International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 03 | Mar 2024 www.irjet.net p-ISSN: 2395-0072

Measurement of Evaporation Using Pan Evaporation

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Abstract - Pan Evaporation is the process of Evaporation which is influenced by various factors such as Meteorological Parameters. Small pan evaporation test is conducted in the Bidadi region of Ramanagara district for various Water Samples such as Fresh water, Salt water, Sewage water for two different exposure conditions such as Open field and Poly covered house. The Test results revealed that Open field exposure condition tend to produce greater evaporation compare to poly covered house and as per our study Fresh water has more evaporation rate than the Salt water and Sewage water. From this study small evaporation pan can also give good results and can replace large conventional evaporation pans.

Key Words: Small Pan Evaporation, open field, Poly covered house, Fresh water, Salt water, Sewage water.

1.INTRODUCTION

Evaporation is the process where liquid state of matter converted into a gaseous state of matter in the presence of heat. Technically evaporation occurs when some water molecule attains sufficient kinetic energy to break through the water surface and escape into atmosphere. Temperature, Wind speed, Surface area, Humidity are the main four factors which affects the rate of evaporation. There are so many methods to find evaporation rate such as Direct methods: Pan evaporation, Lysimeter and Indirect methods: Penman equations, Blaney criddle method, energy and water budget method. The above methods are invented by specialists, researchers.

This research study is based on Pan evaporation, pan evaporation is a measurement of evaporation which consider the effects of different climatic conditions such as temperature, rain fall, humidity, drought, solar radiations and wind speed. Evaporation is more in summer season: hot, windy, sunny days and evaporation is less in Rainy season: cloudy, rainy, humid. There are five different evaporation pans such as, US Class A evaporation pan, ISI Standard evaporation pan, Colorado Sunken evaporation pan, USGS floating pan and small evaporation pan. The basic concept is, for US Class A pan the diameter of pan was 1210 mm and height or depth is 255 mm, it is made up of galvanized iron sheets, the pan should be placed at a height of 150 mm above the ground with the help of wooden platform or base, Evaporation rate is measured in the stilling well with the help of hook gauge. For ISI standard pan width was 1220 mm and depth were 255 mm, this is made up of copper sheets and should be placed 100mm above ground level. For Colorado sunken pan width was 920 mm and depth was 460 mm, this is made up of galvanized iron sheets and it was buried into the ground within 100 mm of the top. For USGS Floating pan width was 900 mm and depth were 450 mm, this was constructed on the surface of lakes or large water bodies for floating. As per this research the pans which discussed earlier was invented by researchers and those pans shows good results on evaporation. As per National weather service Class A pan is most widely used pan because of its best results.

Our study aim is to make the cheapest evaporation instrument, during the research we got to know that small pan Evaporation is the best way to exhibit that so we consider small pan evaporation method, since now no researchers in India willing to use small pan evaporation method for only reason that except small evaporation pan all the evaporation pans having approved or certified pan coefficient values Kp, and having a standard dimension. As per the national weather data the pan coefficient For US class A pan ranges from (0.6 to 0.8), For ISI evaporation pan (0.65 to 1.10), For colorado sunken pan (0.75 to 0.86), For USGS floating pan (0.7 to 0.82), from this study observation small evaporation pan coefficient ranges from (1.1 to 1.4).

The objective of this study is to Evaluate the efficiency of small evaporation pan under poly covered condition. To evaluate the efficiency of small evaporation, pan under open field condition. To reveal the the importance of using pan evaporation for irrigation scheduling. To reveal the evaporation rate of different water samples in different exposure condition.

2.MATERIALS AND METHODS

Our study was carried out in the Bidadi region of the Ramanagara district Karnataka - 562109. Exactly our study location is 77°24′47.63 E longitude and 12°46′27.91 N latitude and 32 km from Bangalore and nearby farmers uses Nelligudde lake water as a source through a small channel which is situated near the study area, the average annual rainfall is about 952 mm. The climate is generally

moderately hot and humid. The maximum and minimum temperature is From 36°C (March) and 16°C (January) respectively. The mean evaporation of the study area is 5.5 mm/day.

