International Symposium on
Hydrology of Mountainous Areas
Shimla (INDIA) May 28-30, 1992

Aquifer Characteristics in Karst Topography

M.V. Somasundaram*, S. Thayumanavan and Engkus Supardi*****

* Scientist F & Professor
** Visiting Faculty
***Former Graduate Student
Centre for Water Recourse, Anna University,
Madras (INDIA)

SYNOPSIS

The study describes briefly the variations in determining aquifer potential parameters in mountainous areas adjoining sea. The hydrogeology of the area is generally characterised by the maximum 100 m horizon pleistocene recent deposits over a maximum 300 m horizon of miocene-pliocene formation with the underlying base of the miocene formation unknown. The time series of water levels in the tube wells show generally decreasing trends. The estimates of storage coefficient and transmissivity by Jacob's straight line approximation method, Theis single well recovery method and Logan's approximation method with or without taking into account well losses show much variations for these limestone aquifers. The application of Ghyben-Herzberg relationship shows that the tube wells are not at risk of sea water intrusion and the static water levels in the wells are generally 6m above mean sea level.

1.0 INTRODUCTION

1.1 The Kwanyar-Modung aquifer area taken up for study is located in Southern Bangkalan regency, Madura island in Indonesia. The areal extent is around 138.68 sq.km. The area is centred on a latitude of 7° 05' to 7° 13'S and a longitude of 112° 50' to 113° 00' E. The area extends to 28.30 km from west to east and 8.90 km from north to south. The climate is characterised by a wet season generally from November to April followed by a dry season most pronounced between June and October. 78% of rainfall falls during the wet season. Mean daily temperature varies from 21.2° C to 34.7° C. The mean relative humidity varies from 70% to 90%. Irrigation of the entire area of the aquifer depends only on the ground water resource of this aquifer.

1.2 The study of the characteristics of the aquifer is essential to have a clear understanding of the aquifer and to predict the response of the aquifer for a given input and output condition and to plan for the optimum utilization of the ground water resources.

2.0 HYDROGEOLOGY

2.1 Madura is composed of deposits laid down in the Tertiary and Quarternary eras. The formations may be divided into Miocene Rembang formation, mio-pliocene kalibeng formation and Pleistocene-recent unconsolidated deposits. The principal aquifer is the Kalibeng formation limestone. A Large anticline is the principal feature of the structure of the Rembang and Kalibeng formation. The exposed surface of the limestone commonly forms a tower karst topography, as well as steep cliff faces where it has been eroded on the flanks of anticlines.

2.2 It is found that the pleistocene- recent unconsolidated deposits of the study area consists of clay, silt, fine-coarse sand, gravel and limestone fragment with thickness varying between 3.25 m to 18.00 m. The thickness of Kalibeng limestone formation is found to vary between 72.5 m to 100 m, fossilliferrous, cemented, massive, compact and soft to hard. From these different types of aquifer materials it is clearly seen that the aquifer is heterogeneous. The transmissivity of the aquifer changes with direction and the grading of the materials in the aquifer points out that it is anisotropic.

2.3 The position of water levels indicate that the water level postion fluctuates above and below the confining layer. It was observed that the aquifer alternates between unconfined to confined conditions.

3.0 PUMP TEST ANALYSIS

3.1 Based on short and long term discharge tests data, transmissivity and storage coefficient were analysed from measurements of the rate of drawdown and recovery of water level in the borehole after pumping test by (1) Jacob's straight line approximation method (2) Theis single well recovery method and (3) Logan's approximation method. The values of transmissivity and Storage coefficients obtained by the above methods with and without well losses is given in Table - 1 & 2.

3.2 From Table - 1 & 2, we can see that the aquifer parameters have wide variations. Analyses of aquifer parameters of transmissivity and storage coefficient by different methods with or without taking into account well loss reveal that transmissivity values range between 534 and 95,325 sq.m./day and storage coefficient between 2.93 $\times 10^{-32}$ and 4.28×10^{-1}. Hence aquifer parameters obtained by Jacob's and Logan's method are not acceptable for the limestone aquifers. Consideration of well losses do not reduce the variability of the aquifer parameters by Jacob's & Logan's method compared to the Theis single well recovery method for limestone aquifers. The tests indicate that the Kwanyar-Modung aquifer is affected with barrier and recharge boundary on contact with rising water level with confining layer. The analysis points to the fact that the aquifer is heterogeneous. As the transmissivity of the aquifer changes with direction and the grading of the materials in the aquifer, it is to be considered as anisotropic.

4.0 CONCLUSION

4.1 The study area has the favourable conditions for natural recharge as

(i) Kalibeng limestone formation outcrop is either under ground or exposed over a large area along the stream channels.

(ii) The presence if Caverns, fractured or faulted zones and cavities in Kalibeng limestone formation.

(iii) karst topography

(iv) Broad pleistocene- recent unconsolidated deposits.

Rainfall recharge and infiltration from irrigated crops are dominant factors. Spring discharges are characteristic features of Kwanyar-Modung aquifer.

4.2 Ground water table fluctuation o: .ne aquifer shows a seasonal pattern of fluctuation. Highest levels occur around February-March (rainy season) and lowest around July-August (dry season). But rainfall does not appear to be an accurate indicator of ground water level changes because the ground water level in December (rainy season) was still under decline.

4.3 Based on the study of sea water intrusion using Ghyben-Herzberg relationship between the elevation of the ground water level and depth to the interface between fresh water and underlying sea water, the aquifer has no risk of saline water as long as overdraft in production well fields do not occur. The EC values and quality classifications show that the aquifer has good to permissible water class for irrigation.

REFERENCE

1. Engkus Supardi, (1989), 'Hydrogeology, Recharge and Abstraction characteristis of Kwanyar-Modung Aquifer, Madura, East Java, Indonesia', M.E. Thesis, Centre for Water Resources, Anna University, Madras, pages 91.

Table 1 Comparison of Transmissivity (m^2/day)

Sl. No.	Well Number	Jacob		Theis	Logan	
		Gross	Effective		Gross	Effective
1.	TW.49	5,000	5,264	7,407	2,476	4,659
2.	TW.56	54,422	-	95,325	45,363	-
3.	TW.62	2,384	5,020	1,658	873	1,784
4.	TW.63	953	-	1.271	707	-
5.	TW.64	1,655	7,034	1,808	534	1,841
6.	TW.71	15,813	-	-	19,764	-
7.	TW.73	63,337	-	-	36,664	-
8.	TW.74	4,219	6,663	2,301	3,243	4,237

Table 2 Comparison of Storage coefficient

Sl.No.	Well Number	Jacob		Theis
		Gross	Effective	
1.	TW.49	6.87×10^{-16}	1.75×10^{-11}	2.15×10^{-17}
2.	TW.56	2.95×10^{-7}	-	1.85×10^{-10}
3.	TW.62	4.96×10^{-15}	2.93×10^{-14}	6.25×10^{-11}
4.	TW.63	6.35×10^{-8}	-	1.71×10^{-10}
5.	TW.64	1.62×10^{-15}	2.93×10^{-32}	3.68×10^{-21}
6.	TW.71	4.28×10^{-1}	-	-
7.	TW.73	6.33×10^{-14}	-	-
8.	TW.74	2.99×10^{-4}	6.94×10^{-6}	6.72×10^{-3}