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THE GROUNDWATER BUDGET OF NİKSAR (TOKAT) VALLEY

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ABSTRACT

The groundwater budger of the "Niksar Valley" calculated according to the general budget equation, Schoeller (1967). All budget elements are calculated seperately for a period of one year, from October 1986 to September 1987. While the surface and ground water observations were carried out from July 1986 to April 1988. The exposed lithological units are ranged from Paleozoic to Quaternary and, shows different hydrogeological characteristics. The valley fill materials are from Poliocene to Quaternary. Aquifer parameters are calculated by permeameters, sieve analysis, pumping and injection tests etc. During the budget period aquifer recieved 2.66×10^9 m^3 and discharged 2.63×10^9 m^3 of water.

INTRODUCTION

The study area, "Niksar Valley" of Tokat district is located in the middle Black Sea region (Göksu, 1962). It covers from 20 to 80 % of 1/25.000 toposheet number of Tokat; G37–C_1, C_2, C_3, C_4, H37–b_2 and G38–d_4, (Fig.1). The geological and Hydrogeological mapping (scale; 1/25.000) of an area about 655 km^2 were studied in the vicinity of the Niksar Valley (Syed, 1989). The valley itself spread over an area of about 141 km^2. The climate of the region is between semi-arid and humid (Ardel et al., 1969). The average presipitation of last twenty years is 456 mm. The average lowest temperature is in the month of January (4.4 °C) and tge highest in July (23.5 °C). The actual evapotranspiration is about 83 % of the precipitation.

HYDROGEOLOGY

The exposed lithological units in the study area range from Paleozoic to Recent. These lithological units bear different hydrogeologi cal characteristics. Among them the units of similar hydrogeological

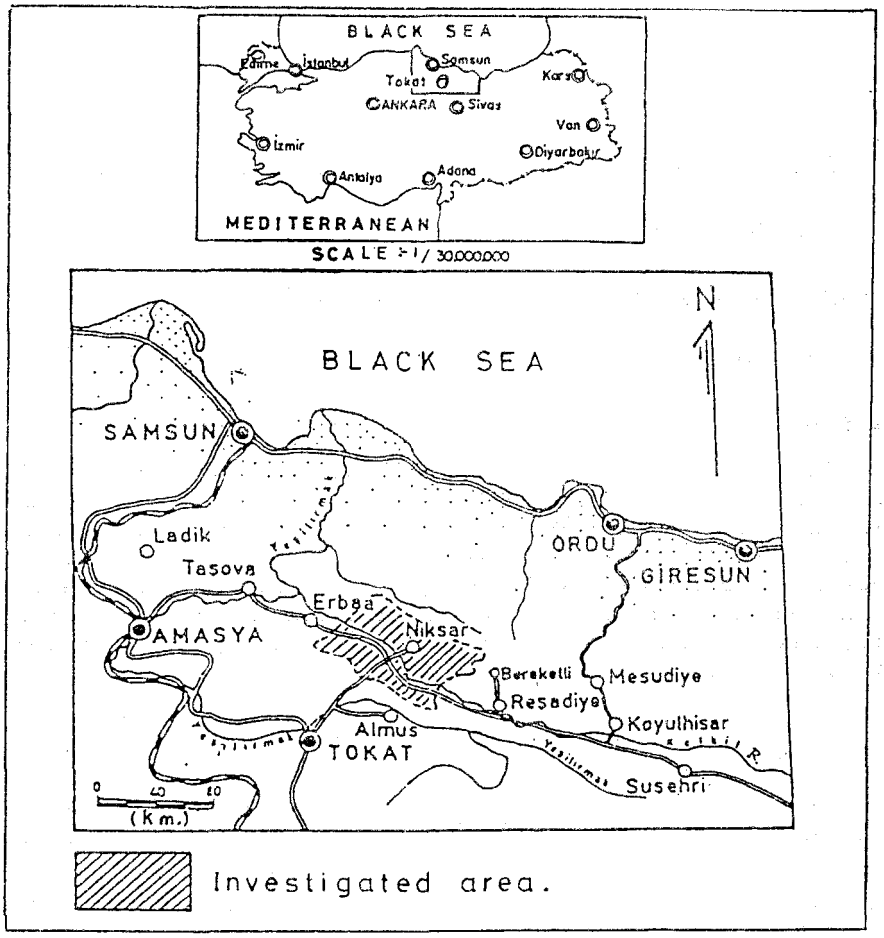

Fig: 1. Location map of the investigated area.

characteristics are qualitatively grouped as impermeable, semipermeable and permeable, (Fig. 2).