Small pan evaporimeter was constructed by galvanized iron sheets of 245 mm diameter and 110 mm depth or height, which is placed at an height of 150 mm above ground level with the help of wooden platform to allow free air circulation below the pan, the mesh like iron material is fitted to the pan to protect the water from birds, animals, Evaporation is measured using depth gauge of 0.1 mm accuracy. This evaporation study considers two different exposure conditions such as Open field and Poly covered condition with three different water samples such as Fresh water, Salt water and Sewage water.

Fig-1: Small pan

Fig-2: Depth gauge

Fig-3: Wooden platform fig-4: Temperature meter

The different water samples were taken to the study region and experiment was done on fresh water, which is available in the lake and sewage water is available in the Bidadi town but for salt water/sea water, we add 35 gram of salt per litre of fresh water because the sea water contains 3.5°/₀ salinity.

For open field Exposure condition, the study area selected is covered with medium natural vegetation, The wooden base was installed at the center place where no shadow occurs from nearby plants or trees, the area should be equally levelled. Then the small pan evaporimeter was placed above the wooden base, the sample which was taken was filled into the pan up to a level of 100mm, because to control sudden overflow of water due to rain. Then we cross checked the initial evaporation rate which is 0 mm. Using the electronic depth gauge the evaporation rate was taken at regular interval of 12 hours for 30 days in the month April (2022), during the observation we got an average daily pan evaporation rate as shown in chart-1 for the month April 2022.

Fig-5: open field

For Poly covered house Exposure condition the same installation procedure is adopted, the area where instrument was placed is at the centre place of poly covered house, using the depth gauge the evaporation rate was taken at regular interval of 12 hours for 30 days in the month of April 2022 for 30 days.

Fig-6: Poly covered house

From Both exposure condition observation, we got an average daily pan evaporation rate as shown in chart-1

The chart-1 shows the average daily evaporation rate for two different exposure condition with different water samples for the month April 2022, From the average daily evaporation rate for both the exposure conditions was used to calculate the pan coefficient.

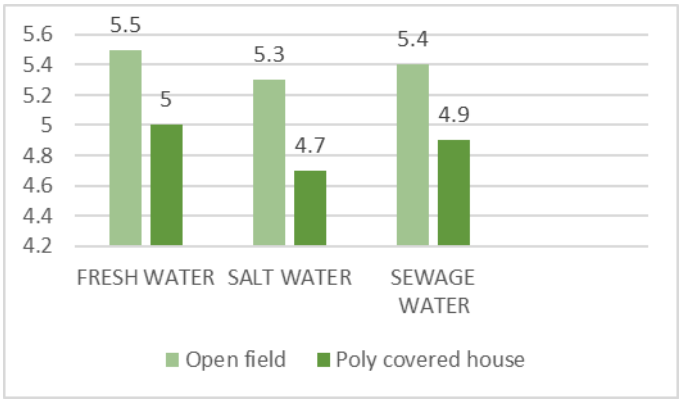
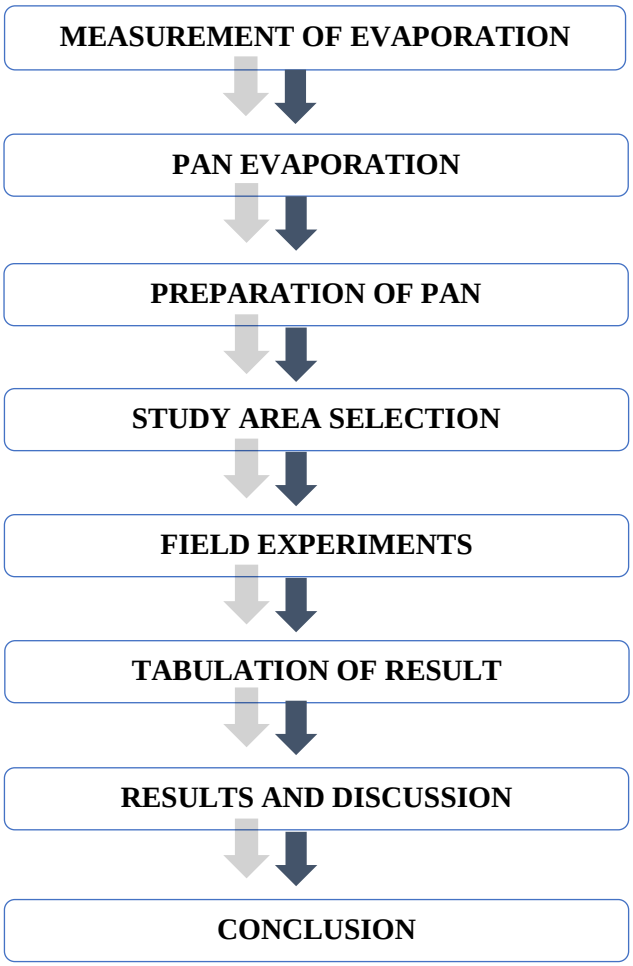


