RELATIONSHIP BETWEEN EVAPORATION FROM WATER SURFACE AND WATER CONSUMPTION OF CROPS IN THE FLOODPLAIN LANDS

I. Golovanova *, V. V. pitshlkina *and Mahmoud M. Ali**

ABSTRACT

The estimation of evapotranspiration (ET) and subsequently plant water requirements needs to consider the heterogeneity of plants, soils, water, and climate characteristics. Methods of estimating water consumption use empirical equations, which express the correlation between the total water consumptions and climatic factors. Where, the amount of evaporation from water surface is a function of temperature, humidity, wind and other ambient conditions. The results concluded that, the correlation coefficients for the perennial grasses, cabbage, corn, and potatoes were 0,926 ± 0,119; 0,927 ± 0,118; 0,907 ± 0,133; 0,928 ± 0,118 respectively, indicating high correlation between these attributes.

INTRODUCTION

Clean water for human consumption and for agricultural production is rapidly becoming a limiting resource affecting daily life in many parts of the world. Various avenues have been considered to deal with water scarcity, including increasing water use efficiency in agriculture, development of new sources of water (desalination; rainfall harvesting) and treatment and reuse of marginal (saline and waste) water. A crucial first step in most scenarios addressing water scarcity is the reduction of water losses especially those due to evaporation from water bodies, which, by some estimates, amount to more than 20% of water, used in irrigated agriculture [Rost et al., 2008; Gökbulak and Özhan, 2006].

Water is commonly stored in small reservoirs and behind dams, and by some estimates up to half of water stored may be lost to evaporation [Craig, 2005; Rost et al., 2008] exacerbating the scarcity problem.

*** Land reclamation Dept., Moscow state University for Environmental Engineering., Russia**

****Soil and Water Dept. (Agric. Eng.), Fac. of Agric., Fayoum Univ., Egypt**

The amount of stored water lost to evaporation depends on many factors including atmospheric evaporative demand, size of reservoir and storage method. Numerous attempts have been made to reduce evaporation losses by altering storage design from increasing reservoir depth, to installing windbreaks or covering reservoir surface [Brown, 1988; Craig, 2005].

MATERIAL AND METHODS

This work-study in Dubna, Moscow Oblast, Russia, Latitude: 56°43′59″N and Longitude: 37°10′00″ E. To achieve a relationship between water consumption of different crops and evaporation, three coefficients need to caculate: 1) $K_{пр}$ – which takes into account the deviation of the water consumption from evaporation (E); 2) K_{δ} – crop coefficient; 3) K_B – which takes into account the soil moisture content. Consequently, the equation of calculating evapotranspiration (ET) as follows:

$$E_{pp} = K_{рп}\, K_{\delta}\, K_B\, E_O \text{ ……. (1)}$$

Moreover, the values of evaporation and $K_{пр}$ for each growing crop were determined.

For obtaining of the $K_{пр}$., the studies have been conducted using a to determine evaporation from water surfaces evaporation and potential water use of crops lysimeter (lysimeter type (GGI-3000), cross 2 m^2, depth 2m). Soil moisture in lysimeter maintained at the optimal range 70-80 % of field capacity.

The principal difference is in the operation of the apparatus, with the contained soil kept at field capacity (the water content of the soil after the saturated soil has drained under gravity to equilibrium) by sprinkling a known quantity of water on the tank when rainfall is deficient.

Field capacity assured by maintaining continuous percolation from the bottom of the tank. Thus, the vegetation cover allowed transpire freely, and the total evaporation loss is depending on the ability of the air to absorb the water vapors.

Existing computational methods use empirical relationships that express the correlation between the consumptive use and climate according to meteorological observations, some of them determines the evaporation E_O, i.e. the maximum possible evaporation from the water surface.

For the transition from evaporation to the total water consumption of a particular culture, transition rates such as: $K_{пр}$, $K_{б}$, K_{B}, should be considered, which reflecting the deviation of the potential water consumption from evaporation, biological features of crops, and the deviation of soil moisture from the optimal values:

RESULTS AND DISCUSSION

The relationship of evaporation and the deficit of air humidity mathematically can described as the following equation.

$$E_O = a_1 d_s^{n_1} \quad \ldots\ldots\ldots.. (2)$$

The relationship of evaporation with the deficit of humidity shown in Fig.1.