In the investigated area the basement is formed by the impermeable (Imp) Paleozoic rocks, composed of Quartz-Chlorite-Biotite schist, Epidot-Quartz-Albite schist and Sericite-Quartz-Biotite schist. At some places mudstone, marl and tuff beds of Upper Maestrichtian also from impermeable boundries.

The semipermeable (Sp) units are composed of conglomerate, sandstone, tuff and marl of Jurassic, conglomerate, sandstone, mudstone

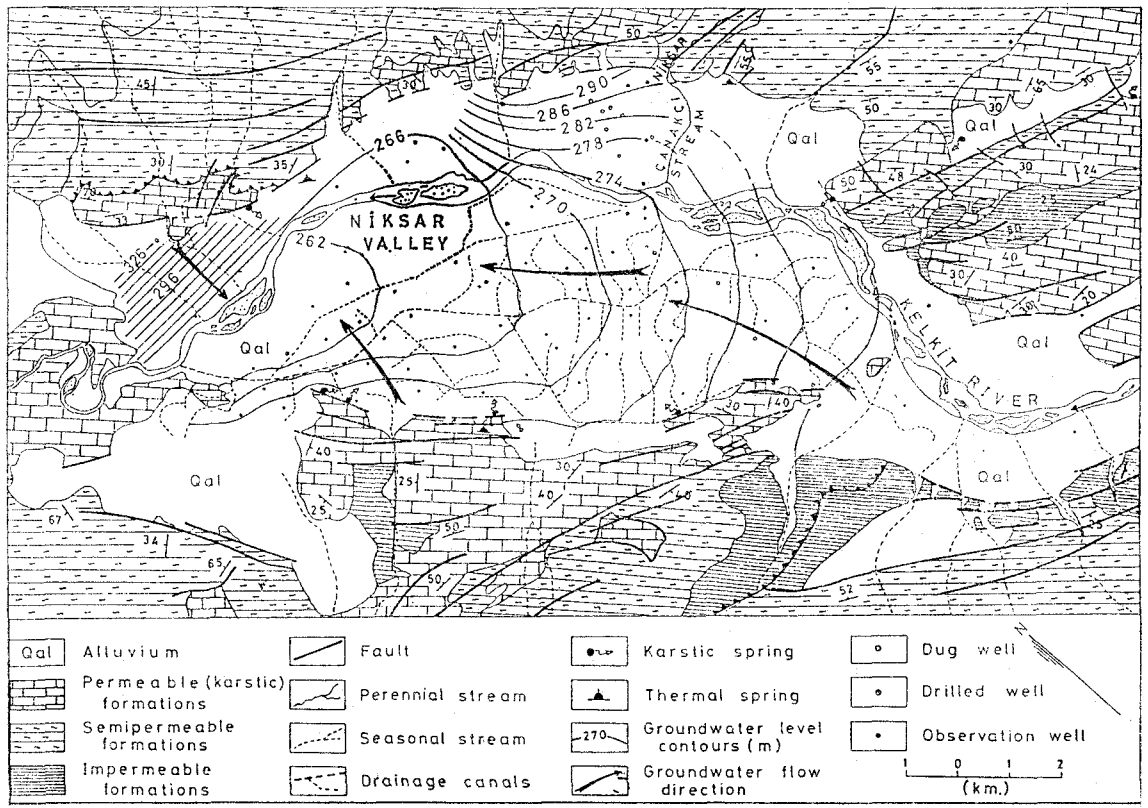

Fig: 2. Hydrogeological Map of the Niksar Valley.

and limestones of lower to Upper Lutetian. Some perennial and intermittent springs of low discharge are fed by these units.

Among permeable (Per) units the micritic, biomicritic, dismicritic and intrasparitic limestones of Upper Jurassic -Lower Cretaceous and

Among permeable (Per) units the micritic, biomicritic, dismicritic and intrasparitic limestone of Upper Jurassic

— Lower Cretaceous and the detritic limestones of Upper Maestrichtian

— Lower Paleocene form the typical karstic aquifers. Many low and high discharge karstic springs emerge from these units.

