Evaluation of the Loss from the Discharge by the Percolation Process along a Selected Section of Hilla River within Hashimiya Region

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Abstract

The study area is located in the southern Babylon governorate - central Iraq within longitudinal (44°36'- 44°47') east and latitudes (32°18'-32°27') north, within the administrative border of Hashimiya district. The study area lies on Mesopotamian plain which is characterized as a flat surface. Flow pattern map is drown by using field measurements of water levels in scattered wells over entire the region and local streams. The interflow quantity is calculated by using Darcy law after dividing the region into 7 sectors. The sectors of 1 to 6 lay north Hilla River within the selected section and the 7 lies south it. Interflow quantity of north is (0.065) m^3/sec and of south is (0.0372) m^3/sec. The quantity of the losing by interflow from Hilla River Channel to both sides within Hashimiya Region (along 17270m) is approximately 0.1071m^3/sec in average. The losing by evaporation is 0.086m^3/sec along same distance. Total sum of both losing represents 2.4% of used surface water in the region which must be added into Hilla's share.

Keyword :- Groundwater flow, Internal flow, Evaporation-free opening, Filtration, Current quotas, Water balance.

الخلاصة

منطقة الدراسة تقع جنوب شرق محافظة بابل (وسط العراق) بين خطي طول ('44°36–'44°47) شرقاً ودائرتي عرض ('32°18–'32°27) شمالاً ضمن الحدود الإدارية لقضاء الهاشمية. تقع منطقة الدراسة في منطقة ما بين النهرين التي تتميز بإستواء السطح فيها.رسمت خارطة لنمط الجريان بإستخدام القياسات الحقلية لمناسيب المياه في الأبار المتناثرة في عموم المنطقة وكذلك مناسيبها في الجداول المحلية. تم حساب كمية الجريان الداخلي بإستخدام قانون دارسي بعد تقسيم المنطقة الى سبعة قطاعات. القطاعات من 1–6 تقع شمال نهر الحلة ضمن المنطقة المختارة والقطاع 7 يقع جنوبة. كمية الجريان الداخلي(0.065 م^3/ثا) و(0.0372م^3/ثا) للمنطقة الشمالية والجنوبية على التوالي.الكميات المفقودة بالتغلغل من جانبي النهر في منطقة الهاشمية على طول 17270م كمعدل تقريباً (0.1071م^3/ثا). والكمية المفقودة بالتبخر (0.086م^3/ثا) في نفس المسافة. المجموع الكلي للكميات المفقودة تمثل 2.4% من المياة السطحية المستخدمة في المنطقة والتي يجب أن تضاف الى حصة الحلة.

الكلمات المفتاحية :- حركة المياة الجوفية ، جريان الداخلي ، تبخر– فتح الحر ، ترشيح ، الحصص الحالية ، موازنة مائية.

Introduction:

Water balance issue, one of the main topics in hydrology, are means of solution of important theoretical and practical hydrological difficulties. On the basis of the water balance method it is possible to make a quantitative evaluation of water resources and their change under the influence of natural actions. Knowledge of the water balance supports the prediction of the consequences of natural changes in the regime of streams, lakes, and ground-water basins. Basins for short time intervals (season, month, week and day) is used for operational management of reservoirs. With water balance data it is possible to compare individual sources of water in a system, over different periods of time, and to establish the degree of their effect on variations in the water regime (Sokolov and Champman, 1974).Infiltration phenomena is a water percolated into a high porous soil, it reduces the peak of surface runoff and sometime contaminant concentration when passing through soil. Infiltration capacity estimation depends mainly upon field measurements and mathematical integration for the area under infiltration rate-time curve (Linsley, 1972).

