Modeling the problem of horizontal drainage on irrigated lands

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***Abstract* —The article discusses the calculation of drainage and its parameters using a mathematical model. Drainage on irrigated land is a complex of hydraulic structures designed to collect and drain groundwater. The main parameters of horizontal drainage are its depth and the distance between drains. A program has been created to calculate the depth of horizontal drainage and the distance between drains**.

***Index terms* — horizontal drainage, irrigation rate, total evaporation, precipitation, growing season, intensity of infiltration supply, drainage flow, distance between drains, drainage rate, horizontal drainage depth, drainage module.**

I. INTRODUCTION.

Irrigated lands are a national treasure and the basis for sustainable development of the agricultural sector of the economy. Therefore, the restoration and preservation of their productive capacity is the most important State task formulated in the Message to the Parliament of the Oliy Majlis by the President of the Republic Sh. M. Mirziyayev (December, 2017) “... it is necessary to develop a comprehensive program for further reform of agriculture, attaching special importance to ensuring the country's food security”[1].

The main purpose of the drainage is to create conditions for lowering the groundwater level, sustainable desalination of saline lands by leaching and maintaining water-salt regimes of soil , eliminating the restoration of salinity during the operation of the irrigation system.

II. FORMULATION OF THE PROBLEM.

The most important issue in the design of drainage systems is the correct assignment of the depth of drainage and the distance between them, on which both the intensity of drainage and the cost of construction, and therefore the economic efficiency of drainage, depend [2,3]. High accuracy and quick calculation of drainage parameters, including the depth of the drainage and the distance between them are an important problem.

III. DECISION.

For balance sheet calculations, the weighted average irrigation rate is adopted, which is calculated by the formula:

$$M = \frac{M_1 \cdot n_1 + M_2 \cdot n_2}{n} \cdot \alpha \quad (\text{m}^3/\text{ga}) \qquad (1)$$

where, M_1, M_2 - irrigation norms for cotton and wheat are taken from the table; n_1, n_2 - the area occupied by cotton and wheat, respectively; n - crop rotation area, $n = n_1 + n_2$; $\alpha = 0{,}88 \div 0{,}92$.

We determine the additional volume of water that goes to create the necessary salt regime of soil:

$$\Delta M = \beta \cdot M \quad (\text{m}^3/\text{ga}) \qquad (2)$$

where, $\beta = 0 - 0{,}25$.

Losses of water for filtration from the canal are found by the formula:

$$Q_l = \left(\frac{1-\eta}{\eta}\right) \cdot \left(M + \Delta M\right) \quad (\text{m}^3/\text{ga}) \qquad (3)$$

where, η – efficiency of the on-farm distributor system.

Determine the water supply during the growing season according to the formula:

$$V_v = M_v + \Delta M + Q_l \quad (\text{m}^3/\text{ga}) \qquad (4)$$

Determine the water supply in the non-growing season according to the formula:

$$V_n = \frac{M_n}{\eta} \quad (m^3/ga) \qquad (5)$$

where, M_n - the amount of irrigation norms for the non-growing season is taken from the table.

The value of the annual water supply is determined by the formula:

The value of the annual water supply:

$$V = V_v + V_n \ (m^3/ga) \qquad (6)$$

where, V_v - water supply for the vegetation period m^3/ha; V_n - water supply for non-vegetation period, m^3/ha;

P - total rainfall for the year taken from the table (m^3/ga); P_v - total rainfall for the growing season taken from the table (m^3/ga).

The total evaporation is calculated by the formula:

$$E = E_v + E_n \ (m^3/ga) \qquad (7)$$

where, E_v - total evaporation for the growing season is taken from the table; E_n - the total evaporation for the non-growing season is taken from the table.

We compose the equation of the total water balance for the year to be able to predict changes in the level of groundwater during irrigation without drainage:

$$\Delta W = P + V_v + V_n - E \ (m^3/ga) \qquad (8)$$

Determine the rise in groundwater level by the formula:

$$\Delta h = \frac{\Delta W}{10000 \cdot \mu} \ (m) \qquad (9)$$

where, μ – coefficient of free water loss $\mu = 0 - 0{,}22$.

We determine the groundwater level by the end of the first irrigation using the formula:

$$h_2 = h_1 - \Delta h \qquad (10)$$

where, h_1 – the groundwater level before irrigation is taken from the table; Δh – groundwater level rise.

The forecast of the rise in the groundwater level at the farm shows that if it is not necessary to build drainage, then the groundwater level will rise to the surface of the earth.

The drainage load is calculated by the formula:

$$D = P + V - E \quad (m^3/ga) \qquad (11)$$

where, v_1 – water intake into the irrigation system; P – precipitation; E – total evaporation and transpiration;

We determine the filtering intensity by the formula:

$$q_f = \frac{D}{10000 \cdot t} \quad (m/day) \qquad (12)$$

where, t=365 days, growing season (from January 1 to December 31); D- drainage (m^3/ga);

For a homogeneous thickness, the distance between drains is determined by the formula:

$$B = 4 \cdot \left(\sqrt{f^2 + \frac{T \cdot H_M}{2 \cdot q_f}} - f \right) \qquad (13)$$

where, T-conductivity of the aquifer (m^2/day); H_M - the excess of groundwater level in the inter-drainage area above the water horizon in the drain (m); q_f - intensity of infiltration nutrition (m /day); f - filtration resistance due to imperfection of drainage from the degree of opening of the aquifer (m).