Chart-1



3.TABULATION OF RESULT

On a particular day in April month, we conducted experiment using fresh water in both exposure conditions. This study considers two meteorological parameters, temperature and wind speed. Temperature was measured using wire sensor electronic thermometer which ranges from -50^{0}C to 110^{0}C, the wind speed was measured using anemometer. Temperature and wind speed are used only as reference for evaporation rate, they are not considered for calculating pan evaporation.

Fig-7: Fresh water from the lake through Mini channel

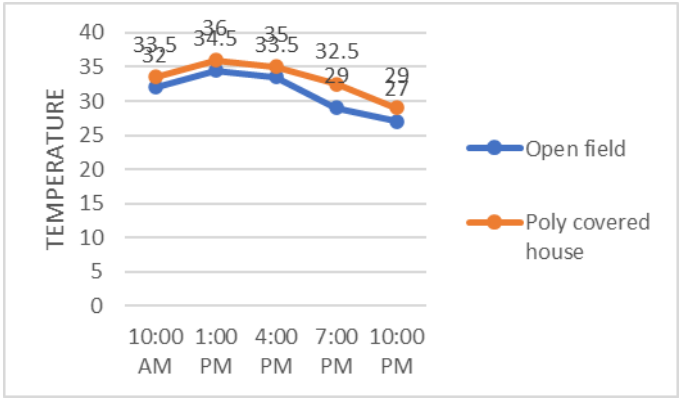


Chart-2

From the chart-2 the graph represents temperature variation with respect to time, it is observed that poly covered house has greater temperature than open field. But wind speed will be lesser in poly covered house compared to open field and Humidity is greater in poly covered house.

Fig-8: Measurement of Pan evaporation

Chart-3 shows the pan evaporation rate in millimeters for open field and poly covered house. this study was conducted for about 12hrs at regular interval of 3hrs. As in the open field temperature increases the rate of evaporation increases but from the result the graph shows rate of evaporation is higher in open field compared to ploy covered house, due to the action of humidity and wind speed.

