NATIONAL UNIVERSITY OF LESOTHO
FACULTY OF AGRICULTURE
DEPARTMENT OF SOIL SCIENCE AND RESOURCE CONSERVATION

SSR415-3 WATER MANAGEMENT

FINAL EXAMINATION PAPER

Programmes

BSc Agriculture (Soil Science, Crop Science) and BSc Agricultural Extension

MAY 2019 **TOTAL MARKS: 100** **TIME: 3 HOURS**

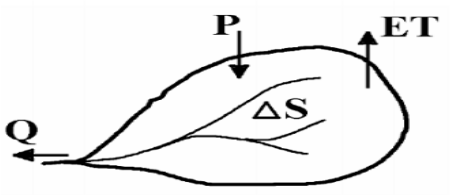
INSTRUCTIONS

1. **Answer FIVE (5) questions ONLY**
2. **It is mandatory to commence each question on a separate sheet**

QUESTION ONE (20 MARKS)

Determine discharges for the following questions

a) Consider being given the data below for Roma catchment. Compute the runoff in m^3/season and m^3/s from the catchment given the data below (5 marks).



- ✓ Catchment area A= 1700Km^2
- ✓ Annual rainfall=300mm/year
- ✓ Annual Evapotranspiration=265mm/year
- ✓ $\Delta s/\Delta t$ is negligible

b) Suppose that a river flows and discharges into a designated area and the average velocity of the flow is 26000cm/hour and the river has a cross sectional area of 15m^2. Calculate the discharge in m^3/s (3 marks).

c) A 5 litre bucket was placed under the spout of a discharge pipe from one spring in Roma catchment area in order to investigate or assess its capacity for water supply. The bucket got filled up in 13sec, 11sec and 9sec respectively. Calculate the discharge in m^3/s needed to fill this 5 litre bucket. (4 marks).

d) Consider a given drainage area for Roma is 0.9km^2 and surface description is wooded given the runoff coefficient of 0.15, the intensity of rainfall is assumed to be 39mm/hour. Apply the rational method to estimate peak flow discharge for Roma in m^3/s. (8marks)

QUESTION TWO (20 MARKS)

a) Area (A) of 29000ha is being planted with a maize crop with ETc= 950mm and the irrigation season for production of the crop is 6 months period and there is no rainfall in the area. What is the crop water requirement in m^3/season and m^3/s? (5 marks).

b) Calculate the available Soil Moisture (RAW) Given:
Planted area of 700ha.
Soil moisture at Field Capacity is 0.48m^3
Soil Moisture at Wilting Point is 0.35m^3.
Root depth is 1.6 m and the soil Depletion Factor is 0.7. (5 marks).

c) Draw of a simplified structure of rain fed crop and label each of the values provided near the correct parameter. Precipitation is 800mm, of which 100mm evaporates, 100mm runs offs into the stream. Of the remaining 400mm that infiltrates into the soil, 100mm percolates to the subsoil and recharges aquifers. (5marks)

d) For the following mass balance equation of an irrigated area, provide the missing parameters of the mass balance. (5 marks).
$P + \ldots = \ldots. + E_s + E_T + E_0 + R + \underline{\varrho}_s + \ldots..$

QUESTION THREE (20 MARKS)

Suppose that water and soil samples were analysed for a farm at Nyokosoba. The parameters under study are; Sodium Adsorption Ratio (EC), Electrical Conductivity (EC), Exchangeable Sodium Percentage (ESP) and Infiltration Rates (IR) and Leaching Requirement (LR).

- Electrical Conductivity of the saturation extract of the soil ECe=2.7 ds/m
- Electrical Conductivity of the irrigation water ECw =1.4ds/m
- LR= 12% salt build up in the upper 35cm
- SAR of irrigation water= 4.69
- Approximate EC= 2.39 ds/m
- The soil tests indicated ESP > 15%
- For SAR of 2.39, infiltration rate was 60mm/hour
- For SAR of 4.69, Final infiltration rate was 45mm/hour

(a) What does the Leaching Requirement (LR) of 12% mean with respect to management of salt affected soils? (3 marks)

(b) What does ESP > 15% indicates about the status of the soil and which major effect occur from this kind soil? (3 marks)

(c) Mention any two (2) management options for the status of the soil in question (b) above (4 marks)

(d) What conclusion can be made with respect to infiltration rate versus SAR and EC of water samples? (3 marks)

(e) Use table 1 below to answer the following questions;

Recorded average value for water samples; EC=2.39 ds/m and SAR=4.68)

Table 1: Summary of the threshold levels for potential water infiltration problem

Threshold for potential water infiltration problems			
	Degree of restriction on use		
SAR	No restriction	Slight to moderate	Severe
	EC of irrigation water (ds/m)		
0-3	0.7	0.7-0.2	<0.2
3-6	1.2	1.2-0.3	<0.3
6-12	1.9	1.9-0.5	<0.5
12-20	2.9	2.9-1.3	<1.3
20-40	>5.0	5.0-2.9	2.9

Source: Adapted from Abduwahed et al., 2018**)**

(i) Assess the suitability of water for irrigation purposes based on degree of restriction for use (3 marks)

(ii) If the irrigation water and soil had higher EC and SAR values, what advice would the farmer need for management of salt affected water and soil? (2 marks)

(f) Irrigation water contains 1.0 me/l, 7.0 me/l, 2.0me/ and 1.2 me/l of CO_2^{3-}, HCO_3^-, Ca^{2+} and Mg^{2+} of which the Residual Sodium Carbonate (RSC) is 5meq/l respectively.