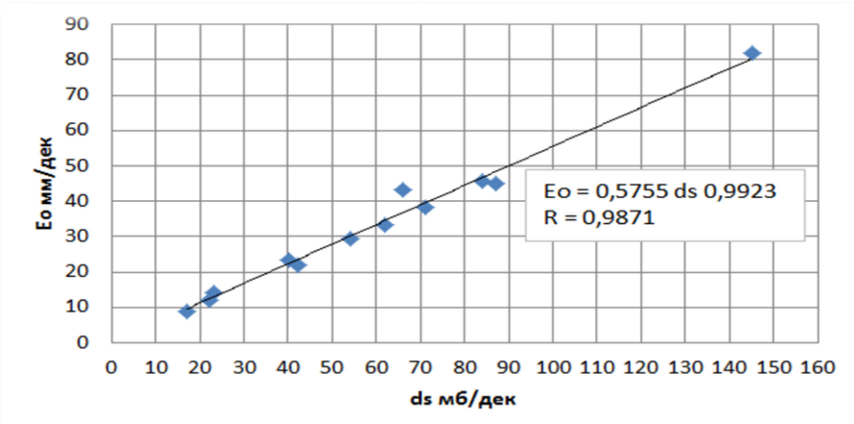

Fig., 1. The relationship between evaporation and the sum of average deficits of air humidity

According figure 1. It can concluded that, there were highly correlation relationship between E_0 and *d*s value, where the correlation coefficient of this relation equal to 0,987+0,051, and the determination coefficient is 0,974. This means that 97, 4 % of the estimated evaporation caused by the fluctuations of air humidity deficit.

Moreover, water consumption by lysimeters when the soil moisture content kept at the optimum range, the regression equation between the potential water use ET_o of perennial grasses, cabbage, corn, potatoes, and the sum of the average deficits of air humidity over decadal periods. Thus, the formula of calculation water consumption of agricultural crops on floodplain lands given as the following:

$$E_p = a_2 ds^{n2} \quad , \qquad (3)$$

Where: Ep - a potential water consumption crops,
ds - the sum of daily average deficits humidity
a2, n2 - empirical coefficients that take into account the climatic zone, crop and soil properties.

Table (1) Empirical coefficients

no	Crops	a_2	n_2
1	Perennial grasses	1,38	0,79
2	Cabbage	1,38	0,80
3	Corn	1,38	0,84
4	Potatoes	1,38	0,68

According to formula (2) and (3) evaporation (Eo) and potential water use crops (Ep) were calculated. The calculation results given in Table 2.

Table (2) the results of calculation of evaporation (Eo) and potential water use crops (Ep) ET_O

Month	A decade	E_0, мм/дек	d_S, мб/дек	E_P, мм/дек			
				Perennial grasses	Cabbage	Corn	Potatoes
Jun	1	40	71	40,03	41,77	49,54	25,05
	2	34,7	62	35,96	37,48	44,21	22,84
	3	47,5	87	47	49,15	58,76	28,76
July	4	35,8	66	37,78	39,40	46,59	23,83
	5	44,2	84	45,72	47,79	57,05	28,08
	6	80,2	145	70,37	73,96	90,25	40,70
Aug	7	29,3	54	32,25	33,56	39,36	20,79
	8	23,2	40	25,44	26,40	30,59	16,95
	9	24	42	26,44	27,45	31,87	17,53
Sep	10	14,2	23	16,43	16,95	19,22	11,64
	11	10,5	17	12,94	13,31	14,91	8,48
	12	13,6	22	15,86	16,36	18,51	11,29

In order to use the formula of evaporation from the water surface to calculate water consumption, the required transition rate Кпр can determined by the formula:

$$K_{РП} = E\text{p}/E\text{o}, \qquad (4)$$

Where: E_P potential water consumption of agricultural crops; E_O – evaporation

Table (3) the transition rates Кпр of evaporation from the water surface to potentially possible consumption

M	A decade	E_0, мм/дек	d_S, мб/дек	$K_{РП}$, мм/дек			
				Perennial grasses	Cabbage	Corn	Potatoes
Jun	1	40	71	1,00	1,04	1,24	0,63
	2	34,7	62	1,04	1,08	1,27	0,66
	3	47,5	87	0,99	1,03	1,24	0,61
July	4	35,8	66	1,06	1,10	1,30	0,67
	5	44,2	84	1,03	1,08	1,29	0,64
	6	80,2	145	0,88	0,92	1,13	0,51
Aug	7	29,3	54	1,10	1,15	1,34	0,71
	8	23,2	40	1,10	1,14	1,33	0,73
	9	24	42	1,10	1,14	1,32	0,73
Sep	10	14,2	23	1,16	1,19	1,33	0,82
	11	10,5	17	1,23	1,27	1,42	0,81
	12	13,6	22	1,17	1,20	1,36	0,83

Using the value of evaporation (E_O) and the Кпр (table.3) reached statistical series for each crop and got a regression equation. The results of the calculations given in Fig.2

However, the estimated values of E_0 and Кпр for each crop presented at the following fig (2).