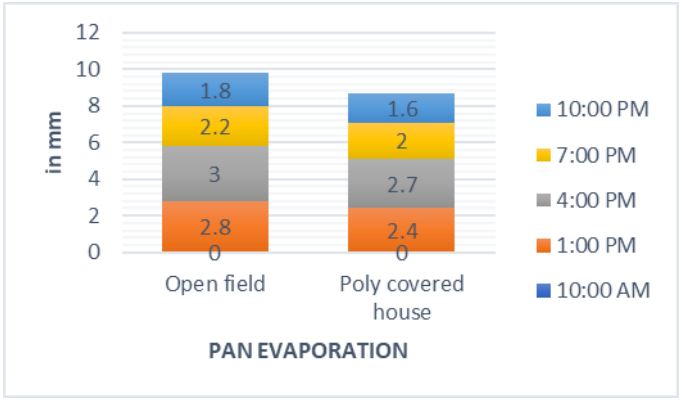


Chart-3

The total pan evaporation rate in open field was about 9.8mm, and in poly covered house it was about 8.7mm. Et = Epan x Kp. Where Et is actual evaporation, Epan is the pan evaporation and Kp is the pan coefficient.

Another day in the month of April the study was conducted for salt water sample in open field and poly covered house exposure condition.

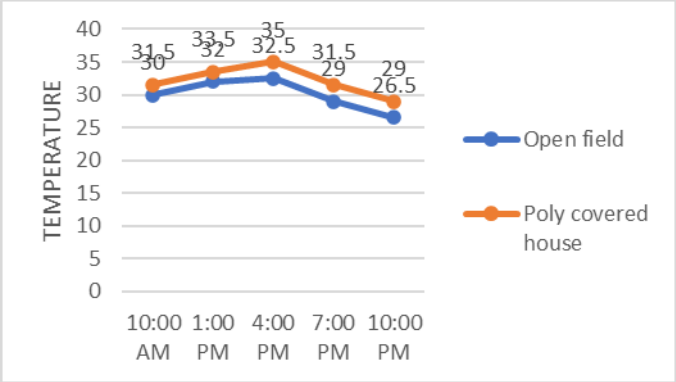


Chart-4

The chart-4 shows the variation of temperature with the time in that particular day, as seen earlier poly covered house has greater temperature than open field.

As shown in chart-5 the evaporation rate of salt water is open field is more than poly covered house. but the rate of evaporation of salt water is low compared to fresh water since salt water contains molecules which are bonded stronger so they need high energy to break their bond and Escape to the atmosphere. The actual evaporation is same as shown earlier, Et = Epan x Kp. The total evaporation in open field for salt water sample was 9.1mm, in poly covered house it was 8.1mm.

Fig-9: Measurement of Pan evaporation for Salt water

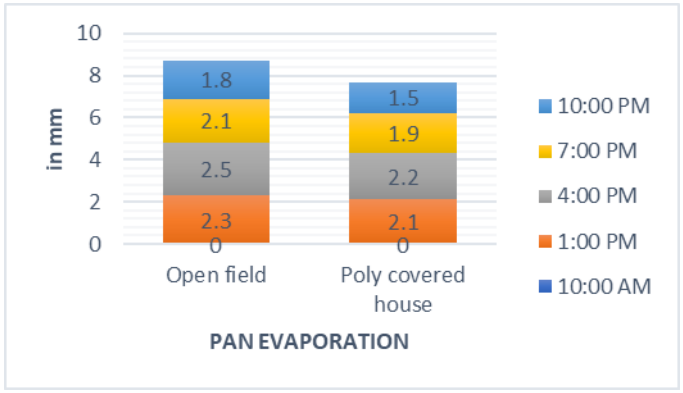


Chart-5

For sewage water sample a particular day in April month was taken and experiment was conducted. It was also conducted in both the field exposure condition.

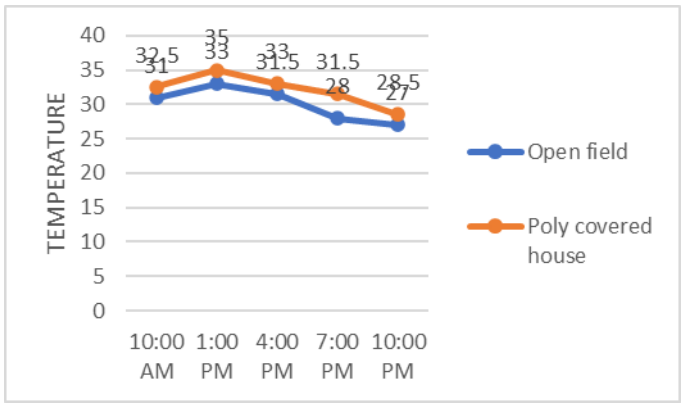


Chart-6

The chart-6 shows the temperature variation with respect to time in a particular day, in both poly covered house and open field.

