الهندسة	**الكلية**
الهندسة المدنية \ السدود والموارد المائية	**القسم**
Hydrology	**المادة باللغة الانجليزية**
هايدرولوجي	**المادة باللغة العربية**
الرابع	**المرحلة الدراسية**
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Precipitation	**عنوان المحاضرة باللغة الانجليزية**
الامطار	**عنوان المحاضرة باللغة العربية**
1	**رقم المحاضرة**
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CHAPTER ONE

Precipitation

Hydrology: Means science of water which deals with the spatial and temporal of characteristics of the earth's water in all its aspect such as: occurrence, circulation, distribution, physical and chemical properties and impact on environment and living things.

Engineering Hydrology: Deal with all these aspects which are pertinent to planning, design, and operation of hydrologic engineering projects for the control and use of the available water.

Hydrology applications: in the

1-Design and operation of water resources projects

2-To estimate the magnitudes of flood flows at different times in the year.

3-To decide reservoir capacity , spillway discharge.

4-To decide dimensions of hydraulic structures.

Hydrologic Cycle:

The total water of earth excluding deep ground water, is in constant circulation from the earth (including oceans) to atmosphere and back to the earth and the oceans. This cycle of water amongst, earth, oceans, and atmospheric system is known as hydrologic cycle.

Precipitation

Moisture is always present in the atmosphere even in clouded less day, for precipitation to occur some mechanism is required to cool the air sufficiently to bring it to or near saturation.

Formation of fog or cloud drops or ice crystals generally requires the presence of condensation or freezing nuclei on which the drops from these nuclei are small particles of various substance ranging (0.1-10)μm in diameter.

Forms of precipitation:

1-Drizzle: Some time called mist , consists of tiny. Water drops, usually with diameter between 0.1 and 0.5mm (0.004-0.02)in.

2-Rain:consist of water drops mostly larger than 0.5mm (0.02in) in diameter.

3-Glaze:Is the ice coating generally clear and smooth but usually containing some air pockets formed on exposed surface by the freezing of supper cooled water drops deposited by rain or drizzle.

4-Snow: Is composed of white ice crystals in complex form often mixed simple crystals and agglomerated in to snowflakes which may reach several inches in diameter.

5-Hail:Is precipitation in the form of balls or irregular ice, range from5 to 125mm(0.2-over5in) in diameter.

6-Sleet:Solid grains ice formed by the freezing of rain drops or freezing of largely of sub freezing air near the earth surface.

Types of precipitation:

Precipitation is often typed according to the factor mainly responsible for lifting the air to effect the large scale cooling required for significant amount of ppt.

1-Cyclonic ppt: result from lifting of air converging in to lower pressure area for cyclone.

2-Convective ppt: caused by the natural rising of water lighter air in colder denser surrounding.

3-Orographic ppt: results from the mechanical lifting over mountain barriers.

Terminal velocity:

There are three forces acting in a falling rain drop:

1-Gravity force , Fg

2-Bouyancy force ,Fb

3-Drag force ,Fd, due to friction between drop and surrounding air.

The volume of sphere $\frac{\pi D^3}{6}$

$Fg = \rho_w \, g \, \frac{\pi D^3}{6}$

$Fb = \rho_a \, g \, \frac{\pi D^3}{6}$

$Fd = C_d \, \rho_a \, A \, \frac{V^2}{2}$

Where:

D = drag coefficient

V = falling velocity

A = cross section area $= \frac{\pi D^2}{4}$

IF the drop is released from result it will accelerate unit it reaches its terminal velocity Vt , at which the three forces are balanced.