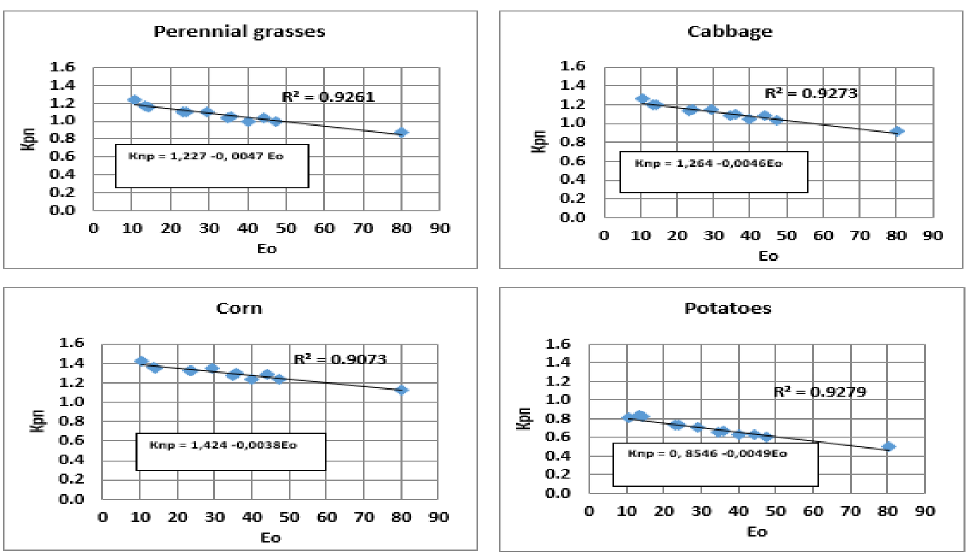

Fig. 2. The relationship of evaporation from the water surface (E_O) and the transition factor (Кпр) for the crops.

Thus, Fig.2 shows that the correlation coefficient for perennial grasses, cabbage, maize and potatoes, were respectively 0,926±0,119; 0,927±0,118; 0,907±0,133; 0,928±0,118, this means that, there were highly correlation between these considered characteristics.

Then, according to the presented results in table (4) and illustrated in fig (3), the transition coefficients of Кпр can highly recommended for the practical use.

Using the regression equation in Fig.3 the ratio of Кпр calculated, and the calculation results summarized in table.4. Thus the transition coefficients of the Кпр for practical use.

Biological factors K_δ given in table (5).

Table (4) Evaporation from the water surface and the coefficients of the Кпр

Eo, мм/дек	coefficient Крп			
	Perennial grasses	Cabbage	Corn	Potatoes
10	1,180	1,218	1,386	0,806
15	1,156	1,195	1,367	0,781
20	1,133	1,172	1,348	0,757
25	1,109	1,149	1,329	0,732
30	1,086	1,126	1,310	0,708
35	1,062	1,103	1,291	0,683
40	1,039	1,080	1,272	0,659
45	1,015	1,057	1,253	0,634
50	0,992	1,034	1,234	0,610
55	0,968	1,011	1,215	0,585
60	0,945	0,988	1,196	0,561
60	0,945	0,988	1,196	0,561

On the other hand, as mentioned above, to estimate the crop requirements for different agriculture crops, K_δ coefficient should be expressed. Formula Pchelkin (2003) highly describe this relation between water consumptive by crops and the Biological coefficient K_δ given in table (5).

$$E_{\text{рф}} = K_{б} a_2 d s^{n2} \quad , \qquad (5)$$

Table (5) Biological factors crops on drained

Month	A decade	Perennial grasses	Cabbage	Corn	Potatoes
May	1	0,5-1,4	0,5-1,6	0,8-1,6	0,7-1,6
	2	0,56	-	-	-
	3	0,78	-	-	-
Jun	1	0,97	0,73	0,77	0,78
	2	1,00	0,81	0,84	0,,83
	3	0,85	0,88	0,89	0,90
July	1	0,88	0,93	0,93	0,95
	2	1,00	0,97	0,95	0,98
	3	1,00	0,99	0,97	0,99
Aug	1	1,00	1,00	1,00	1,00
	2	1,00	1,00	0,94	0,99
	3	1,00	0,99	0,92	0,97
Sep	1	1,00	0,96	0,87	0,94
	2	0,98	0,92	-	0,89
	3	0,80	0,87	-	-

However, from formulas (1) and (5) the relationship between the actual water consumption $E_{р\phi}$ which calculated by the formula (5) and E_{pp}, calculated by formula (1) was illustrated in fig. (3).

