.1
12	2800	472	1750	7.4	12	39	330	17	147	741	40	3.0
13	721	146	481	7.3	39	12	115	5	84	195	56	0.2
14	4500	66	2350	8.1	10	10	700	4	650	872	60	0.2
15	90	16	77	7.6	3	2	10	1	47	6	nil	0.1
16	390	73	285	7.2	16	8	26	16	118	37	70	0.1
17	550	90	462	7.4	16	13	46	6	60	27	17	0.3
18	960	210	630	7.5	63	13	122	12	189	206	35	0.3
19	1120	288	750	7.4	76	24	125	12	232	212	49	0.2
20	175	33	138	7.3	10	2	16	6	64	21	6	1.0
21	1130	209	755	7.1	51	20	161	13	209	240	61	0.1
22	1100	143	790	7.2	34	14	140	6	52	237	59	0.2
23	5225	1410	4752	7.8	23	200	800	5	229	1610	625	0.3
24	190	51	164	7.8	17	2	12	1	92	13	8	0.1
25	70	2	45	7.1	0.5	0.5	7	3	85	9	nil	nil
26	436	185	285	7.4	28	11	40	2	127	47	32	0.1
27	460	45	265	7.1	10	5	65	3	29	20	11	0.1
28	2800	582	2518	7.8	85	90	550	19	395	572	675	0.3
29	220	57	125	7.1	13	6	14	1	105	14	10	0.1
30	650	199	400	7.2	55	15	59	5	178	53	9	0.1
St	85	38	60	7.1	10	3	6	1	5	15	8	nil

Table 1: Chemical Analysis of Well Water as parts per million (ppm).
SL: Sample Locations.
St: Sample from Andella Oya.

sampling areas.

Group A - High bicarbonate type water. Most wells occur in the western side hilly areas and other higher lands. Quality of water is good.[3]

Group B - Low bicarbonate type water. Very shallow wells which are located in thin weathered overburden and thinly deposited sandy clay areas. Generally the quality of water is good.

Group C - Low chloride type water. Deep wells which are located in thick weathered overburdens and thickly deposited sandy clay areas. Generally the water quality is poor.[3]

Group D - High chloride water. Wells are located in the coastal sandy area. Water is of the brackish type.[3]

According to these chemical groups, groups B and C show that the water quality has changed with the thickness of weathered rock overburden. Due to the uneveness of the terrain, all water may be stored in structurally controlled basins and the groundwater levels of each of these basins may not get connected together during the dry season. Most of the salts in solution in thick weathered overburden areas and thick sandy clay areas will be dissolved as water percolates through the soil zones and the TDS content therefore depends upon local factors. This may be the reason for the poor quality water in Group C.

Brackish water (sodium chloride type) is found in the eastern boundary area and has a TDS range higher than 1000 ppm. One well is located near the lagoon where sea water may intrude into the well. The other wells are however located more than 5m above sea level and about 1-2 km away from the lagoon towards the land side. Hence sea water may not intrude the shallow areas according to the GHYBEN-HERZBEY relation between fresh water and saline water.[5]

These wells are located in the raised beach area. Hence the percolation and recharging water throughout the year may be mixed with the salt water which had been deposited in the subsurface areas due to the percolation of sea water during the Quaternary period marine transgression or the left over sea water in the subsurface areas.

However the general quality of groundwater is found to be suitable for drinking.

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