RAINWATER HARVESTING

Rainwater harvesting is the process of collecting, filtering, storing and using rainwater. This has gained increasing importance in the current situation of exploding demand for water. Rainwater harvesting is relevant for both urban and rural areas. Examples are the implementation of projects in Bangalore by Rainwater Club in urban setting and by Tarun Bharat Sangh in E Rajasthan in rural setting.

Bangalore gets its water from the Cauvery river at about 95 km away and from 500 m depth. Groundwater in the city is either polluted or getting depleted in many areas. Surface water bodies are on the decline. Since demand for water is picking up the sole service provider viz. BWSSB, is faced with the Herculean task of providing water for the city. Rainwater harvesting can be an important supplement given the fact that on the average Bangalore gets 970 mm of rain (based on data for the last 10 years). A 100 sq. m roof area gets 97,000 litres of water and with a little change of design at least 60,000 to 70,000 litres can be harvested either through storage in sumps/tanks or through recharge of open wells and borewells or a combination of both storage and recharge. Given the current building practices and sensitivity to design, house-owners, architects and engineers are now seriously considering rain harvesting. Institutions and industries faced with high tariff for water can also harvest rain since they would generally have large site and roof areas.

Rainwater Club seeks to arm people with information by working on the requirement of quality and quantity as well as design, to enable them to make informed choices of managing water. A small booklet and a website *www.rainwaterclub.org* has been created and further work with students is on to work out a research agenda. Bangalore gets the equivalent of 3000 million litres of rainwater per day on its 1279 sq. km CDP area, which is nearly double the ultimate water supply of 1500 million litres per day planned by the BWSSB. It is therefore every citizen's responsibility to ensure full utilisation of the rainfall through rainwater harvesting.

Rainwater Club, Bangalore S. VISHWANATH,

DISCUSSION

HYDROGEOLOGICAL INVESTIGATIONS OF THE EASTERN PART OF DHAKA CITY USING GEOPHYSICAL WELL LOGGING by D. Hossain and R.K. Majumder. Jour. Geol. Soc. India, v.56, 2000, pp.161-168.

N. Lakshmi Narayana, Geohouse, Plot No.32/B, Road no.2, Adarsh Nagar, Nagole, Hyderabad - 500 068 comments:

1. The technical aspects of logging system are missing, which would have helped to understand or have the perspective view of logs for better interpretation and correlation. Some aspects include the electrode configuration in Resistivity Sonde, Time Constant (T.C.) in Natural Gamma Log recording system etc.
2. The statement reads: "R_w was not determined from SP logs since all the parameters required for its evaluation were not available". Then how R_w was determined? In the beginning R_w has to be estimated either through SP logs [Todd, 1980, p.446 (12.4)] or by Archie's formula (Lazrez, 1972). The parameters of porosity, cementation factor and water saturation of the water sample collected from the aquifer zone are to be used for calculating the formulation factor (F) with the known R_0 from the resistivity log. The calculated F for any geo-electric unit is expected to be the same for the area under study.
3. To evaluate the anisotropy (λ), the parameters required are transverse resistivity (ρ_n) and longitudinal resistivity (ρ_l), which are in turn calculated based on the resistivity (R_0) derived from the resistivity log. How two unknowns (ρ_n and ρ_l) were derived from one (R_0) known factor?
4. The statement reads as "clays and shales usually exhibit higher level of radioactivity than sand units", but in Fig.2, particularly the gamma log in BH.No. DW5/20 and DW6/10, significantly shows contradicting responses to the statement like "gamma ray response for the sand unit is higher than that of the upper clay unit". The high gamma response in sand unit (GEU-2) is explained as due to the presence of heavy

minerals and silica clay minerals, mica etc. Clay shows low gamma response due to the presence of high content of sand and silt. If this explanation is valid for BH. No. DW5/20 and DW6/10, then the same logic failed at BH No.DW5/17 and DW6/12, which are very near to the BH.No.DW5/20 and DW6/10 respectively.