The study area is located on the active "North Anatolian Fault Zone" the Niksar valley depression is developed due to the young tectonic activities (Miocene). This depression is filled with detritic sediments. The lower levels of this valley fill material are composed of loose cemented conglomerate and sandstone with sandy gravel and clay lenses of Pliocene. The clay is of plastic nature and under suitable hydraulic conditions form confined aquifers (Bower, 1976). The upper levels are composed of Quaternary alluvium. The important aquifer has developed in the valley fill material (Qal), selected for the budget calculation. These materials show a random distribution both vertically and horizontally. The porosity values vary from 16 % to 35 % and the permeability values are from 1.1×10^{-3} to 2.7×10^{-6} m /s. The valley is flat, average inclination is from zero to 2 %. The general flow direction of the aquifer water is from Northeast to the Southwest. Precipitation and the surface waters (Kelkit River) are the major sources of fluctuation in the water table.

BUDGET ELEMENTS

To calculate the ground water budget from October 1986 to September 1987, the general budget equation of Schoeller (1967), Canik (1971) are used, which in its simplest from may be written as follows.

$$P + Q'r_1 + Q'r_2 + Q'n + Q'a = Etr + Qr + Qnr + \Delta s + Qa_1 + Qa_2$$

P = Precipitation.

$Q'r_1$ = Recharge from Kelkit rives.

$Q'r_2$ = Recharge from Çanakçı stream.

Q'n = Recharge from other aquifers.

$Q'a_1$ = Recharge from irrigation waters.

Etr = Evapotranspiration

Qr = Surface runoff.

Qnr = Discharge to Kelkit river.

Δs = Addition in the aquifer reserve.

Qa_1 = Discharge by drainage canals.

Qa_1 = Water withdrawal from aquifer by pumpage.

Precipitation (P).

In the selected period the average amount of precipitation for the investigated area, calculated by the Theissen polygon and isohyetal methods, is 575.6 mm. the total amount of precipitation being, $P = 0.81 \times 10^9$ m^3.

Recharge from Kelkit River to the aquifer ($Q'r_1$).

In the investigated area Kelkit river is flowing from Southeast to Northwest and passes through the center of the valley. During the budget period the total amount of river discharge measured at "Hamidiye Bridge", the point where the river enters the Niksar Valley was 3.41×10^9 m^3.

The average seepage coefficient of the river water is about 5 %. Which is selected on the basis of the aquifer transmissivity, prosity, permeability and other hydrogeological properties of the river bed and the aquifer (Calvo, 1986).

$$Q'r_1 = 1.71 \times 10^9 \text{ m}^3.$$

Recharge from Çanakçı Stream to the Aquifer. ($Q'r_2$).

From October 1986 to September 1987 the stream discharge 0.23×10^9 m^3 water in the valley. Just like Kelkit river the average seepage coefficient is about 5 %. So the recharged amount from stream water to the aquifer is, $Q'r_2 = 0.01 \times 10^9$ m^3

Recharge from Other Aquifers. (Q'n).

Geological and Hydrogeological studies of the valley show that the Quaternary sediments are hydraulically connected only with the permeable limestones of Upper Jurassic-Lower Cretaceous and of Upper

Maestrichtian-Lower Paleocene. These limestones from good karstic aquifers. The seepage from these karstic aquifers to the investigated aquifer is calculated with the Darcy's law, Q'n = TLi.

The average transmissivity (T) of Karstic aquifers is 3.5×10^{-4} m^2/s and the average hydraulic gradient (i) is 0.02. The total width (L) of all exposed limestone units is about 30.5×10^3 m. The calculated amount of recharged water from karstic aquifers to the underground aquifer is 0.07×10^9 m^3.

Recharge from Irrigation Water (Q'a);

In the Niksar Valley an area of about 90 km^2 is irrigated by Kelkit river by means of cemented irrigation canals. Crops are generally irrigated from April to September. From October 1986 to September 1987 the quantity of water used for irrigation is 0.4×10^9 m^3 (State Hydraulic Works, Niksar District Directorate). In the valley about 15 % of the irrigation water percolates to the aquifer, (State Hydraulic Works, Planning Revision Report 1986). According to this research the amount of water which passes down to the aquifer is,

$$Q'a = 0.06 \times 10^9 \text{ m}^3.$$

Evapotranspiration (Etr).