Fd = Fg _ Fd

Let V = Vt

$$C_d\, \rho_a \frac{\pi D^2}{4}\,\frac{Vt^2}{2} = \rho_w\, g\frac{\pi D^3}{6} - \rho_a\, g\,\frac{\pi D^3}{6}$$

$$Vt = \sqrt{\frac{8\left(\rho w\,\frac{\pi D^3}{6} - \rho a\,\frac{\pi D^3}{6}\right)}{Cd\,\ \rho a\,\pi\, D^2}}$$

$$Vt = \left[\frac{4\,g\,D}{3\,Cd}\left(\frac{\rho w}{\rho a} - 1\right)\right]^{1/2}$$

Drag coefficient for spherical rain drop at standard atmospheric pressure (101.3 kpa) & air temp. (20C°)

Drop Diameter	Drag Coefficient
0.2	1.2
0.4	1.66
0.6	1.07
0.8	0.515
1	0.671
2	0.517
3	0.503
4	0.559
5	0.66

Example: Calculate the terminal velocity for (1mm)diameter rain drop falling in still air at stander atmosphere (101.3kpa) and air temp. (20cº).

Solution:

C_d = 0.671 from table

(ρ_w=998 $\frac{kg}{m^3}$ & ρ_a=1.2$\frac{kg}{m^3}$) at 20cº

$Vt=[\frac{4\ g\ D}{3\ Cd}(\frac{\rho w}{\rho a}-1)]^{1/2}$

$Vt = [\frac{4*9.81*0.001}{3*0.671}(\frac{998}{1.2}-1)]^{1/2}$

Vt = 4.02 m/sec

Precipitation Gauge Network:

For an existing network of rain gauge stations, we need to know the adequacy of the rain gauge station & the number of the rain gauge stations N required for a desired accuracy.

N:is given by : $N = (\frac{Cv}{\epsilon})^2$

Ɛ= maximum error in percent

Cv = the coefficient of variation of the rainfall values at the existing m stations in percent.

$Cv = \frac{\delta m-1}{p}*100$

$\sigma m - 1$: stanadard deviation

$\sigma m - 1 = \sqrt{\frac{\sum_{i=0}^{m}(\rho i - \rho)2}{m-1}}$

ρi: ppt. measured at the station

ρ: mean ppt. where $\rho = \dfrac{\sum_{i=0}^{m} \rho i}{m}$

$$\mathcal{E} = \text{is usually taken as } 10\%$$

Example: A catchment has eight rain gauge stations. the annual rainfall recorded by these gauges in a given year are listed in the table, below, what should be the min. number of rain gauge stations in the catchment for estimating the mean rainfall with an error less than 7%.

Solution:

Rain gauge	Annual Rainfall	$\rho i - \rho$	$(\rho i - \rho)^2$
A	80.0	-32.1	1030.4
B	87.6	-25.3	640.09
C	102	-10.9	118.81
D	160.8	47.9	2294.4
E	120.4	7.5	56.25
F	90.8	-2.1	4.41
G	142.3	29.4	864.36
H	98.5	-14.9	207.36
Total	903.2		5216.1

$$\rho = \frac{\sum_{i=0}^{m} \rho i}{m}$$

$\rho = \dfrac{903.2}{8} = 112.9\text{cm}$

$\sigma m - 1 = \sqrt{\dfrac{\sum_{i=0}^{m}(\rho i - \rho)^2}{m-1}} = \sqrt{\dfrac{5216.1}{7}} = 27.298$

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$$Cv = \frac{\sigma m-1}{\rho} * 100 = \frac{27.298}{112.9} * 100 = 24.18$$

$$N = (\frac{Cv}{\varepsilon})^{\wedge}2 = (\frac{24.18}{7})^{\wedge}2 = 11.93$$

Estimation of Missing Data:

The missing is estimated using the rainfall data of the neighboring rain gauge stations, by:

1-Simple Arithmetic Mean:

$$px = \frac{1}{3}(pA + pB + pC)$$

When the variation is less than 10%

2-Normal Ratio Method:

$$px = \frac{1}{3}\left(\frac{Nx}{NA}pA + \frac{Nx}{NB}pB + \frac{Nx}{NC}pC\right)$$

When the variation is more than 10%

$$Variation = \frac{Nmax - Nmin}{Nmin} * 100$$

Example: Estimate the missing data for the station x according to the following information:

Station	Normal Annual ppt(cm)	ppt(cm)
A	44.1	4.2
B	36.8	3.5
C	47.2	4.8
X	38.5	px