PUMPIT

user manual

A tool to assess the impact of groundwater salinity on pasture yield.

Introduction

PUMPIT is an empirical model describing the relationship between irrigation water salinity and pasture yield. Irrigation water salinity is calculated from the amounts and salinity of pumped groundwater, drainage water and channel supply water.

Computer requirements

To run PUMPIT you require an IBM compatible computer with a minimum of Windows 3.1.

Installing PUMPIT

1. Start Microsoft Windows
2. Insert the disk into drive A
3. Select File from Program Manager
4. Choose Run
5. Type ‘A:\setup’ and press ‘enter’

Starting PUMPIT

To start PUMPIT, double click its icon in the Program Manager.

<u>The Main menu</u>

File: Reset – resets the screen to the default settings.
Exit – will close PUMPIT; always exit before shutting off your computer!

Units: Salinity – This activates the salinity conversion windows which allows the user to convert between different salinity units.
Area - Currently not activated

Using PUMPIT

To use PUMPIT, enter farm details in the white boxes. Alternatively, use the scroll buttons on the side of the white box to increment listed values. Changes in pasture yield and water budget are automatically calculated and displayed.

INPUTS

Irrigation Details.

Surface supply. The volume and salinity of channel supply water that is used for irrigation on your farm annually. The volume in ML and salinity in EC (µS/cm). If you are unfamiliar with EC units, then use the salinity conversion option to convert your units to EC units.

Groundwater supply. You need to specify the volume of groundwater pumped each year and the salinity of the groundwater.

Drainage diversion. The volume and salinity of drainage diversion utilised on you farm

Farm Details.

Crop type. Specify the crop which you are growing. In this version, the only option available is summer pasture

Soil type Specify major soil type of your property. The only option available in this version is Lemnos Loam.

Irrigation area. Input the area of your farm that is irrigated.

Climate Details.

Annual Rainfall. Enter average annual rainfall (mm).

Reference ET. Enter average annual reference crop evapotranspiration. This is approximately 1200mm in north eastern Victoria.

OUTPUTS.

Crop Yield. This graph indicates the resulting yield. Green area is actual yield. The red area is lost production. Yield is reduced as a result of under irrigation and irrigation water salinity being too high.

Water Balance.
Total applied water is partitioned into plant water use (evapotranspiration), water lost below the rootzone (deep percolation) and excess irrigation water that results in surface runoff (runoff). The partitioning is shown graphically in a pie chart or listed by selecting the 'Details button'

Details

Actual values for the following components of the water budget are listed by selecting the details button.

- Total applied water
- Actual evapo-transpiration
- Deep percolation
- Runoff
- Average applied water salinity

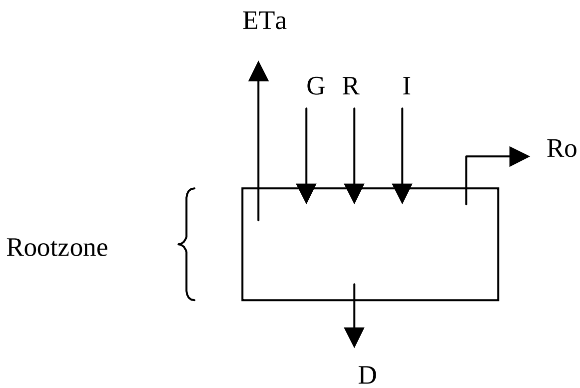
Salinity Conversions.

This option is activated by firstly selecting the 'Units' and then 'Salinity' option on the menu bar. The 'salinity conversion' box is then activated. Select the salinity unit that you want to convert and salinity unit to convert to. Type in your salinity measurement. This is automatically converted to the required salinity unit.

Model Theory

A conceptual model of the groundwater and farm management system was developed to assess the impact on production of different farm salt management options. Equations describing the water and salt balance of this conceptual model were based on the work of Prendergast (1993). These equations were found to provide good prediction of pasture yield from average annual irrigation water salinity (Prendergast, 1993). This approach assumes the system is in a steady state, refer to Prendergast (1993) for more detail. The fluxes of water entering and leaving the rootzone are summarised in Fig 1.

Fig 1. Conceptualisation of the rootzone.