Many of analytical, experimental and empirical formulas have been delivered to represent downward movements of infiltration but they are constrained with assumptions and limitations (Horton ,1940) .A widespread studies were made by

many researchers among them;(Jinquan *et.al.*, 1996) field lysimeter experiments were used to show the relationships between rain and recharging by percolation movement at diverse groundwater depths. They applied 1.5, 3, 4.5, and 5 m lysimeters depths at stable groundwater levels to develop a mathematical model. Accordingly GW algorithm was classified into shallow, middle and deep groundwater. (Arnold *et.al.*, 2000) used two methods to determine the groundwater recharge and discharge (base flow) upper of Mississippi River catchment area. A water balance technique is used in the first mode whereas the second mode composed of 2 steps for base flow and recharge estimating of daily stream flow: firstly a parting of base flow from daily flow and secondly a adjustment of hydrograph curve technique to estimate groundwater recharge. The two methods are actually good to supply a reasonable estimation of base flow and recharge to be latterly used in regional groundwater models. (Rousta *et.al.*,2012) the effects of gypsum less than (5%) on infiltration rate was tested, with different ratios: without gypsum (0)%,15cm of top soil mixed with 0.5kg/m of gypsum and15cm of top soil mixed with 1kg/m of gypsum before adding infiltration water. The results showed that a gypsum addition of 0.5 kg/m to infiltrated water considerably increased.

Significance of Study

Hilla River waters are mainly divided between two governorates of Hilla and Diwaniya without taking into consideration the lost quantity by percolation along river section, if we know that the river across distance more than 95 km within Hilla governorate and the percolated water computes from their share.

Aims of Study

The study is aimed to:

1. Assessment of the lost quantity of water by an interflow from Hilla River channel within a selected section in Hashimiya region.
2. Estimate the quantity which must be added to Hilla's share of water from the same river.

Location

The study area is located in the southern Babylon governorate - central Iraq between longitudinal ($44^{\circ}36'$- $44^{\circ}47'$) east and latitudes ($32^{\circ}18'$-$32^{\circ}27'$) north, within the administrative border of Hashimiya district. Two main roads and Railway across the study area which link the study area with Hilla city. The study area included two Holy places they are Emmam Al-Qassim and Emmam Al-Hamza, in addition to archaeological site for the Abbasiya State (Al-Saffah traces). The Study area covers about 100km2 (Figure 1).

Topography

The study area lies on Mesopotamian plain which is characterized as a flat surface. It declines gently from the northern-east direction toward the southern-west. At study area contour line of (27 m.a.s.l.) passes on the west parts while the contour line of (24.2 m. a.s.l.) passes at the east border, (Fig.(1) then the decline factor being (28cm/km) causing water velocity is about 0.3m/sec.

Groundwater Movement

The groundwater flow in the study area is characterized by being complex, because the heterogeneity of the aquifer, the movement of groundwater in the study area is complex in general as the whole area of Mesopotamian zone (Jassim &Goff, 2006). Water levels were measured in scattered wells over entire the area and the local streams, which were used to draw flow pattern in the region, (Fig.2).