Fig-10: Measurement of evaporation for sewage water

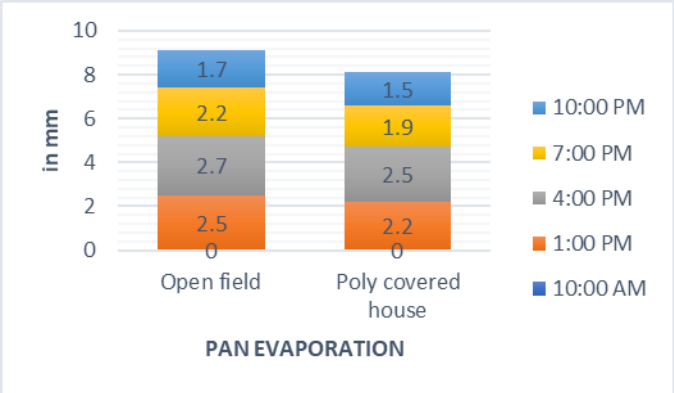


Chart-7

The evaporation rate in open field is more than poly covered house. since sewage water absorbs more heat from the atmosphere, the rate of evaporation is slightly more than salt water. The total evaporation in open field is about 8.7mm and in poly covered house 7.7mm.

Comparison of Fresh water, Salt water and Sewage water in the open field condition.

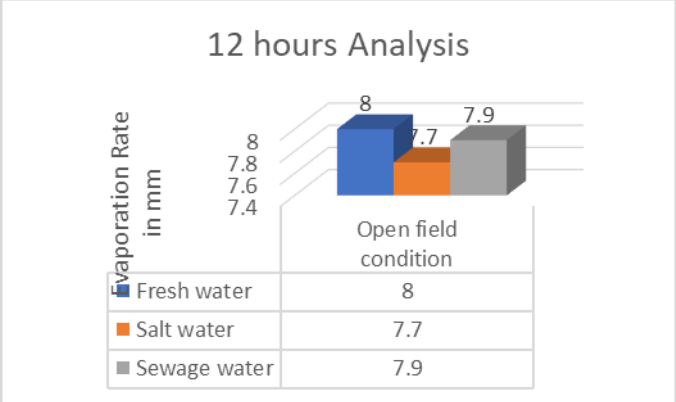


Chart-8

As Fig-11 and Fig-12 shows this study was taken for 3 water samples and tested in open field Exposure condition, the obtained results are 8mm,7.7mm and 7.9mm for fresh water, salt water and sewage water respectively. so the rate of evaporation is more in fresh water compared to other 2 samples. The measured ph value of fresh water was 7, salt water was 8, and sewage water was about 6.5, the evaporation in sewage water was faster than salt water, due to presence of turbidity which absorbs heat from the atmosphere, but in salt water due to presence of salt in it salt evaporation rate is lowered.

Fig-11

Fig-12

Fig-11 and Fig-12: Comparison of Fresh water, Salt water and Sewage water in Poly covered house condition.