In the Niksar Valley an area of about 50 km^2. has been offected by water logging. In this area the depth of water table ranges from 0.10–2.0 m. Aquifer water evaporates directly from the area and evapotranspirates from rest of the valley by means of vegetation cover Thornthwaite (1948) system is used to calculate the actual evapotranspiration for the investigated period, i.e. 354.3 mm, (Table 1). This amount in terms of volume is, Etr = 0.5×10^9 m^3. The average actual evapotranspiration of last 20 years is 83 % of the precipitation.

Surface Runoff (Qr).

The average inclination of Niksar valley is about 0–2 %, and is used for agricultural purposes. In the greater part of the valley the surface runoff is very low. But laong the margin of the valley inclination is increased due to the alluvium cones and the surface runoff is relatively increased in these parts of the valley. The surface runoff calculated by means of Thornthwaite's method i.e. 154.6 mm, (Table 1). The calculated amount of precipitation for the same period is 575.6 mm. And the surface runoff is, Qr = 0.12×10^9 m^3.

Table 1. Comparison of the Precipitation and Evapotranspiration, from October 1986 - September 1987.

Months	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May.	Jun.	July.	Aug.	Sept.	TOTAL
Monthly average tem. (°C).	14.2	6.7	5.4	6.1	7.6	5.3	11.5	18.7	20.4	23.5	21.3	19.1	—
Temperature Index	4.8	1.5	1.1	1.3	1.8	1.1	3.5	7.4	8.4	10.4	9.0	7.6	—
Potential Evapo-transpiration (mm).	55.6	19.5	14.5	16.8	23.3	14.1	41.45	81.6	92.1	112.0	97.7	84.1	652.8
Latitude Correction (40°–35°)	0.9	0.8	0.8	0.8	0.8	1.0	1.1	1.2	1.2	1.3	1.2	1.0	—
Corrected evapotranspiration (mm)	50.0	15.6	11.6	13.4	18.6	14.1	46.1	101.1	110.5	145.7	117.3	84.1	728.1
Precipitation (mm).	26.5	66.7	78.4	77.9	32.5	73.5	87.0	27.8	41.6	15.6	23.4	—	550.9
Actual Evapotranspiration (mm)	26.5	15.6	11.6	13.4	18.6	14.1	46.1	101.1	68.3	15.6	23.4	—	354.3
Reserve water (mm).	0	51.1	100.00	100.0	100.0	100.0	100.0	26.7	0	0	0	0	—
Excess Water (mm).	0	0	17.9	64.4	13.9	59.4	40.9	0	0	0	0	0	196.5
Deficient Water (mm)	23.5	0	0	0	0	0	0	0	42.2	130.1	93.9	84.1	373.8
Surface runoff (mm).	0	0	8.9	36.6	25.2	42.3	41.6	0	0	0	0	0	154.6

Discharge from Aquifer to the Kelkit River (Qnr).

In the middle of the Niksar valley the aquifer starts to dischrage its water to the Kelkit river towards the end of the valley. The discharge takes place from both sides of the aquifer i.e. North and South. The discharged amount from both sides calculated seperately with Darcy's law, by using average values as follows.

Qnr = T.L.i

Qnr = Total Discharge (m^3).

T = Coefficient of transmissivity (m^2/s).

L = Width of the aquifer (m).

i = Hydraulic Gradient.

Discharge from Northwards.

T = $9.0x10^{-3}$, L = $10.5x10^3$, i = $5.0x10^{-3}$

Qnr_1 = $0.15x10^9$ m^3.

Discharge from South wards.

T = $9.0x10^{-3}$, L = $13.5x10^3$, i = $1.1x10^{-3}$

Qnr_2 = $0.04x10^9$ m^3

Qnr = Qnr_1+Qnr_1

= $0.19x10^9$ m^3

Addition into Aquifer Reserve (Δs).

In september 1987 the water table was high as compored to October 1986. The difference ranges between 0–2 m. On the basis of this difference the water table map of equal change area is prepared, (Fig. 3). The values of Δs are calculated with the following equation.

$\Delta s = S. \Delta h. m.$

Δs = Addition of water in the aquifer recerve (m^3).

S = Equal change area (m^2).

h = Amount of change (m).

m = Porosity (%).