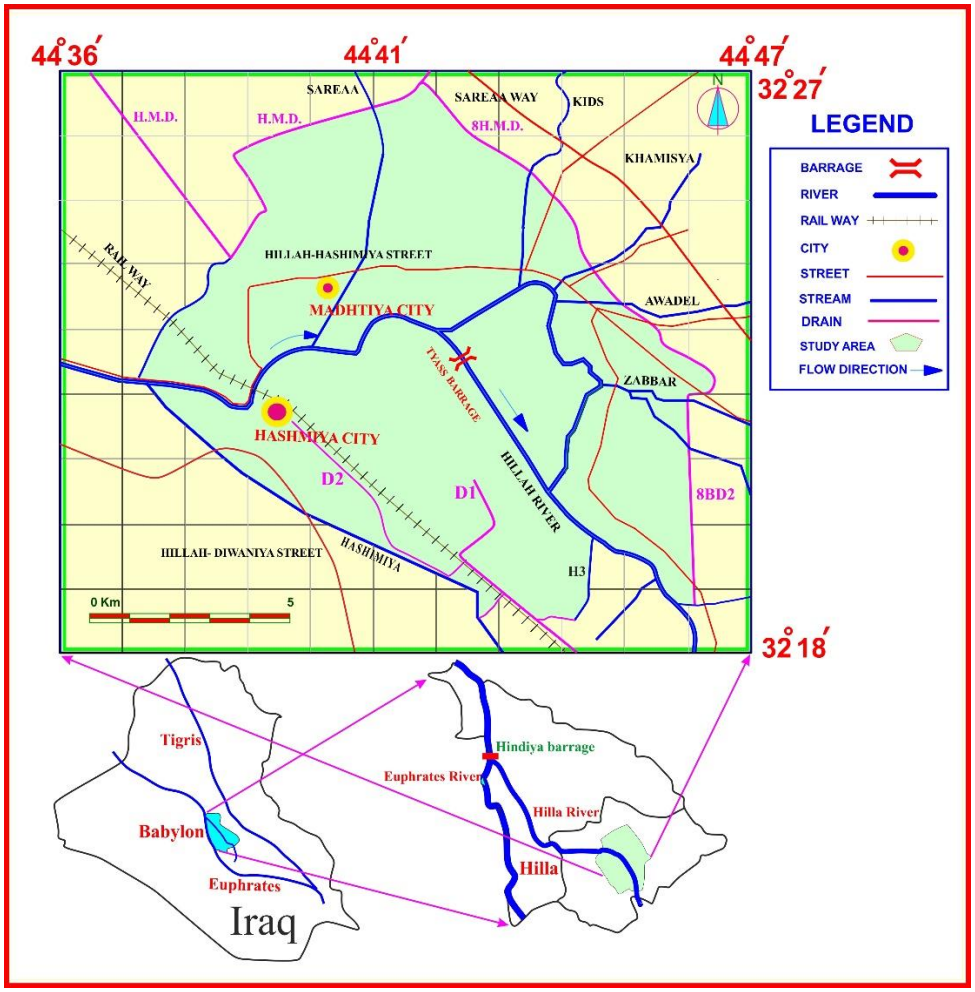

Fig.(1) Location & Topography Map of the Study Area

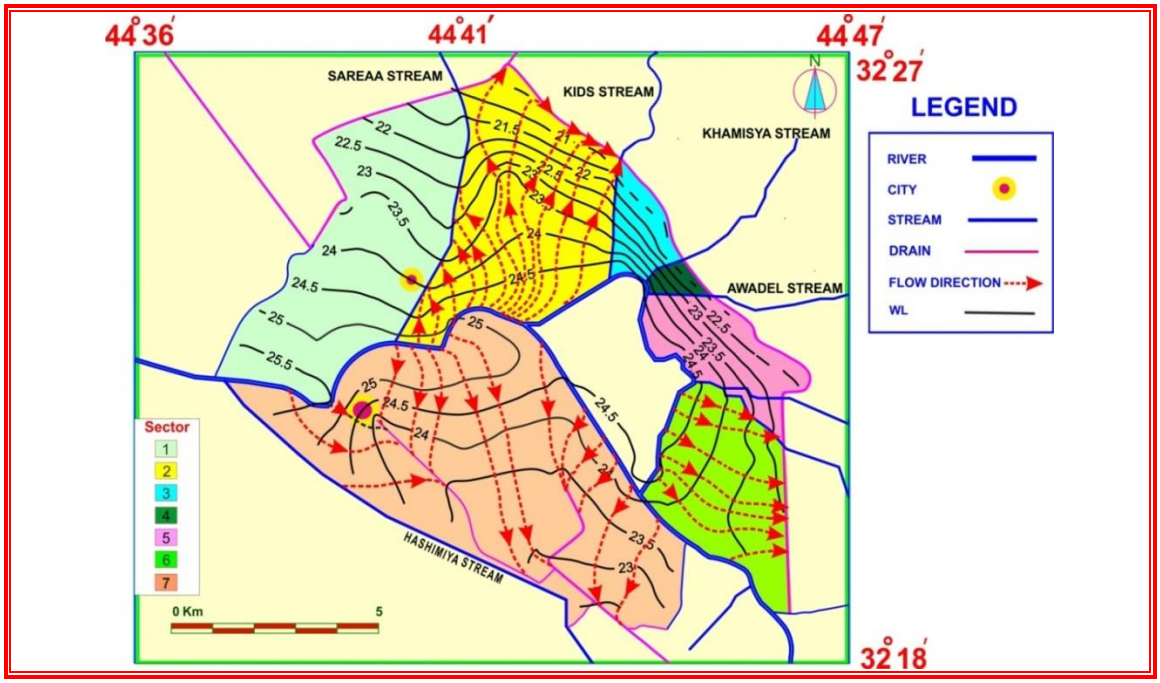

Fig.(2) Groundwater Movement of Study Area.

