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Estimating Evaporation from Bare Saline Soils

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Abstract—Iran is an arid country, its average rainfall is one third of world's rainfall while it evaporates 3 times more than the world average. Evaporation takes place from vegetation cover, from bare soil, or from water bodies. In the absence of a vegetation cover, soil surface is exposed to atmosphere which increases the rate of evaporation. Evaporation of soil moisture will not only lead to water losses even it will also increase the risk of soil salinity. The risk is increased under low annual rainfall, saline irrigation water, and deep water table. Soil and water salinity is common in arid and semiarid regions where using saline water is common under insufficient fresh water resources. This research was conducted at Ferdowsi University of Mashhad, Iran. PVC pipes with a diameter of 110 mm, and an effective height of 1 m filled with loamy sand soil was used in this study as lysimeter for calculating evaporation rate. The results showed that salinity decreased evaporation and there was a chance for better prediction of evaporation at stages I and II.

***Keywords*—**Evaporation process, Sandy clay, Soil salinity, Soil moisture.

I. Introduction

IN Iran, agriculture sector consumes about 94 percent of the total available water.

Evaporation is one of the main components of water balance in each region, and it is also one of the key factors for proper irrigation scheduling towards improving efficiency in the region[8].

On the other hand evaporation has a significant role in global climate through the hydrological cycle and its proper estimation is important for predicting runoff, predicting crop yield, and prediction of soil salinity, water loss, design of irrigation canals, water structure and also on natural disasters such as drought Phenomenon.

On the average, 70 percent of the rain that reaches the land surface evaporates and transpires to the atmosphere. This amount may be as high as 90% under severe arid condition.

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So due to the importance of bare soil evaporation, its accurate measure is highly important.
Direct evaluation of evaporation is difficult, however, so it is need to find an indirect method.

In the absence of a vegetation cover, soil surface is exposed to sunlight and wind and maximum evaporation takes place.
If this process is not controlled, there would be a substantial water loss from irrigated lands and from dry land areas.Under regular condition of one-year crop cultivation, some parts of soil surface is exposed to atmosphere, especially when the crops are germinating and are in their early growth. In these periods, abundant soil moisture is evaporated that may hinders plant growth for establishment. Rapid drying of soil, makes severe problems for the emergence of seeds and prevents growth of young newly plants.Similar situation would be for young orchards for which most of the soil is often bare especially in the first few. The other example may be due to dry land areas on which the land is not covered for part of the year.

For continuous evaporation to maintain, three situations need to be fulfilled. At first, it needs that latent heat is satisfied, for example through a continuous source of heat.
Second, the vapor pressure in the atmosphere above the object must be less than the vapor pressure at the evaporation surface, so the vapor can be transferred by diffusion or convection or both. These two processes, i.e. sufficient energy and transferring mechanism, are external factors and are governed by atmospheric parameters, such as temperature, wind velocity, and humidity. These factors determine the maximum evaporation rate from the soil body. The third issue controlling the evaporation, is the availability of water in the soil body, or an external source of water, such as shallow water table.

There are three distinct phases for evaporation process.
Step Rate – initial , This stage is when the soil is wet enough to transfer water to evaporate at a rate proportional to the evaporative demand.

During this stage, the evaporation rate by external weather conditions (solar radiation, wind, temperature, humidity, etc.) are limited and therefore can be controlled , In other words, the role of soil characteristics will occur., In this case the air phase - control (at this stage the stage profile – control).

Next step is to reduce the rate of evaporation rates during this stage of succession is less than the potential rate

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(evaporation, atmospheric variability).At this point, evaporation rate, the rate at which the soil caused by the drying up , Can deliver the level of moisture evaporation in the area is limited and controlled. So it can be a half step occurs - called control.This may be longer than the first stage.

Finally, the remaining steps slower rate , The stage is finally set for several days at a rate of almost constant , Week , Or even months lasts.Apparently when the soil surface is dry to the extent that , It is effectively cut off from water , This phase starts.This stage is often called vapor diffusion process where the surface layer so as to be able to dry quickly can be important.

