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Groundwater fluctuations and calculation of effective porosity of laterite and effective fissure porosity of basalt of the Karanja Basin, Karnataka, India

H. CHANDRASHEKHAR, S. S. CHANDRASHEKHARMATH AND S. N. GANACHARI
Department of Mines and Geology, Bangalore

Abstract

The estimated evaporation and surface run-off have been used to calculate the effective porosity of laterite and effective fissure porosity of weathered basalt which ranges between 0.50 to 6.04 per cent and from 0.94 to 1.67 per cent respectively.

Introduction

The area under discussion forms a part of Bidar district, Karnataka, India and is composed of laterite, covering basaltic flows (Chandrashekhar, 1974). There are 51 observation wells in the Karanja Basin out of which annual record of water levels is available for 8 observation wells. The observation dug wells and the nearest raingauge station are shown in Fig. 1.

The dug wells are in laterite. Wells at Sl. Nos. 2, 3, 5, 6 and 7 have pierced the laterite cover and ended in jointed and weathered basalt.

Data For Analysis

Rainfall: Rainfall data for 1973 for the three raingauge stations are given along with Potential Evapotranspiration (PE), Actual Evapotranspiration (AE) and water surplus in Table I. Surplus has been computed as suggested by Duba (1972).

Surface Run-off: At present, data on surface run-off are not available. Hence from the computed surplus (S) estimated recharge (15% of rainfall) to groundwater is deducted to get the value of surface run-off (Duba, 1972).

The groundwater levels in the 8 observation dug wells has been measured with a tape once every month on a particular date.

Discussion

The rainfall measured at a particular raingauge station and the depths to groundwater table measured in the corresponding observation dug well(s) are graphically represented in Fig. 2.

A look at the hydrographs of the wells clearly indicates that the rainfall causes rise in the groundwater table in the succeeding month. The authors do not have sufficient data to indicate the exact time required for rain to recharge groundwater storage. For this, continuous recording of groundwater level and rainfall is necessary. For the present, it is assumed that the rise in groundwater table is related to the rainfall during the previous month.

Todd (1959, p. 23) defines effective porosity of a rock or soil as the ratio expressed as a percentage of the volume of water which after being saturated can be

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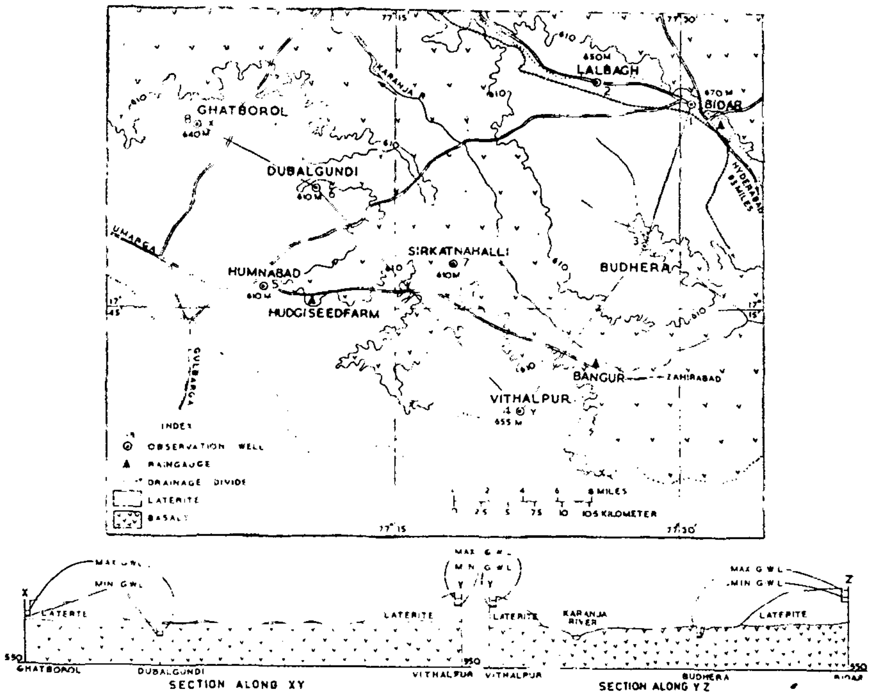

Figure 1.