5. For implementing some useful concepts like (a) calculation process of transverse resistivity and longitudinal resistivity from the resistivity logs; (b) estimation of shale volume from gamma log by calculating radioactivity index, necessary details were missing but for a reference of Majumder (1996) which itself is a unpublished one.
6. From Fig.2, it appears that the SP was not developed properly.The resolution of gamma log is very confusing to derive any useful information. Probably higher T.C. in gamma recording would have improved the quality of recording/data?
7. For correlating purposes, the second geo-electric unit is delineated as sand unit, leaving some clay bands occurring within it. At Khilgaon-4 (DW6/12) and Rajarbagh (DW6/10), the aquifer zones were identified in the depth range of 37.5-165.5 m and 23.5-153.5 m respectively, leaving some clay bands within it. If the groundwater borehole has to be cased with slots filter against the aquifer zones(s) or is already cased, the clay bands may create problem in the due course of time, as clay due to its sticky nature slowly seals the slots/filter, which finally results for the non-supply of groundwater.
8. The upper clay unit (GEU-1) consists of 20% clay and 80% sand and silt. This GEU-1 may be identified as sand (?) as the low gamma response against this supports/confirms for the change i.e., sand unit.
9. Against GEU-1, the significant features like "low resistivity", "high sand and silica content (80%)" and "low gamma response" do not match to call this as clay unit (?)
10. In the normal practice, the factor anisotropy (λ) will be calculated by conducting the sounding (VES) parallel and perpendicular to the expected geological strike of the formations. But, here the statement "the determination of anisotropy (λ) for a unit (based on the resistivity log data) is important for the correct interpretation of sounding (VES) data" puts the sequence on the reverse direction.
11. Is the conclusion that "the flow of the groundwater is towards the southeastern part within the study area" based on the geophysical log data? The geo-electric cross sections of A-A' and B-B' (Fig.3), do not clearly indicate the flow direction of groundwater i.e., towards southeast. The use of flowmeter and its correlation from one borehole to another will give the direction of groundwater flow.
12. From Table 1, the resistivity (R_0) of GEU-2 ranges from 141 Ohm m (DW1/27) to 232 Ohm m (DW5/20) and probably by using R_0=F.R_w, the estimated groundwater resistivity (R_w) of the aquifer ranges from 15 Ohm m to 53 Ohm m. If the formation resistivity factor (F) is assumed to be same for the area/unit under study, how R_w values like 141/F=15 and 232/F=53 are justified? If 'F' is not same in the study area, at each borehole, the log data has to be used to estimate 'F' value. Then, when 'R_0=F.R_w' can be used to estimate the groundwater resistivity (R_w) knowing the formation resistivity (R_0) from the resistivity log.
13. Any variation in the estimation of R_w (point-12) also influences the further estimations of TDS and chloride content in groundwater of GEU-2.
14. "The relative salinity of the groundwater and mud filtrate and the volume of shale (clay) in the aquifer (V_{sh}) have been determined using SP log data". But as shown in Fig.2, in all the four boreholes DW5/20, DW5/17, DW6/12 and DW6/10, SP log do not show much variation (?) and no useful information can be extracted.
15. In any groundwater exploration, the sequence followed is sounding (VES), drilling and geophysical logging with a view of characterizing the aquifer zone. Surprisingly, in this paper, the authors place the sequence the other way i.e., "the λ value is useful in interpreting the vertical electrical sounding (VES) data and 1-D sounding can be effectively applied to groundwater exploration of the study area". After calculating the anisotropy (λ) from the geophysical log data, is it necessary to conduct soundings (VES) for groundwater exploration in the study area ?.

D. Hossain, Department of Geological Sciences, Jahangirnagar University, Savar, Dhaka 1342, Bangladesh and **R.K. Majumder,** Beach Mineral Sand Exploitation Centre, P.O. Box no.15, Cox Bazar 4700, Bangladesh reply:

We are thankful to Lakshmi Narayana for his interest and comments on our paper. Following are the replies to his comments:

1. The technical aspects/details of the logging system are not given in the paper due to space limitations, but are considered in log interpretation.

2. R_w has been determined from the water samples collected from the aquifer zone (Majumder, 1996). The calculated F for the aquifer zone within the study area is in the range of 3.5-5.5. The change in F is due to change in lithology.
3. To evaluate the coefficient of anisotropy (λ), the parameters of transverse resistivity (ρ_n) and longitudinal resistivity (ρ_l) were calculated as follows:

$$\rho_n = \sum_{i=1}^{m} (\rho_i h_i) / \sum_{i=1}^{m} h_i$$

and

$$\rho_l = \sum_{i=1}^{m} h_i \;/ \sum_{i=1}^{m} (h_i/\rho_i)$$

where, ρ_i and h_i are the resistivity and thickness of individual layer respectively, and m is the number of layers in the geo-electric unit.
4. In spite of the wells DW5/17 and DW6/12 being respectively very close to DW5/20 and DW6/10, there is change in gamma ray response in the former ones, which may be attributed to lithological change. This, however, could not be studied in detail.
5. The calculation procedure for transverse resistivity (ρ_n) and longitudinal resistivity (ρ_l) is given in para 3 of the reply. The radioactivity index is calculated as $I_{GR} = (GR\text{-}Gr_{min})/(Gr_{max}\text{-}Gr_{min})$ (Rider, 1986), where GR is radioactivity value read on log, Gr_{min} is radioactivity value read against clean formation (100% sand), and Gr_{max} is radioactivity value read against shale (100% shale).
6. The SP measurements were carried out with the available information. The T.C. of 4 sec. has been used in gamma recording, while the logging speed was 275 m/h. The author agrees with the suggestion that higher T.C. may have improved the quality of recording.
7. The wells are designed on the basis of lithologs.
8. Despite the given composition of (the upper geo-electric unit) clay (20%) with very fine sand and silt (80%) at 8 m depth (Hassan, 1986), it is traditionally referred to as Madhupur Clay. Morgan and McIntire (1959) also termed this older terrace of Pleistocene age as Madhupur Clay.
9. The upper geo-electric unit, as mentioned in para 8, is a composite of clay, silt and very fine sand. In the case of pure clay, resisitivity should be much lower. The resistivity of 50-60 Ohm m is due to increased size of of particles like silt, very fine sand etc.
10. The reply to this comment has clearly been given on page 166. The interpretation of VES over layered anisotropic earth provides us with geometric mean resistivity and mean equivalent thickness. The VES derived thickness is the product of true thickness and the coefficient of anisotropy (λ) (Meekes and van Will, 1991; Hossain, 1995), i.e., for correct interpretation of VES data, λ is necessary.
11. The direction of groundwater flow has been inferred from water table contour maps.
12. As mentioned earlier, R_w values are obtained directly from water samples and from them F values for different wells are estimated. Hence the comments are not valid.
13. Since R_w for some wells are assumed to be constant, the TDS values and chloride content also thereby remain constant. However, variation in R_w from well to well (from 15 to 53 Ohm m) is duly noted.
14. Not all the logs (including SP) could be presented in the paper. The estimation of relative salinity and shale volume is based on some representative SP logs having higher resolution.
15. The importance of VES is not all underestimated. However, for correct interpretation of VES data over layered anisotropic earth, the knowledge of anisotropy (λ) is necessary. This anisotropic information can be applied for VES interpretation both in the study area (in case of no drilling) and the regions surrounding it.

References

Archie, G.E. (1950) Introduction to petrophysics of reservoir rocks. Bull. Am. Assoc. Petr. Geol., v.34(5), pp.943-961.

Hassan, M. (1986) Stratigraphical and sedimentological studies on Quaternary deposits of the Lalmai Hills (with relation to Madhupur Tract and the adjoining flood plain), Bangladesh. D.Sc. Dissertation, VUB, Brussels, 199p.

Hossain, D. (1995) Vertical electrical sounding: some aspects of application in the Chittagong-Noakhali Coast, Bangladesh. Jour. Bangl. Acad. Sci., v.19, pp.19-26.

Lazrez, H. (1972) Application of surface resistivity methods to the detection of salt-water intrusion in Shippegan, New Brunswick. CEM Trans., v.LXXV, pp.32-41.

Majumder, R.K. (1996) Hydrogeological investigations of the eastern part of Dhaka city using geophysical well logging. Unpublished M.Sc. Thesis, Department of Geological Sciences, Jahangirnagar University, Savar, Dhaka, Bangladesh, 182p.

Meekes, J.A.C. and van Will, M.F.P. (1991). Comparison of seismic reflection and combined TEM/VES methods for hydrogeological mapping. First Break, v.9, no.12, pp.543-551.

Morgan, J.P. and McIntire, M.C. (1959). Quaternary geology of the Bengal basin, East Pakistan and India. Bull. Geol. Soc. Amer., v.70, pp.319-342.

Rider, M.H. (1986). The Geological Interpretation of Well Logs. John Wiley and Sons, New York, 175p.

Todd, D.K. (1980) Groundwater Hydrology. John Wiley and Sons, New York.

Printed by M. Nagaraju and published by M. Ramakrishnan on behalf of Geological Society of India, 63, 12th Cross Basappa Layout, Gavipuram, Bangalore - 560 019 and Printed at Pragati Graphics, 33 & 34, 3rd Main Road, Khadi Layout, Vivekananda Nagara, Bangalore - 560 085 and published at Bangalore - *Editor:* M. Ramakrishnan.