While the transition from the first stage to the second stage is generally faster , Second stage to the third stage becomes very slow, and thus these two steps can not be easily separated from the.

Excessive accumulation of salts in the soil will cause agricultural productivity to decline occurred. Soil salinity is a term that is used to specify the position of the amount of salt dissolved in the soil for plants is so dangerous.In dry areas , Lack of adequate rainfall and irrigation of the soil and thus prevent vertical leakage of salts in the soil often are pooled.
The combined effects of insufficient rain , High evaporation rates and high saline ground water leading to the formation of salt[1].

Apart from the nature of soil salinity , Misplaced irrigation causes salinization in some areas of dry land is fertile say that salt-inducible.This salinization, is a serious threat[2].

Given the importance of evaporation in arid and semi-arid and the soil salinity problems and also very difficult to measure evaporation from the soil and its characteristics, The purpose of this study , The calculation of evaporation from bare soil without the use of soil hydraulic properties in saline soils has been[4],[5] and[6].

II. MATERIALS AND METHODS

Data collection study in the greenhouse during the months of April and May 2013 Water Engineering Research Laboratory, Faculty of Agriculture, Ferdowsi University.

This area has a longitude of 59 degrees 38 minutes latitude 36 degrees 16 minutes and at a height of 988 meters above sea level and is located.

In this study, the calculated evaporation (stage I and II) of saline soil without soil , This study was conducted to test the texture of sandy clay and four salinity levels (0.7, 2, 4 and 8 dS /m(The study used a PVC pipe with a diameter of 110 mm and a height of about 1 m (for the 90 cm soil profile).The larger diameter of the , The big problem being too small in diameter to the problem of imbalance followed.Bottom of the pipe , The bottom section of PVC pipe with a diameter of 110 mm Closed.The holes will make it easier for the withdrawal of water from the pipe end , Also inside the tube to a height of 5 mm pebbles as a wrapper to facilitate the passage and prevent the accumulation of water in the soil columns were poured in the lower region.

The soils of different soil composition obtained after passing the 5 mm sieve for 24 h in contact with air, air – dried. Evaporation measurements and weight measurements were performed using a water balance.

Were used at the onset of saturation of the soil column and Moisture content decreases with time and were dried.Also the water out of the soil columns were carefully measured.Weight was measured in soil columns was done with a digital scale with an accuracy of 5 g.

The calculation of evaporation , Obtained by subtracting the weight of the soil column twice in a row, low weight and water out of the soil column , Weight gain in the first days of evaporation, as several times a day and the following days with intervals of more , Was performed.

To approximate the capacity of evaporation moisture profiles are based on similarity. That have:

$$\bar{e}_p = \frac{(\pi/2) S_e^2}{\bar{e}_p t_d} \qquad (1)$$

$\bar{e}_p$:Evaporation intensity of the first stage in the mean time

t_d : The time between the last irrigation or rainfall and drying stage second

S_e :Desorptivity

With different equations, Evaporation can be estimated independently:

$$F_{diff} \cong \begin{cases} \bar{e}_p t & t < t_d \\ \frac{4}{\pi} \bar{e}_p t_d \left[\frac{t}{t_d} - \left(1 - \frac{\pi^2}{16} \right) \right]^{\frac{1}{2}} & t \geq t_d \end{cases} \qquad (2)$$

The above two equations , The equations that are used for the second stage of drying does not require direct measurements of soil moisture characteristics.

The derivation of this equation, we estimate the evaporation rate during the second stage of drying

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$$f_{diff} \cong \frac{}{\pi} e_p \left[\frac{t}{t_d} - \left(\frac{\pi}{} \right) \right] \quad (3)$$

There are a variety of statistical indicators to assess the validity and accuracy of predicted values.