During the budget period the amount of water added in the aquifer reserve is,

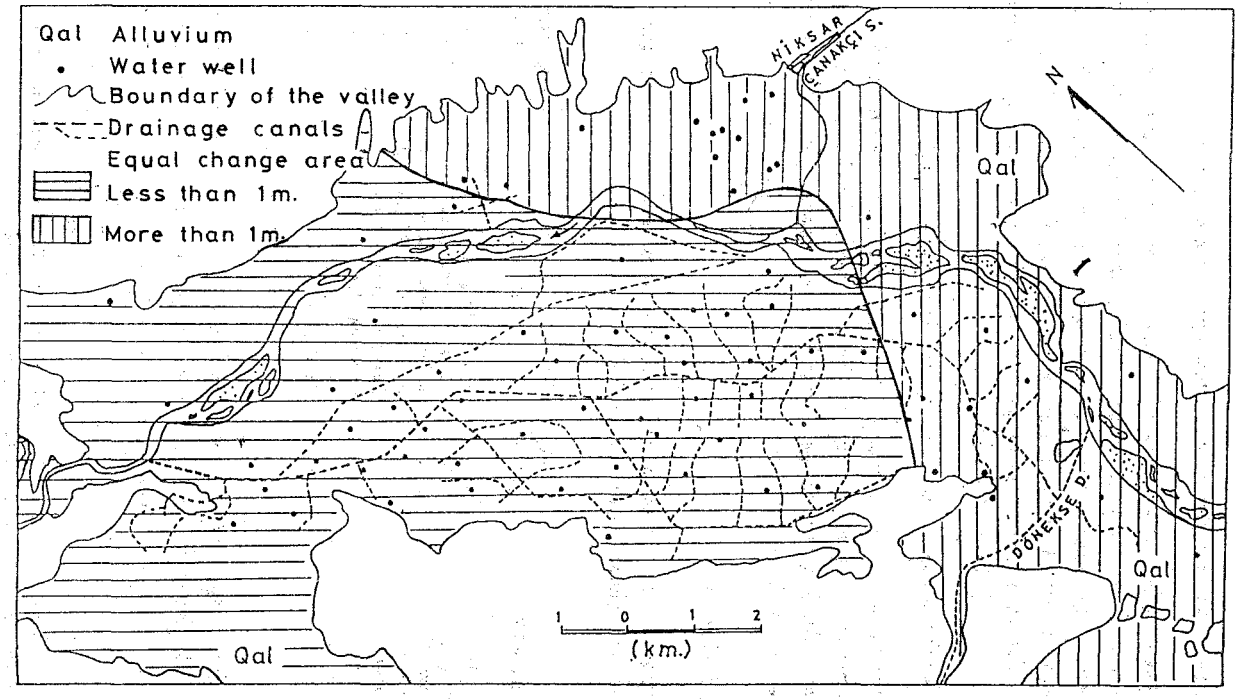

Fig: 3. Groundwater Fluctuation Map of the Study Area.
(Between October 1986 - September - 1987).

$\Delta s = 0.55 \times 10^9$ m.^{3}

Discharge from Aquifer with Drainage Canals (Qa_1).

The Niksar Valley in an area of about 50 km^2, the water table ranging from 0–2 m. To lower the water table, about 2 meter deep major and minor drainage canals have been dug out in the area. The water from drainage canals flow to Kelkit river. From October 1986 to September 1987 the measured discharge amount of water through drainage canals is, $Q'a_1 = 1.25 \times 10^9$ m^3.

Water Withdrawal from Aquifer by Pumpage, (Qa_2).

In the investigated area many pumping wells, dug wells, and hand pumps are present. Water is pumped from these wells for domestic and industrial uses. During the budget period the estimated pumped amount is about, $Qa_2 = 0.02 \times 10^9$ m^3.

CONCLUSIONS

According to the investigated budget elements, the underground water budget of Niksar Valley is as follows.

RECHARGE	VOLUME x10^9 m^3	DISCHARGE	VOLUME x10^9 m^3
Precipitation (P)	0.81	Evapotranspiration (Etr)	0.50
Kelkit River ($Q'r_1$)	1.71	Surface Runoff (Qr)	0.12
Çanakçı Stream ($Q'r_2$)	0.01	Kelkit River (Qnr)	0.19
Other Aquifers (Q'n)	0.07	Addition in the Reserve (Δ S)	0.55
Irrigation Water (Q'r)	0.06	Drainage Canals (Qa_1)	1.25
		Pumping (Qa_2)	0.02
Total Recharge	2.66	Total Discharge	2.63

During the budget period the difference of 0.03×10^9 m^3 between recharge and discharge is due to the average values of some elements, measuring errors, non measured elements etc.

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