Environmental Studies – Module 1

Water Resources:

Problems on Computation of average or mean rainfall over a basin:

1. Arithmetic average method:

$P_{ave} = \frac{P_1 + P_2 ... + P_n}{n} = \frac{\Sigma P}{n}$, Where P_1, P_2, P_3 … P_n etc., are the precipitation or rainfall values measured at n rain gauge stations.

2. Thiessen polygon method:

$P_{ave} = \frac{A_1P_1 + A_2P_2 ... + A_nP_n}{A_1 + A_2 ... + A_n} = \frac{\Sigma(AxP)}{\Sigma A}$, Where A1, A_2, A_3 ….A_n are the area of Thiessen polygon.

3. Isohyetal method:

$$P_{ave} = \frac{\Sigma Ax\left(\frac{P_1 + P_2}{2}\right) + ... + A_{n-1}\left(\frac{P_{n-1} + P_n}{2}\right)}{A_1 + A_2 + ... + A_n}$$

1. Problem: - The rainfall values for the four sub-basins constituting a large river basin are 289, 334, 442 and 397 mm. The areas are 360, 275, 420 and 650 Km^2 respectively. Compute the depth of average rainfall for the basin as a whole by Arithmetic average method and Thiessen polygon method.

Solution: $P_1 = 289mm$, $P_2 = 334mm$, $P_3 = 442mm$ and $P_4 = 397mm$.

$A_1 = 360Km^2$, $A_2 = 275Km^2$, $A_3 = 420Km^2$, $A_4 = 650Km^2$.

Arithmetic average method:

$$P_{ave} = \frac{P_1 + P_2 + P_3 + P_4}{4} = \frac{289 + 334 + 442 + 397}{4} = \mathbf{365.5\ mm\ (Ans)}$$

Thiessen polygon method:

$$P_{ave} = \frac{A_1P_1 + A_2P_2 + A_3P_4 + A_4P_4}{A_1 + A_2 + A_3 + A_4} = \frac{360x289 + 275x334 + 420x442 + 650x397}{360 + 275 + 420 + 650}$$

$= \mathbf{375.12mm\ (Ans)}$

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2. Problem: - Following table indicates the area in Km^2 between isohyets. Calculate the mean precipitation over the area.

Values of isohyets bounding the strip in cms	Area in Sq. Km
30 - 40	42.0
40 - 50	148.0
50 - 60	87.0
60 - 70	92.0
70 - 80	228.0
80 - 90	120.0
90 - 100	45.0

Solution:

$$P_{ave} = \frac{A_1\left(\frac{P_1+P_2}{2}\right)+A_2\left(\frac{P_2+P_3}{2}\right)+A3\left(\frac{P_3+P_4}{2}\right)+A4\left(\frac{P_4+P_5}{2}\right)+A_5\left(\frac{P_5+P_6}{2}\right)+A_6\left(\frac{P_6+P_7}{2}\right)+A_7\left(\frac{P_7+P_8}{2}\right)}{A_1+A_2+A_3+A_4+A_5+A_6+A_7}$$

$$= \frac{42\left(\frac{30+40}{2}\right)+148\left(\frac{40+50}{2}\right)+87\left(\frac{50+60}{2}\right)+92\left(\frac{60+70}{2}\right)+228\left(\frac{70+80}{2}\right)+120\left(\frac{80+90}{2}\right)+45\left(\frac{90+100}{2}\right)}{42+148+87+92+228+120+45}$$

$P_{ave} = 66.23$**cms (Ans)**

3. A watershed has five rain gauges installed in the area the annual rainfall recorded for one year is as follows. Determine optimum number of rain gauges assuming 10% error in estimation of mean rainfall.

Rain gauge station	1	2	3	4	5
Annual rainfall in cm	125	95	175	110	90

Solution:

1) Calculate the mean average annual rainfall i.e.

$\bar{P} = \frac{\Sigma P}{n}$ where n = existing number of rainguage stations.

$\bar{P}$ = (125+95+175+110+90)/ 5 = 595/5 = 119 cm

2) Calculate the mean of squares i.e.

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$$\overline{P^2} = \frac{\Sigma(P^2)}{n} = [(125)^2 + (95)^2 + (175)^2 + (110)^2 + (90)^2] = 75475/5 = 15095$$

3) Calculate the standard deviation i.e.

$$\sigma = \sqrt{\frac{n}{n-1}\left[\overline{P^2} - (\bar{P})^2\right]} = \sqrt{\frac{5}{5-1}\left[15095 - (119)^2\right]} = 34.16$$

4) Calculate the coefficient of variation i.e.

$$Cv = \frac{100\sigma}{\bar{P}} = (100 \times 34.16)/\ 119 = 28.71$$

5) Optimum number of rain gauges (N) is given by

$$N = \left(\frac{Cv}{E}\right)^2 \doteq \left(\frac{28.71}{10}\right)^2 = 8.24 = 8 \textbf{ Nos. Ans}$$

6) Additional rain gauges required to be installed = N – n = 8 - 5 = **3 Nos. Ans**

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