Aquifer conductivity:

$$T = K \cdot m \qquad (14)$$

where, K-layer filtration coefficient is taken from the table, m/day; m-layer height is taken from the table (m).

Filtration resistance is determined by the formula:

$$f = m \cdot \sigma \qquad (15)$$

where, m-layer height is taken from the table (m).

Resistance is calculated by the formula:

$$\sigma = 0{,}73 \cdot \lg \frac{2 \cdot m}{\pi \cdot d} \qquad (16)$$

where, d-calculated diameter of the drain(m); m-layer height is taken from the table(m). For open drains provided $b > h_0$

$$d = 0{,}5 \cdot b + h_0, \quad (м) \qquad (17)$$

where, the b-width of the drain on the bottom is taken from the table, m; h_0-depth of water in the drain, m.

For closed drains with dusting, its calculated diameter is determined by the formula:

$$d = 0{,}56 \cdot p_d \qquad (18)$$

where, p_d-wetted perimeter of the drainage contour (dusting)(m).

$$p_d = 2 \cdot h + b \qquad (19)$$

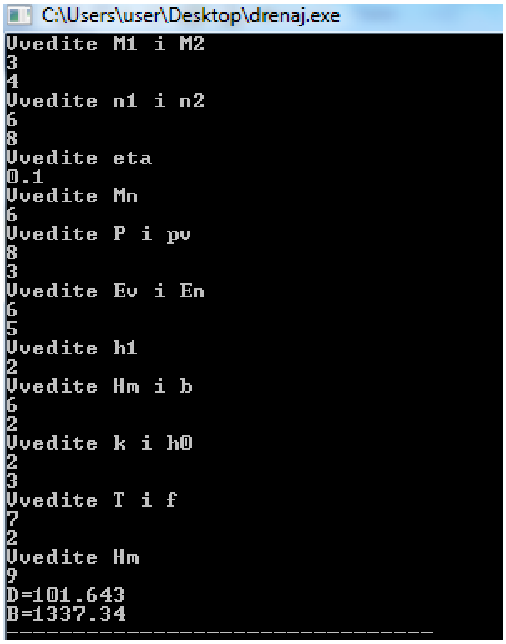
The depth of laying is determined by the formula [3]:

$$h_d = H_n + H_m + h_0 \quad (m) \qquad (20)$$

where, H_n – the drainage rate is taken depending on the mechanical composition of the soil, $H_n = 0{,}8 - 1{,}5$ (m); H_m – the excess of groundwater in the middle between the drains above the water level in them, $H_m = 0{,}5 - 1$(m); h_0 – the depth of water in the regulating drains, $h_0 = 0{,}1 - 0{,}2$ (м).

A C++ program for calculating water flow has the following form:

```
#include <iostream>
#include <math.h>
 using namespace std;
int main()
{
const float alf=0.88, beta=0.25, myu=0.22, t=365.0;
 float
M1,M2,M,dM,n1,n2,eta,Ql,Vv,Mn,Vn,V,P,Ev,Pv,En,dW,dh,h1,
h2,D,qf,Hm,b,k,h0,d,B,Pd,T,f,m,sigma;
cout<<"Vvedite M1 i M2"<<endl;
cin>>M1>>M2;
cout<<"Vvedite n1 i n2"<<endl;
cin>>n1>>n2;
M=(M1*n1+M2*n2)/(n1+n2);
dM=beta*M;
cout<<"Vvedite eta"<<endl;
cin>>eta;
Ql=(1-eta)/eta*(M+dM);
Vv=M+dM+Ql;
cout<<"Vvedite Mn"<<endl;
cin>>Mn;
Vn=Mn/eta;
V=Vv+Vn;
cout<<"Vvedite P i pv"<<endl;
cin>>P>>Pv;
cout<<"Vvedite Ev i En"<<endl;
cin>>Ev>>En;
  float E=Ev+En;
dW=P+Vv+Vn-E;
 dh=dW/(10000*myu);
 cout<<"Vvedite h1"<<endl;
cin>>h1;
 h2=h1-dh;
 D=P+V-E;
 qf=D/(1000*t);
 cout<<"Vvedite Hm i b"<<endl;
cin>>Hm>>b;
cout<<"Vvedite k i h0"<<endl;
cin>>k>>h0;
Pd=2*h0+b;
d=0.56*Pd;
 cout<<"Vvedite T i f"<<endl;
cin>>T>>f;
cout<<"Vvedite Hm"<<endl;
cin>>Hm;
 B=4*(sqrt(f*f+T*Hm/(2*qf))-f);
 cout<<"D="<<D<<endl;
 cout<<"B="<<B;
}
```



IV. CONCLUSION.

Using the recommended program facilitates the calculation of the depth of the drain and the distance between them, both designers and it may be used for educational purposes in higher educational institutions.

References

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