Inter Flow Calculation

The value of the inter flow was calculated by the procedure which is divided the study area to seven sections dependence on the existence of hydraulic borders of each section in order to be the calculations of inter flow are more accurate. The summation of the values of inter flow for each sections obtain the total recharge, according to the Darcy equation, (Todd, 1980):-

$$Q = KIA \quad \text{..... (1)}$$

$$Q = K * \frac{dh}{L} * (a * b) \quad \text{..... (2)}$$

$$Q = T * \frac{dh}{L} * a \quad \text{..... (3)}$$

Where that *Q*: discharge, *K*: conductivity, *dh:* difference in head between adjacent lines contour, *L:* average of the distance between adjacent lines contour between adjacent lines contour, *a:* average of the length of contour segments, Fig.(3).

Q_{out} =*Q1 + Q2 + Q3+ Q4 + Q5+ Q6 + Q7*..... (4)

= 8905 m^3/day

Equation (4) represents the whole quantity of interflow which percolates from Hilla River within Hashimiya region.

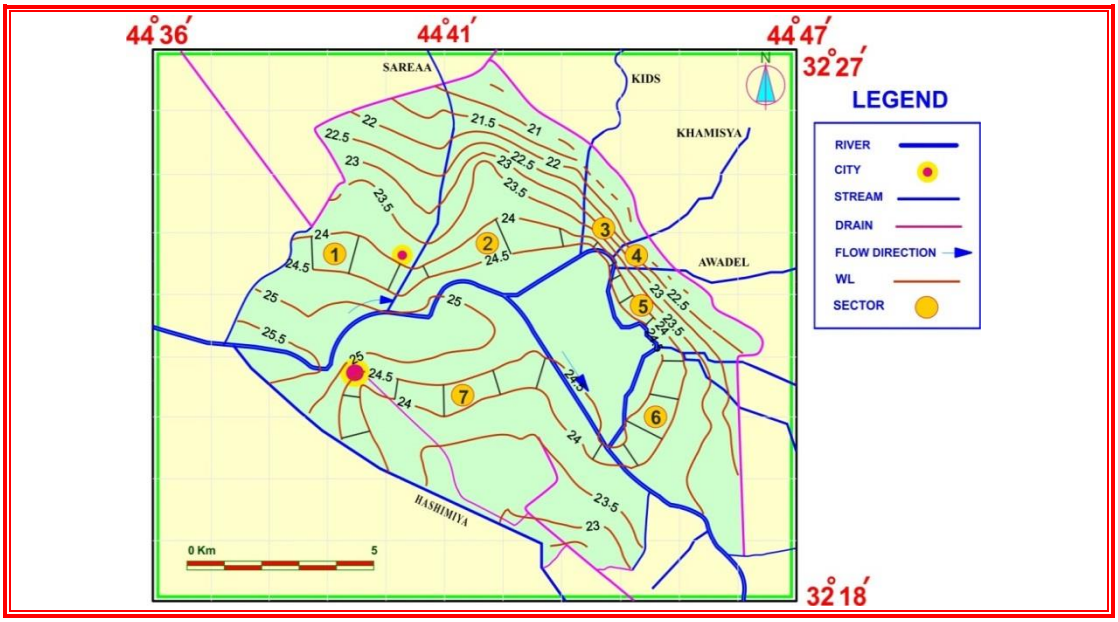

Fig.(3) Inter Flow Algorithm and Flow Pattern of Study Area

Table (1) Inter Flow Calculation of Study Area

No. of Sector	T,(m^2/day)	dh,(m)	L,(m)	a,(m)	Q,(m^3/day)
1	389	0.5	864	3257	733
2	369	0.5	576	5151	1650
3	347	0.5	227	1061	811
4	345	0.5	227	379	288
5	342	0.5	349	2803	1373
6	341	0.5	758	3712	835
7	394	0.5	636	10378	3215