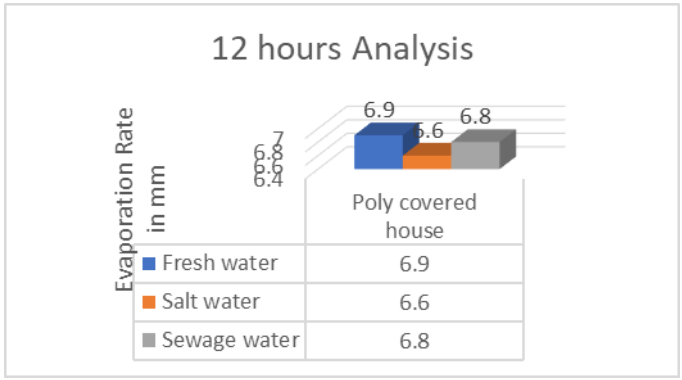


Chart-9

Fig-13 shows the evaporation rate of 3 different water samples at poly covered house condition. the temperature in poly covered house is more than open field due to heat trap. In this condition also the evaporation is higher in fresh water about 6.9mm, 6.6mm in salt water, and 6.8mm in sewage water. The water sample was kept for about 12 hrs and readings were taken at certain time intervals.

Fig-13

4.RESULTS AND DISCUSSION

From the tabulation of result obtained results are pan evaporation rate of 3 samples at two different exposure conditions. But Actual evaporation or Potential evapotranspiration is needed for exact evaporation results of that area.

Actual evaporation rate of that area PET = Epan x Kp, Where PET is actual or potential evapo transpiration. Epan is the pan evaporation rate, Kp is the pan coefficient. It is the

simplest formula to calculate the actual evaporation rate, Epan is obtained in tabulation of results and pan coefficient Kp is calculated using blaney criddle formula, Pan coefficient value of small pan is ranges from 1.1 to 1.4.

From Blaney criddle formula PET = $\frac{2.54 \times K \times Tm \times Ph}{100}$ in centimeters (cm), for millimeter (mm) multiplying the equation by 10. Where, K is the Crop factor, this study was conducted in the medium natural vegetation, so K=1, Tm is the monthly mean temperature in Fahrenheit (F) and Ph is the monthly percentage of annual Sunshine hours, Tm and Ph values are obtained in Climate/Data.org.

Tm value for April 2022 in study area was about 81.9F (27.7^{o} C), Ph value for the year 2022 was 2901.7 hours and April month 2022 was 319.65 hours, therefore the value of Ph = $\frac{monthly\ sunshine\ hours}{annual\ sunshine\ hours}$ x 100 = $\frac{319.65}{2901.7}$ x 100, Ph = 11.01, therefore PET = $\frac{2.54 \times 1 \times 81.9 \times 11.01}{100}$ x 10 = 229 mm, The monthy pan evaporation rate in April 2022 was 180 mm, so Kp = $\frac{PET}{Epan}$ = $\frac{229}{180}$ = 1.27 (pan coefficient for April 2022). From the pan coefficient the actual evaporation is calculated, for example in the April month one particular day the pan evaporation rate was about 6mm (Epan), then Et = 6 x 1.27 = 7.62 mm is the actual evaporation rate of the area.

The pan evaporation and actual evaporation values are in the pan diameter area, which means for 245 mm of area the results are obtained. In order to measure the evaporation rate for 1mm or 1cm or 1inches the obtained results as to be converted.

5.CONCLUSION

Small pan evaporation produces good results both in open field and poly covered house exposure condition. Small pan evaporation is cheapest and simplest method to calculate evaporation rates. This method can be used for different water samples with giving better results. The calculation of this method is convenient when compared to other evaporation measurements methods. The small evaporation pan is durable since it is made of galvanized iron sheets. Small pan evaporation can compete with large conventional evaporation pans.

6.REFERENCE

1) Awe Gabriel Oladele*, Akomolafe Tunde Nathaniel, Umam Japhet, Ayuba Margret Busola, 2020. Efficiency of small pan evaporimeter in monitoring evapo transpiration under poly-covered house and open-field conditions in a hot, tropical region of Nigeria: a case study, Nigeria, Journal of Hydrology: Regional Studies 32 (2020) 100735

2) Zhuo, H., Chen, B., Wang, S., Guo, Y., Zuo, B., