THE DEVELOPMENT OF GROUNDWATER FOR WATER SUPPLY

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ABSTRACT

This paper presents results of groundwater investigations carried out at Yombo Dovya Village, Temeke District in Dar es Salaam Region. The study has included hydrogeological and geoelectric resistivity sounding survey data obtained at the test site in Yombo Dovya village. The results of this investigation based on the application of vertical electrical sounding probe predictions have indicated the existence of reasonable amounts of groundwater resource for development. To verify these results borehole drilling tests were also conducted at the same site (Borehole No.DSM 79/99), and the results obtained by this method compares very well with those obtained earlier by the resistivity sounding method. According to further analysis made the water was found to be within drinking standards and had a pH value of 6.5.

INTRODUCTION

One of the most significant progress that the Government of Tanzania has made is in the development of water resources, with the objective of improving the living conditions of the rural population as well as the urban. As Tanzania enters the new millennium, the Government is still endeavouring to meet its commitment to bring portable water within reasonable reach of 400 meters to all citizens by the year 2002.

The provision of water is implemented through integrated development of surface and groundwater. Because of the adverse economic conditions, scarcity of resources, increasing expenses for surface water development, paying more attention to groundwater as a potential water resource can also contribute into achieving the ambitious target whose date now seems to be not far away.

Up to 1988, statistics show that about 44% of all communities living in rural areas were provided with clean water [1]. However, in most rural areas communities still do not have access to clean and safe water. Thus, the need to develop groundwater is very great. More so, the quality of groundwater for rural areas should not pose major constraints since this is affected by the downward movement of water in recharge areas through percolation, and the lateral movement through aquifers. The percolation of water through the surface soils of the recharge areas generally results in significant purification [2]. However, the effectiveness of this purification process depends on the depth of soil above the water table, the type of soil, and the concentration of pollutants in percolating water, which for rural conditions are less severe. In other rural (or semi-urban) communities where population densities are high, water contamination may be encountered resulting in outbreaks of water borne diseases. It is therefore sensible to tap groundwater sources free from surface contamination using boreholes and dug wells fitted with pumps.

In this paper the author presents results of groundwater investigations carried out at Yombo Dovya village which is essentially a semi-urban area in Temeke District, Dar es Salaam region. The investigation was conducted using a hydrogeological and geoelectric resistivity sounding method for preliminary predictions and identification of groundwater site. The study included also borehole drilling tests to verify earlier results obtained by making use of the resistivity sounding method. These results are of significant importance in view of enhancing clean and safe water supply to communities in Yombo (Dovya, Vituka, Kilakala and Makangarawe) villages.

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GENERAL PROJECT AREA FEATURES

Location and Climate

The location of the study area was Yombo Dovya, Temeke District in Dar es Salaam Region, adjacent to Mpakani river. The geographical location of the area can be found on a topographical map No.186/4, at Longitude 39° 15' East and Latitude 6° 53' South. The altitude above mean sea level (a.m.s.l) is about 20 m. A schematic representation of the study area is shown in Figure 1.

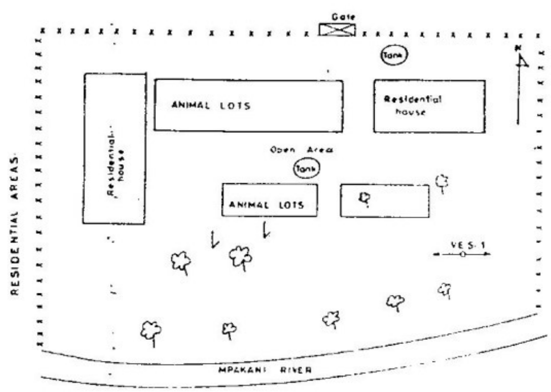

Fig. 1 Schematic drawing of the study area at Yombo Dovya (Temeke District)

The investigated area, as many other parts in the coastal areas of Tanzania experiences two rainy seasons (the heavy Masika rains from March to May; and short Vuli rains in November and December). The average annual precipitation for this area is about 1000 mm, and there is a dry period with temperatures ranging between 15°C to 35°C.

Hydrogeology

The surveyed area is largely comprised of a relatively high land of the erosional surface of deep slope which is blanketed by neogene sedimentary sequence. The sediment covered is mostly sand, and the eastern boundary of the area is represented by Mpakani river which collects runoff water from this area and its surroundings discharging it to a nearby Yombo river.

An abundance of relatively shallow wells with maximum depths of 7 m, exist in the study area which is a clear indication that the area has potential for groundwater resource. Information gathered from previous study also indicate the presence of sand layers and minor clay layers. This type of deposition suggests the existence of a good groundwater aquifer.

INVESTIGATION METHODOLOGY

Resistivity Method

Although groundwater cannot be seen on the earth's surface several techniques exist to provide information concerning its occurrence, and even its quality from the surface [3,4]. For this study a Vertical Electrical Sounding (VES) method was employed to investigate the geological and hydrogeological situation of the subsurface formations of the area under investigation. The technique was performed using ABEM-4000 TERRAMETER, and measurements were made by adopting Schlumberger electrode configuration as can be seen in Fig. 2(a) to probe the area.

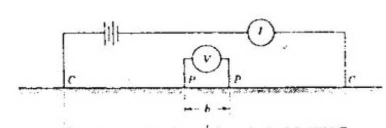

Fig. 2(a) Common electrode arrangement for resistivity determination (Schlumberger arrangement)

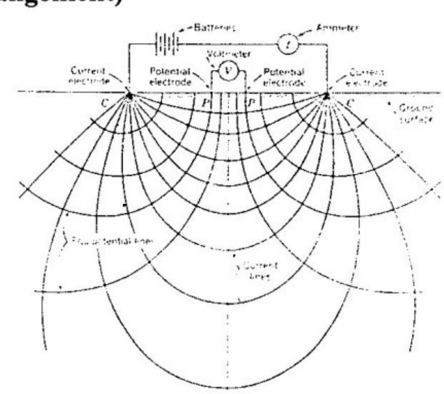

Fig. 2(b) Typical electrical circuit for resistivity determination and electrical field for homogeneous subsurface formation

$$\rho = \frac{RA}{L} \qquad 1$$

The electric resistivity of a land formation limits the amount of current passing through it when an electric potential is applied. If a material of resistance R has a cross-sectional area A and a length L, then its resistivity ρ can be expressed in a general form as [2,3]

and units of resistivity are ohm-m. The value of resistivity vary over a wide range depending on the condition of the material, but there are no fixed limits for resistivity of various rock formations. A representative guide to electric resistivity ranges of various sediments and rocks that can be used for practical purposes is shown in Fig. 3. The values shown suggest the presence of fresh groundwater; and saline water will shift these values at least an order of magnitude to the left.

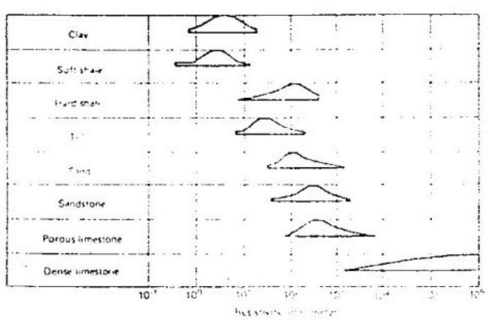

Fig. 3 Representative ranges of electrical resistivity for various sediments and rocks

The resistivity measurement procedure used in this study involves measuring a potential difference between two electrodes L/2 placed in the ground of the surveyed area resulting from an applied current through two current electrodes A and B set at 80 m. The measured current and potential difference yield an apparent resistivity over an unspecified depth as can be seen in Fig. 2(b). The potential electrodes L/2 were increased according to Schlumberger arrangement at intervals of 0.5 m to 20.0 m, apart. This arrangement allowed to achieve a deeper penetration of the electric field and different apparent resistivity values (in ohm-meter) were then calculated to corresponding Schlumberger array formula similar to Eq.1 put in the following form [4,5]

where, L and b are the current and potential electrode spacings, respectively (see Fig 2(a)), V and I are the corresponding potential and current. Theoretically, L is greater than b, but for practical application good results can be

$$\rho_a = \pi \frac{\left(\frac{L}{2}\right)^2 - \left(\frac{b}{2}\right)^2}{b} \frac{V}{I} \qquad 2$$

obtained if L equals 5b. The results of apparent resistivity values obtained were plotted against electrode spacing L/2 for various spacing at intervals of 0.5 m to 20 m at the site being studied, and these are presented in form of a smooth curve, plotted in a double log sheet of modulus 62.5 as can be seen in Fig. 4. Interpretation of field curves are carried using (Orellana and Mooney) Standard Master Curves [6,7,8].

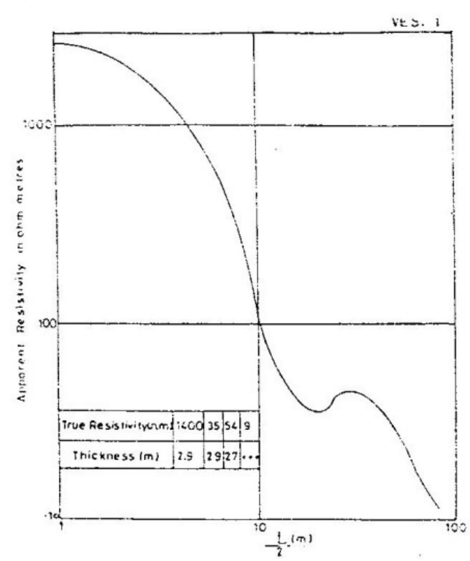

Fig. 4 Interpretation of a four-layer VES probe measurement

Test Drilling Method

To verify probe results obtained by using VES method discussed above, Test Drilling Method was employed to ascertain the geological and groundwater conditions of the identified well site. During test drilling investigation, a borehole with a diameter of 200 mm, was constructed using rotary mud drilling approach (PAT DRILL 291C). A study of the variation of the actual vertical rock profile was made and the results obtained are compared with those obtained using the VES method.