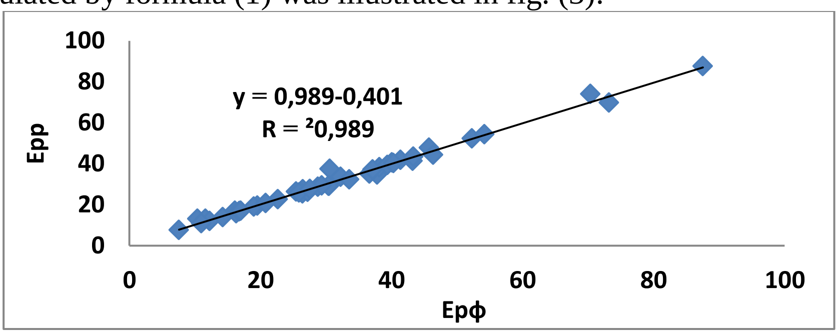

Fig.3. relationship of the actual consumption $E_{Р\Phi}$ calculated by the formula (5) with the calculated E_{PP} calculated by the formula (1)

Fig.3 shows that the correlation coefficient was 0,989±0,027, which suggests a close connection between the considered characteristics. Therefore, the formula (1) highly recommended for practical use.

CONCLUSIONS

In recent study, the relationship between evaporation from the water surface and the water requirements of crops presented and described in formula (1).

The transition rate of the Kпр from evaporation (E_O) to potentially possible water use E_P expressed.

The relationship between the actual water consumption $E_{рф}$ which calculated by the formula (5) and E_{pp}, calculated by formula (1), the correlation coefficient of this relation was 0,989±0,027, consequently this relation can be highly recommended for practical use.

REFERENCE

Brown, J. A. H. (1988), The potential of reducing open water evaporation losses: A review, paper presented at Hydrology and Water Resources Symposium, Aust. Natl. Univ., Canberra, 1–3 Feb.

Craig, I. P. (2005), Loss of storage water due to evaporation—a literature review, Univ. of South. Queensland, Toowoomba, Australia.

Gökbulak, F., and S. Özhan (2006), Water loss through evaporation from water surfaces of lakes and reservoirs in Turkey, E-Water, 24 July 2006/7. (Available at http://www.ewaonline.de/journal/online.htm)

Pchelkin V. V. 2003. Substantiation of ameliorative regime of drained wetlands M. 253 p.

Rost, S., D. Gerten, A. Bondeau, W. Luncht, J. Rohwer, and S. Schaphoff (2008), Agricultural green and blue water consumption and its influence on the global water system, Water Resource. Re s., 44, W 09 40 5, doi: 10.1029/2007WR006331.

الملخص العربي

العلاقة بين معدل التبخر من سطح الماء والاحتياجات المائية للمحاصيل في أراضي السهول الفيضية

أ. د/الكسندر ايفانوفتش جلفانوف* ، أ. د/ فيتالي بيتشولكن* و د/محمود محمد على**

يعتبر البخر نتح القياسي من أهم العوامل لحساب الاحتياجات المائية للمحاصيل المختلفة ويوجد طر ق مباشرة لحساب الاحتياجات المائية مثل الليزمترات وطرق اخرى غير مباشرة تعتمد علي المعادلات التي تستخدم لحساب البخر نتح باستخدام بيانات الأرصاد الجوية ، إلا أن دقة هذه المعادلات تختلف حسب عدة عوامل منها البيانات المناخية. وتعتمد طرق تقدير الاحتياجات المائية على العلاقة بين مجموع استهلاك المياه والعوامل المناخية .حيث أن كمية التبخر من سطح المياه مرتبطة بكلا من درجة الحرارة والرطوبة والرياح والظروف المحيطة الأخرى . لذلك، لتحقيق وجود علاقة بين استهلاك المياه للمحاصيل المختلفة والتبخر وتم تحديد قيم التبخر لأربع انواع من المحاصيل وهي عشب النجيل، والملفوف، والذرة والبطاطس .وتم عمل تجربه حقلية باستخدام الليزميتير وخلصت النتائج الى صحة المعادلة السابقة وكان معدل الارتباط يتروح بين ٠.٩٠٧ و٠.٩٢٧

***قسم استصلاح الاراضي– كلية الهندسة البيئية – جامعة موسكو الحكوميه للهندسة البيئية – روسيا.**
****قسم الأراضى والمياه (هندسة زراعية) – كلية الزراعة– جامعة الفيوم.**