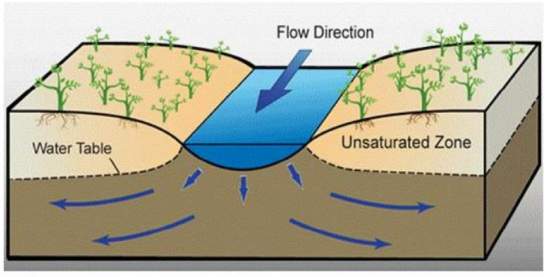
- RSC (meq/l) threshold levels for irrigation water= 1.25 and 2.5 meq/l or lower=marginal

>2.5meq/l= excessive

Provide the recommendation to the farmer regarding the suitability of the irrigation water for crop production (3 marks)

QUESTION FOUR (20 MARKS)

(a) State the concept of hydraulic head (4 marks)
(b) Mention 3 types of aquifer classification (6 marks)
(c) Mention four hydrogeological classifications with respect to groundwater (8 marks)
(d) The figure below shows groundwater recharge. State whether groundwater recharge occurs to a River or from the River (2 marks)



QUESTION FIVE (MARKS 20)

a) Calculate Evapotranspiration in mm/day by computation of the following methods.
   i. Modified FAO Penman Monteith (14 marks)
   ii. Hargreaves Method (4 marks)
b) Which parameter is dominant for both methods (2 marks)

Elevation Z=1875 m above sea level, Location Lat, Long= Latitudes 29^0 S, Minimum air temperature Tmin = 20 ^{0}C, and Maximum air temperature Tmax =36.9 ^{o}C,
Wind speed U_{2m} = 2.6m/s,
Net global solar radiation, Rn =28 MJ/m^2 day,
Soil heat flux density, G = 1.4 MJ/m^2 day.
Extra-terrestrial solar radiation Ra in MJm2/day= 1367 MJm2/day

QUESTION SIX (20 MARKS)

(a) Provide the role of the Lesotho Water Act of 2008 (2 marks)

(b) Which institution is the custodian for Lesotho water resources management? (2 marks)

(c) Define the term water governance (2 marks)

(d) Explain the term water valuation (4 marks)

(e) Differentiate between diffuse and point sources of water pollution (4 marks)

(f) List any two international principles underpinning transboudary water management (2 marks)

(g) Explain the following two aspects of sovereignty with respect to transboudary water management

(i) Absolute territorial sovereignty (2 marks)

(ii) Absolute territorial integrity (2 marks)

Fundamental equations to be utilized as a guide to answer questions based on calculations

- $TAW = (\Theta_{FC} - \Theta_{WP}) \times Z_R$
- $RAW = p.TAW$
- $Run\ from\ the\ catchment: P(t) \times A - ET(t) \times A - Q(t) = \Delta s/t$
- $Discharge\ formular\ Q = VA$
- $Mannings\ formula\ Q = 1.49AR^{2/3} S^{1/2}/n$
- $Rational\ method\ Q = C*I*A$
- $Reservoir\ storage\ capacity\ C = K*D*W*T$

- $LR = ECw/\ 5(ECe) - ECw$
- $AW = ET/\ (1-LR)$
- $SAR = Na^{+}/\sqrt{(Ca^{2+} + Mg^{2+})/2}$
- $RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$
- $PET_{PM} = \dfrac{0.408 \times \Delta \times (R_n - G) + \gamma \times 900/\ Ta+273 \times u_2 \times (e_s - e_a)}{\Delta + \gamma \times (1 + 0.34 \times u_2)}$
- $ET_{HS} = 0.0023 \times R_a \times (Tmax - Tmin)^{0.5} \times (Ta + 17.8)$
- $Priestley\ and\ Taylor\ method: PET_{PT} = \dot{\alpha} \times \Delta / \Delta + \gamma \times (Rn - G)/\lambda v$
- $e_s = 0.611.exp\ [(17.3 \times T_a)/\ (T_a + 237.3)]$
- $e_a = 0.611exp\ [(17.3 \times T_{min})/\ (Tmin + 237.3)]$
- $\Delta = (4098 \times e_s)/\ (Ta + 237.3)^2$, Δ = Slope of saturation vapour pressure to air temperature curve (kPa/^{o}c)
- P_{atm} = atmospheric pressure (KPa)= $101.3\ \{[293 - (0.0065 \times Z_{site})]/293\}^{5.26}$
- $\lambda_v = 2.501 - 0.002361 \times T_a$
- $\gamma = (P_{atm}/\lambda_v) \times 0.00163\ MJ/kg^oc$