In order to be able to make such comparison it is essential to construct a geologic log using rock samples examined from well cuttings collected at frequent intervals during the drilling test. The results of a geologic log obtained for the investigated borehole No.DSM79/99 located at Yombo Dovya area of Dar es Salaam are presented in Fig. 5.

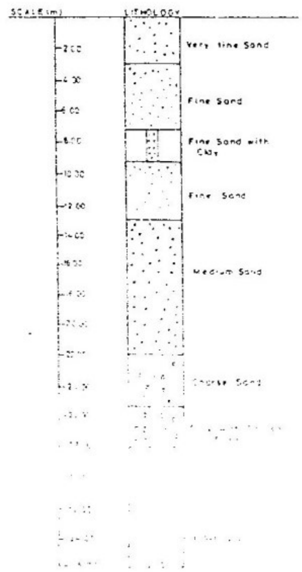

Fig. 5 Geologic log bore-hole DSM 79/99 prepared from well cuttings

DISCUSSION OF RESULTS

Vertical Electrical Sounding Results

The interpretation of resistivity - spacing curves in terms of subsurface conditions is a complex and frequently difficult problem. The solution for this study was obtained using essentially a four-layer hydrogeological model in which Eq.2 was used with measured data to compute resistivity values with varying layer thicknesses beneath the surveyed area [4,6].

Results from a Vertical Electrical Sounding (VES) probe as shown in Fig. 4, illustrate the interpretation of four-layer electrical resistivity measurement using Schluemberger electrode spacing. The resulting VES measurements at point VES.1, indicate that the top layer is characterised by a relatively high value of resistivity of about 1400 ohm-m which suggests the presence of dry sand. The thickness of this layer is about 2.9 m. The resistivity value for the adjacent layer was found to be 35 ohm-m which is an indication of the existence of a sand layer of about 29 m thick. This was predicted by the VES probe to be the main layer expected to be saturated with water.

In the third layer encountered the resistivity value was found to increase to about 54 ohm-m, a value higher than the previous one. The interpretation made from the measurements gave an indication of the presence of a relatively poor water bearing sand aquifer of about 7 m thickness. Measurements of the bottom fourth layer gave resistivity value of about 9 ohm-m, but the extent of its thickness could not be determined at this lowest layer. However, the interpretation made for this layer suggests the presence of a porous Neogene sand formation contaminated with some clay material, which is the characteristic of formations with resistivity values below 10 ohm-m [4,7,8]. Experience gained from previous works show that such vertical profile of this sedimentary formation should constitute a good water bearing formation. On the basis of these results the depth at which a borehole would be drilled without encountering salt water was therefore predicted to be 35 m below the surface. The resulting interpretation of the four-layer VES probe measurement as can be seen in Fig. 4.

Test Drill Results

According to the geologic log that was constructed for the investigated site using rock samples examined from well cuttings collected at frequent intervals, the top layer composed of about 3.0 m thick was found to be covered by very fine and dry sand. The rock profile beyond 3.0 m to 27.0 m depth comprised of fine , medium and coarse sands. Below this depth up to 36.0 m, a black clay was observed [3,8].

During test drilling water was struck at a depth from 9.0 m to 27.0 m, which confirms earlier predictions made by the VES probe of the well site. The resulting geologic log of the borehole DSM79/99 prepared from well cuttings is shown in Fig. 5. These results compare very closely with those predicted by the VES method discussed above.

Physical examination of water samples collected during test drilling show the water had no colour, and had pH value of 6.5. According to the analysis done on the water samples the water was therefore found to be within the drinking water standard.

CONCLUSION

The results of groundwater investigations conducted at borehole No.DSM 79/99 suggest that, the surveyed area has a good potential for groundwater development. These results were obtained by making use of Vertical Electrical Sounding (VES) probe prediction procedure applied to a four-layer hydrogeological model. Interpretation of the resulting field curves was carried using [Orellana and Mooney] Standard Master Curves.

Verification of the results obtained by the Vertical Electrical Sounding method was made by conducting drilling tests at the investigated site. Analysis of rock cuttings collected at the borehole at frequent intervals gave results that compare well with those predicted earlier by the VES probe. Physical examination of water samples collected show it to be colourless. According to further analysis made the water was found to have a pH value of 6.5, and hence, it is within drinking water standards.

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