These values are used to assess the reliability of the analysis and residual error between measured and predicted values

$$AE = \frac{1}{n} \sum_{i=1}^{n} |P_i - O_i| \quad (AE) \quad (4)$$

$$RMSE = \left[\frac{\sum_{i=} (P_i - O_i)}{n} \right] \quad (RMSE) \quad (5) \qquad (CD)$$

$$CD = \frac{\sum_{i=1}^{n} (O_i - \bar{O})^2}{\sum_{i=1}^{n} (P_i - \bar{O})^2} \quad (6)$$

$$EF = \frac{\sum_{i=1}^{n} (O_i - \bar{O})^2 - \sum_{i=1}^{n} (P_i - \bar{O})^2}{\sum_{i=1}^{n} (O_i - \bar{O})^2} \quad (EF) \quad (7)$$

$$CRM = \frac{\sum_{i=1}^{n} O_i - \sum_{i=1}^{n} P_i}{\sum_{i=1}^{n} O_i} \quad (CRM) \quad (8)$$

Where , P_i :The predicted values , O_i :Measured values (observed) , n :number of samples used, $\bar{O}$:Average value of the measured parameter

III. RESULTS AND DISCUSSION

To estimate the intensity of evaporation in the first stage , The first step is to take time to evaporate.This time , The measured data is obtained.It is explained to , When a failure occurs in the first stage and the second stage is the first stage of evaporation , It will be the end of the first stage of evaporation.After obtaining estimates for the first stage of evaporation and vapor phases I and II , It evaporation calculated from the measured weight , Is compared.

In pictures 1 to 4 and calculate the first and second stage of evaporation estimates , For sandy clay texture and separation it is observed salinity levels.

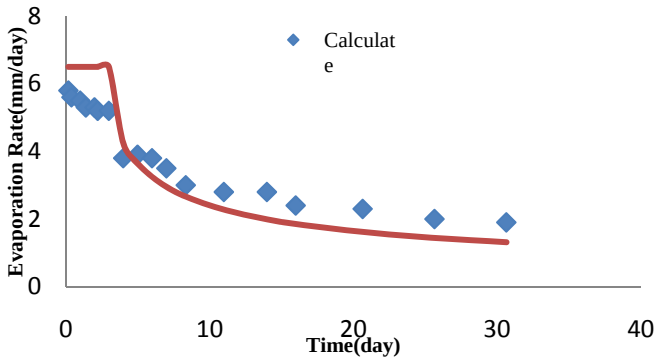

Fig.1.Estimating and calculating evaporation in the first level of salinity

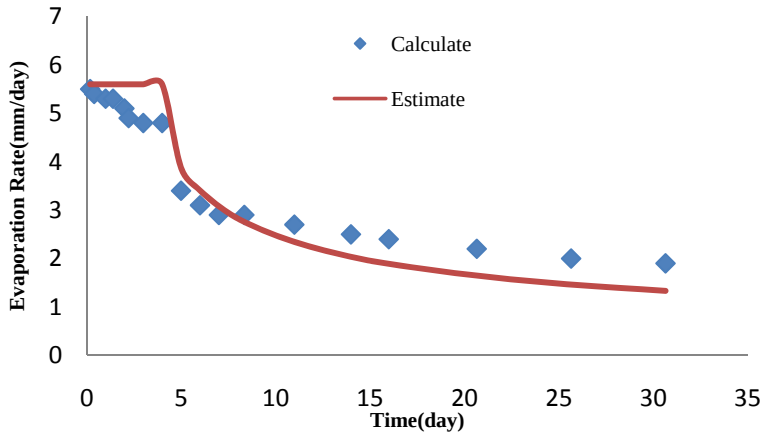

Fig. 2. Estimating and calculating evaporation in the second level of salinity

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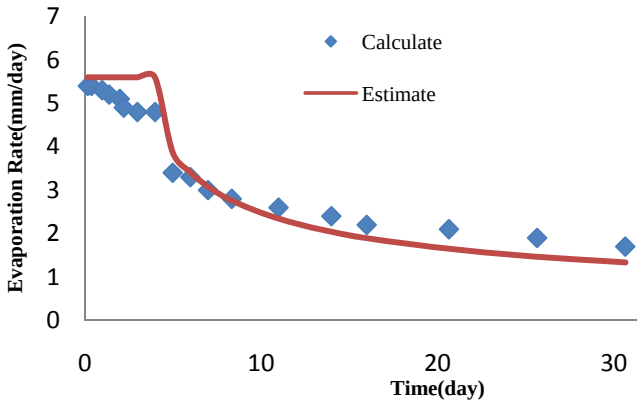