System Adjustment Requirements

The values of Table (1) are tested before their dependence in system analysis. Many of parameters are used as hereinafter:

Evapotranspiration Algorithm

Evapotranspiration value is computed to March only by using Thornthwait pattern, because the field measurements of system are achieved during it. It is worth mention,the cultivated area is about 20% from total area according to the directorate of Hashimiya agriculture statistics (2016).

Table(2) Evapotranspiration Algorithm of Hashimiya Region

Month	Temp. c°	j=(tn/5) ^1.514	$P_{EX=16(\frac{10tn}{J})^a}$	T	D	$P_{EX*DT/360}$	PE_c mm
March	17.3	6.55	32.78	7.7	31	32.78*31*7.7/360	21.73

PE_c: Corrected Evapotranspiration

Free Surface Evaporation

The average of evaporation in the study area is (135.9) mm (General Meteorological Organization and Seismology, 2014). The length of specified river section is about 17270m and the average width is about 100m then the total evaporation is (1857.6) m^3 during six hours.

Infiltration Experiment & Field Measurements

The test was conducted according to ASTM (D 3385 – 9403). Double ring Infiltrometer is used to determine the infiltration. Recorded data was Time-Depth (mm/hr.), Table (3), (4) and (5). Double ring Infiltrometer is better than single ring Infiltrometer. When using double ring Infiltrometer the water will penetrate in one direction,that is towards the ground water without much wastage of water (Amreeta, 2014**)**.

Calculation of Infiltration Rate & Accumulated Infiltration Rate

Infiltration Rate determines by using Horton equation of the form:

$f_p(t) = f_c + (f_o - f_c)e^{-kt}$ ..... (5)

The formula is used to determine the infiltration rate after it has been fitted to a specified data but the difficulty in using it is the determination of the factor k which is mainly depends upon the fitted data further simplifications offer:-

By the integration of both sides of eq. (5) to obtain a formula that can be used to calculate the accumulated infiltration. The result of integration;

$k = \frac{1}{t}\ln(\frac{f_o - f_c}{f_p(t) - f_c})$ ..... (6)

as follow: $AF_p(t) = f_c t + \frac{(f_o - f_c)}{k}(1 - e^{-kt})$ . ..... (7)

Generally, infiltration rate and accumulated infiltration rate curves have inverse relationship and then become two horizontal lines when the infiltration processes has been stopped, (Figs.(4),(5) and(6).

Main Local Infiltration Source

Locally, the main source of infiltration is irrigation water over entire a year through the cultivation activities. The farmers depend on the old way of irrigation by flooding the lands. This process depletes a huge quantity of water leading to increase the salinity of soil especially during summer in addition to increase the percolated water into groundwater. Irrigation is achieved by a division the lands into geometrical shapes which are called (Loah), its dimensions are of several meters of the length and width but do not increase than 30m in both directions and the applied depth of irrigation water in loah continues for 2 hrs, then the considered time of infiltration rate is 2hrs. Two experiments of infiltrometer are achieved in the northern area and one in the southern area corresponding to areas.

Table(3) Infiltration Algorithm data of Sector 2

Accu. Depth, mm	Time, hr.	Inf. Rate, mm/hr.	Accu.Inf., mm
2	0.083333	24.0001	1.878974
3	0.166667	17.99996	3.539073
4	0.25	16	5.011259
6	0.5	12	8.548253
9	1	9	13.16766
10	1.25	8	14.80951
11	1.5	7.333333	16.21547
12	1.75	6.857143	17.47222
13	2	6.5	18.63461
14	2.5	5.6	20.80227
14	3	4.666667	22.86934
14	3.5	4	24.89617

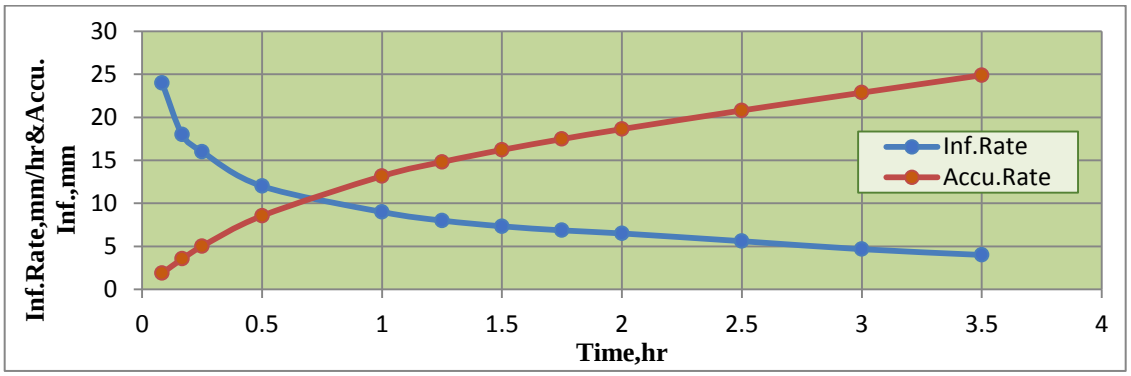

Fig.(4) Infiltration rate in comparison with accumulated rate of sector 2

Table(4) Infiltration Algorithm data of Sector 6

Accu. Depth, mm	Time, hr.	Inf. Rate, mm/hr.	Accu Inf., mm
2	0.083333	24.0001	1.847379
3	0.166667	17.99996	3.425054
4	0.25	16	4.779337
5	0.5	10	7.853961
6	1	6	11.51672
7	1.25	5.6	12.76075
8	1.5	5.333333	13.82734
9	1.75	5.142857	14.79317
10	2	5	15.70175
	2.5	4	17.43542
10	3	3.333333	19.1237