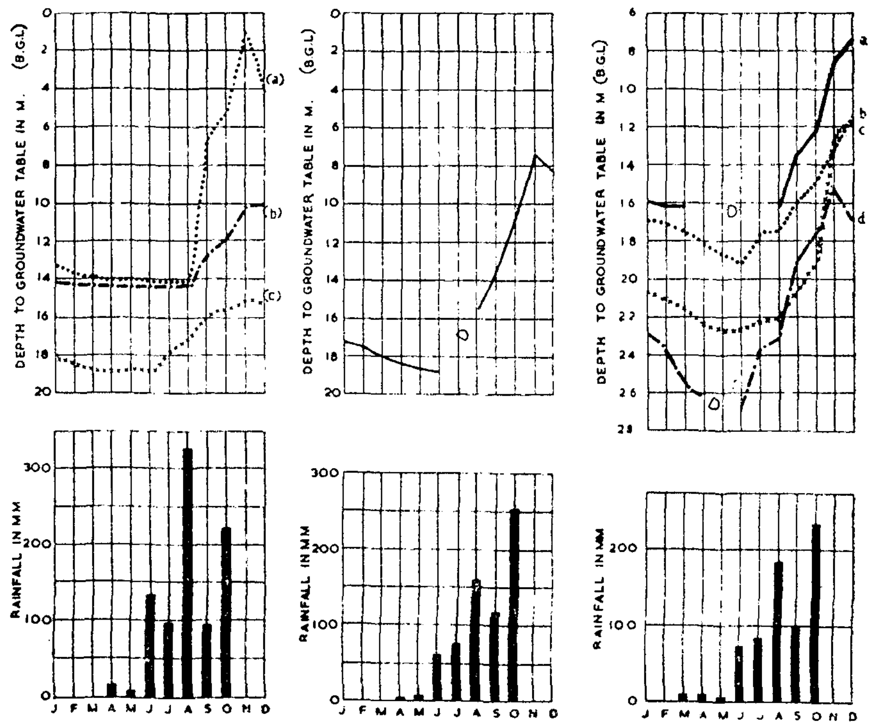

Figure 2.

TABLE I

CLIMATIC WATER BALANCE FOR 1973 IN THE KARANJA BASIN BASED ON THREE RAIN GAUGES—(in mm)

Observatory		Annual
	P.E.	1753.6
	Rainfall	902.3
BIDAR	A.E.	606.20
	Surplus	296.1
	Q	213.51
	P.E.	1753.6
	Rainfall	677.6
BANGUR	A.E.	517.8
	Surplus	159.8
	Q	96.12
	P.E.	1753.6
	Rainfall	689.1
HUDGI SHEED FARM	A.E.	532.1
	Surplus	157.0
	Q	95.27

P.E. :—Potential evapotranspiration (1931–1960 average

A.E. :—Actual evapotranspiration

N.B. :—Monthly P.E., A.E. & Rainfall have been considered to calculate monthly surplus and monthly surface run-off.

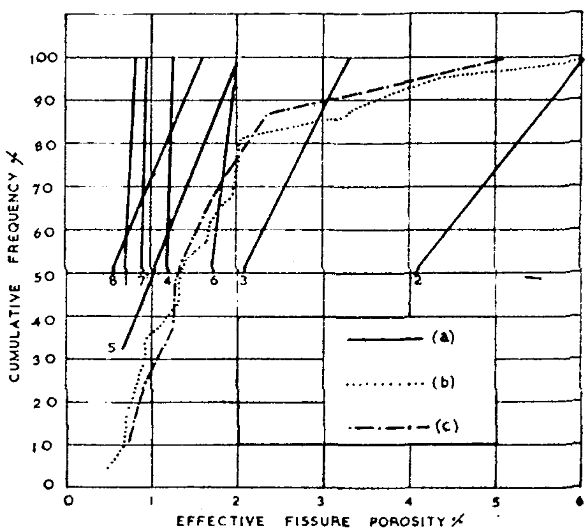

Figure 3.

drained by gravity to the gross volume of the rock or soil. Further the term is synonymous with specific yield and it is a fraction of the total porosity of an aquifer. Since the effective porosity in hard rocks is due to fissures and cracks, the term 'effective fissure porosity' is used (Fagerlind and Nordberg, 1973, p. 318).

Water budget equation is:

$$P = Q + E + \triangle S \qquad (1)$$

where P = Precipitation

Q = Surface run-off

E = Evapotranspiration

$\triangle S$ = Change in the groundwater storage

$$\triangle S = P - (Q + E) \qquad (2)$$

$\triangle S$ is assumed to be directly proportional to the change of groundwater level ($\triangle h$).

Then $$\triangle S \propto \triangle h \qquad (3)$$

$$\therefore \triangle S = N \cdot \triangle h \qquad (4)$$

Where N = Effective porosity or effective fissure porosity.

Inserting equation (4) into equation (2), we get the following equation:

$$N = \frac{P - (Q + E)}{\triangle h} \cdot 100 \qquad (5)$$

as the effective porosity is expressed as a percentage.