ETa = actual evapotranpsiration (mm/yr)
G = depth of irrigation with groundwater (mm/yr)
R = depth of rainfall (mm/yr)
I = depth of irrigation with channel supply water (mm/yr)
D = drainage of water below the rootzone (mm/yr)
R_o = depth of runoff (mm/yr)

<u>ET by water balance</u>
The water balance is calculated by summing the fluxes of water to and from the rootzone and by assuming no change in water storage in the rootzone on an annual time step (eq 1).

$$I + R + G - R_o - D - ET_a = 0 \qquad \text{eq 1}$$

ET_a can be evaluated (eq 3) by calculating Ro as a fraction (R_u) of total applied water (eq 2) and combining eq 1 and 2. ETa cannot exceed a maximum ET of the plant (ET_m). When ET_a=ET_m, surplus applied water is accounted for by increasing the R_o. ET_m is calculated from reference crop evapotranspiration (ETo-FAO56) and a crop factor K_c (eq 4).

$$R_o = (I + R + G)(R_u) \qquad \text{eq 2}$$

$$ET_a = \min\{(1 - R_u)(I + R + G) - D), ETm\} \qquad \text{eq 3.}$$

$$ETm = K_c.ET_o \qquad \text{eq 4}$$

D is calculated from the leaching fraction (LF) and total depth of applied water (eq 5). An initial estimate of LF is made. For Lemnos Loam this was assumed to be 10 %. ET_a can now be calculated (eq 3).

$$D = LF(I + R + G - R_o) \qquad \text{eq 5}$$

ET due to salt stress.

Crop yield due to salt stress (Y_s) is calculated as a function of average rootzone salinity (eq 6, Maas and Hoffman, 1977). A is the salinity threshold of the crop and B is the relative yield reduction per unit increase in average soil salinity (EC_{se}).

$$Y_s = 1 - B(EC_{se} - A) \quad C_{se} > A \qquad \text{eq 6}$$

A= salinity threshold of crop.
B = yield reduction per unit increase in soil salinity.
EC_{se}= average soil salinity

EC_{se} is calculated using the empirical leaching equation of Rhoades (1974), with locally developed coefficients (eq 7) (Prendergast, 1993). The leaching fraction used in eq 7 is the same as eq 5. The average salinity of applied water is calculated from the depth and salinity of channel supply water (I,C_I), groundwater (G,C_g) and rainfall (R,C_r) (eq 8).

$$EC_{se} = 0.2 \cdot C_w (1 + \frac{1}{LF}) \qquad \text{eq 7}$$

$$C_w = \frac{I.Ci + G.Cg + R.C_r}{I + G + R} \qquad \text{eq 8}$$

Doorenbos and Kassam (1979) developed a relationship expressing crop yield as a function of actual evapotranspiration (ET_s), maximum evapotranspiration (ET_m) and a yield response factor (K_y) (eq 9).

$$Y_w = 1 - K_y (1 - \frac{ET_s}{ET_m}) \qquad \text{eq 9.}$$

ETs can be calculated by rearranging eq 9 and substituting Y_s for Y_w in eq 6. ETs, the evapo-transpiration of the plant taken into account salt stress, must equal the ET_a calculated by volume balance eq 10.

$$ET_s - ET_a = 0 \qquad \text{eq 10}$$

A linear program is used to adjust LF until the water balance constraint (eq 10) is met. Equations 1 to 10 are solved for each new value of LF.

Attachment 5

Program structure

1: Data Input

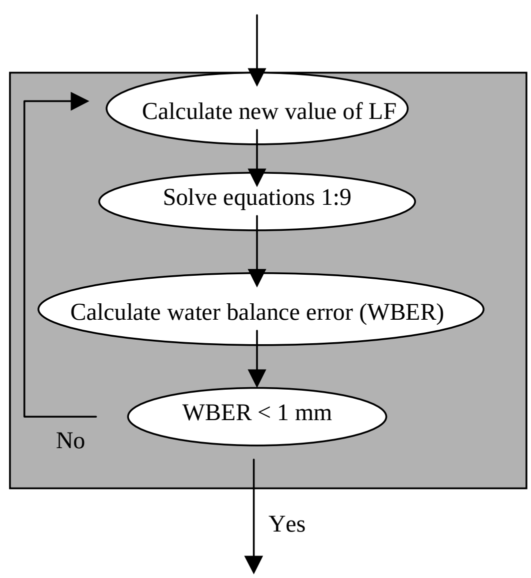
Irrigation Details
Enter values for
I,C_i (volume and salinity of channel supply water)
G,C_g (volume and salinity of groundwater)
D,C_d (volume and salinity of drain diversions)

Farm Details
Enter values for
CT (crop type)
ST (soil type)
A (irrigated area)

Climate Details
Enter values for
R (rainfall)
ET_o (reference crop evapo-transpiration)

Initialise run
Set initial value for LF
Convert all input parameters into standard units.
Solve equations 1 to 10

2: Main Program



3: Data output

Update output data
Write warning message when Cw exceeds 0.8 dS/m
Update water balance graph
Update yield reduction graph

Sample output

In this example, surface supply water is 600 ML at salinity 100 µS/cm. 200 ML of groundwater is pumped at salinity of 10 000 µS/cm. The irrigated area is 100 Ha, annual rainfall is 480 mm and reference crop evapotranspiration = 1200 mm.

The graphical output shows that the pasture yield is reduced to approximately 40 %.