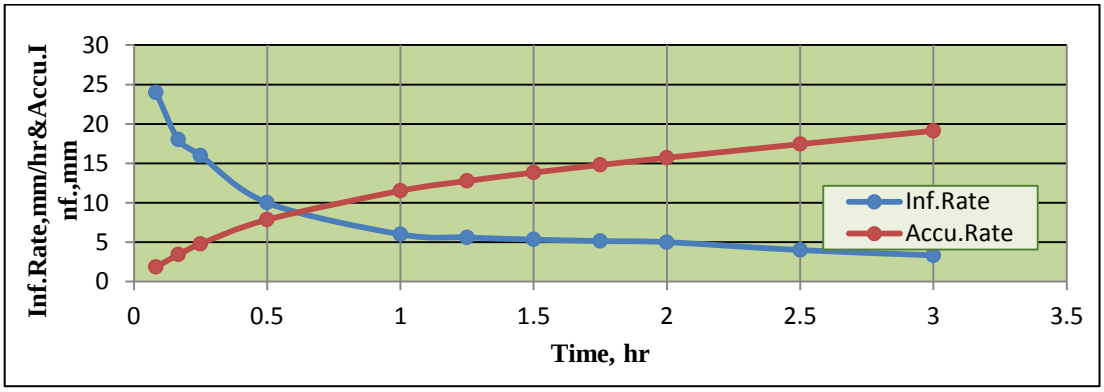

Fig.(5) Infiltration rate in comparison with accumulated rate of sector 6

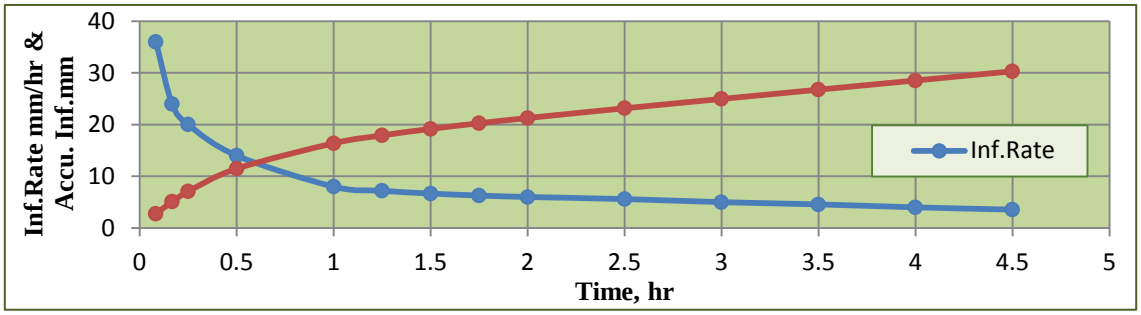

Fig.(6) Infiltration rate in comparison with accumulated rate of sector 7

Table (5) Infiltration Algorithm data of Sector 7

Accu. Depth, mm	Time, hr.	Inf. Rate, mm/hr.	Accu. Inf., mm
3	0.083333	36	2.760059
4	0.166667	24	5.096156
5	0.25	20	7.081246
7	0.5	14	11.48429
8	1	8	16.38801
9	1.25	7.2	17.91908
10	1.5	6.666667	19.17236
11	1.75	6.285714	20.26798
12	2	6	21.27413
14	2.5	5.6	23.15607
15	3	5	24.9672
16	3.5	4.571429	26.75554
16	4	4	28.53652
16	4.5	3.555556	30.31515

Current Releases of Hashimiya Region

The Releases of local streams of Hashimiya region are listed in Table (6) according to the directorate of Hashimiya water resources operation plan (2016).

Table (6) Current Releases of Local Streams in Hashimiya Region.

Streams	Sareaa	Kids	Zabbar	Hillah River	Hashimiya
Current Releases (m^3/sec)	0.35	0.523	1.25	150	0.97

Water Balance Equation Applications

The current study is adopted two proposed formulas to adjust the system (empirical forms) which uses to explain the hydrologic system, first as below:

$$Q_{interflow} + Q_{Percolated\ irrigation\ water} = Q_{Evapotranspiration} + Q_{Drain} \quad \text{..... (8)}$$

This study ignores the quantity of rain because it isn't required to recharging the aquifer over the entire year. Depending of Darcy law, the amount of interflow is (3215) and (5690) m^3/day of the area which lies south and north of Hilla River within Hashimiya region respectively, Table (1), Fig. (2).The potential infiltration capacity quantity of 20% of lands that could be cultivated is (21409.98) and (29957.19) m^3/day. The evapotranspiration and drain discharge are computed of March to be

(4946), (7913) m^3/day and (0.253), (0.348) m^3/sec, respectively too. The balance is being in m^3/sec:

0.0372+0.248=0.057+0.228

And:

0.065+0.35=0.091+0.324

For the south and north of the specified area, respectively. The slight differences between the field and theoretical values of drain discharge may be belonged to the excesses of popular farmers by direct releases of surface water into drain cannals.

The second form as below:

$$QB=QA-(Q_{\text{local streams discharge}} + Q_{\text{pumps withdrawal}} + Q_{\text{Free evaporation}} + Q_{\text{interflow}}) \quad \ldots\ldots\ldots (9)$$

Where: QB, QA: the discharge of Hilla River at the ultimate southern end and at the beginning of region respectively.

94.853=102.86-(6.393+1.64+ 0.086+ Qinterflow)

Qinterflow= 0.112m^3/sec. Generally, the average of interflow according to both forms is 0.1071m^3/sec.

Conclusion

1. The quantity of the losing by interflow from Hilla River Channel to both sides within Hashimiya Region (along 17270m) is approximately 0.1071m^3/sec.
2. The losing by evaporation is 0.086m^3/sec along same distance.
3. Total sum of both losing represents 2.4% of used surface water in the region which must be added to Hilla's share.

Recommendation

1. Studying an infiltration along the whole Hilla River to calculate entire percolation water Quantity.
2. Re-exploitation of a percolated water in agricultural activities to face the scarcity of water resources

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