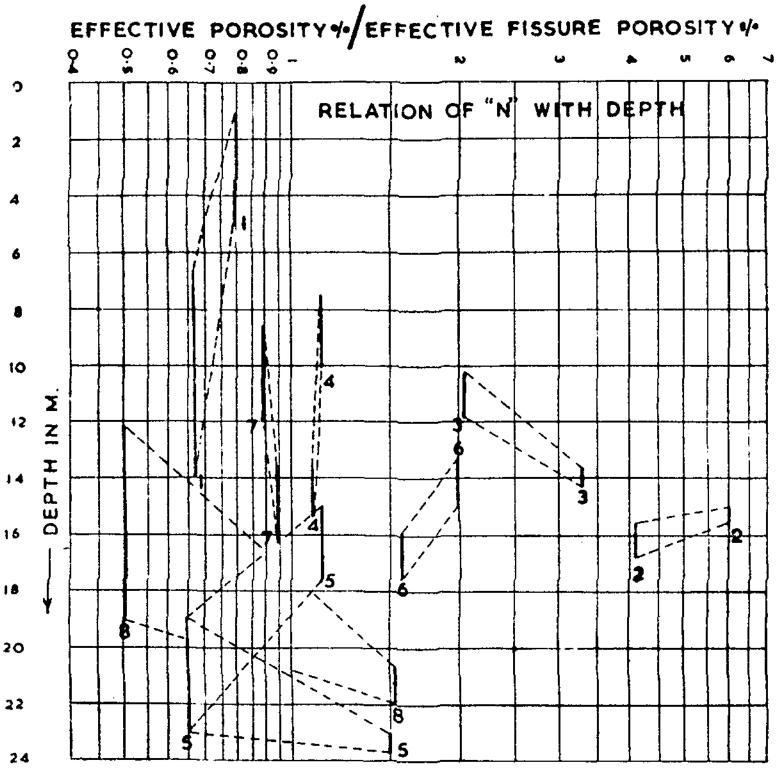

Figure 4.

Fagerlind and Nordberg (1973, p. 327) have assumed that there was no surface run-off, and the calculations become easier. Thus they have calculated $N_{max.}$ and $N_{min.}$ But, for the present study such method could not be applied as there is surface run-off, of which the details are not available at present. Hence indirect method was adopted to calculate E and Q as described above.

N has been calculated by inserting the appropriate values of P, Q and E of a particular month and $\triangle h$ of the succeeding month in the equation (5), since the rise of groundwater table ($\triangle h$) is related to the rainfall of the previous month (P). N ranges from 0.50% to 6.04% (Table-II).

TABLE II

EFFECTIVE POROSITY OF LATERITE AND EFFECTIVE FISSURE POROSITY OF BASALT NEAR 8 OBSERVATION DUG WELLS IN THE KARANJA BASIN

Sl. No.	Observation well	Rock formation	Total depth (m)	Porosity/Fissure porosity as percentage with the corresponding rise in groundwater levels 1	2	3	Average of 1, 2 & 3
1.	Bidar	Laterite	19.98	0.68 (14.00– 6.73)	0.79 (5.33– 1.11)*	— —	0.74
2.	Lalbagh	,,	20.20	4.07 (16.88–15.67)	6.04 (15.55–15.0)	— —	5.06
3.	Budhera	,,	14.33	3.28 (14.25–13.75)	2.05 (11.87–10.25)	— —	2.67
4.	Vithalpur	,,	18.90	1.19 (15.43–13.4)	1.25 (10.56– 7.55)	— —	1.22
5.	Humnabad	,,	27.00	1.98 (23.64–23.0)	0.65 (23.0 –18.9)	1.25 (17.75–15.0)	1.29
6.	Dubalgundi	Laterite & weathered basalt	19.10	1.67** (17.53–15.92)	1.99 (14.95–13.2)	— —	—
7.	Sirkatnahalli	,,	16.20	0.94** (16.2 –13.35)	0.89*** (12.15– 8.26)	— —	0.92
8.	Ghatborol	Laterite	22.70	1.58 (22.00–20.3)	0.50 (18.96–12.05)	— —	1.04

* Figures within bracket indicate depth of an aquifer zone in meters of which fissure porosity has been calculated.

** Effective fissure porosity of weathered basalt.

*** Combined value of effective fissure porosity of weathered basalt and effective porosity of laterite.

The values of N around the observation dug well at Sirkatnahalli need a bit of elucidation. The N value of 0.89% relates to the combined effect of both laterite and the underlying basalt. In this case the laterite prevails up to a depth of 10.6 m., whereas the said value belongs to a zone between 8.26–12.15 m. The other value of N for the observation well relates to deeper zone in weathered basalt.

It is curious to note that a minimum value of N for basalt is higher than that of laterite, which is just the opposite of what one would expect. This anomaly may be due to the disproportionate number of determinations of N in each formation. This has to be modified when more data over a longer period becomes available.

The cumulative frequency of all values of N and average values of N are presented in Fig. 3. The distribution of N values is fairly even, except those of well No. 2. The cumulative curve of individual N values and the cumulative curve of average N values behave almost similarly.

The values of N were plotted against the corresponding depth range on a semi-log graph paper (Fig. 4). It is seen from the graph that more values of N are restricted to the range of 0.5% to 1.2%, between the depth range of 1.11 m to 23 m.

Further it is evident from the graph that, value of N decreases, with increase in depth, excepting in 3 cases.

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