Fig.3. Estimating and calculating evaporation in the third level of salinity

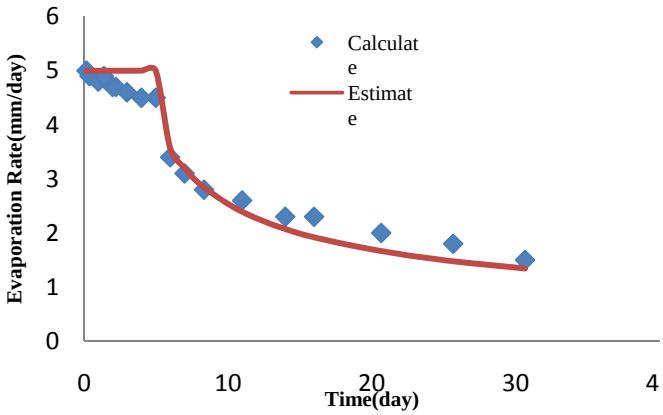

Fig.4. Estimating and calculating evaporation in the fourth level of salinity

Sandy clay texture of the First Council , As Figure 1 suggests, the transition happens from the first stage to the second stage of evaporation, evaporation from the beginning of the third day.

Evaporation estimates in the first stage , Estimate is greater than the value calculated. In the second stage of evaporation , Have a good estimate evaporation estimates calculated , But gradually evaporated estimates calculated distance is less than the evaporation estimates.

The second level of salinity , Transition from the first stage to the second stage on the fourth day since the start of evaporation, evaporation occurs.Also, in the first stage of evaporation , Than the calculated evaporation , Evaporation estimates are overestimated, but the difference has declined over the past.Also in the second phase of the low estimate evaporation is evident in the data is closer to the measured data.

In sum, both the first stage and second stage of the latter, a better estimate of evaporation compared to the previous figure shows.The third level of salinity , Transition from the first stage to the second stage of evaporation, evaporation occurs on the fourth day.

In the first stage of evaporation estimates there are still overestimated but the difference is more than Figure 2.

Evaporation estimates in the second and third level is the same, but it does increase the difference is less evaporation calculated from the third level to reduce the amount of salt that is poorly.

Figure 4 shows the time of failure and the transition from the first stage to the second stage evaporation occurs on the fifth day.

Both the first and second stage of evaporation, evaporation estimates are well done and very little in the first stage we estimate evaporation overestimation.

The salinity level of salinity than the previous estimate of evaporation has been more appropriate.

Table 1. Indicators to assess the different levels of salinity

RMSE	AE	EF	CRM	CD	Salinity
					First level Salinity
0.97	0.83	0.38	-0.07	0.34	
					second level Salinity
0.66	0.54	0.71	-0.06	0.49	
					third level Salinity
0.67	0.57	0.68	-0.08	0.46	
					fourth level Salinity
0.4	0.34	0.89	-0.04	0.62	

IV. CONCLUSIONS

Sandy clay texture transition from the first stage to the second stage of the first level of salt evaporation on the third day and the second and third levels of salinity on the fourth day and the fifth day of the fourth level of salinity.

Evaporation decreases with increasing salinity of the soil, even in the first stage mentioned earlier by external meteorological conditions (eg, radiation, wind, temperature, humidity) controlled, observed[7].

It should be recognized that the ability of the atmosphere to evaporate completely independent of the properties of the object that it is no evaporation occurs.

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Moreover, if we assume that the object is completely independent of the properties of water surface evaporation exactly equals, salinity reduced the water vapor pressure resulting in reduced evaporates.

The first stage of evaporation decreases with increasing salinity, evaporation would be justified.

Evaporation decreased with increasing salinity, which corresponded with the results of previous research.

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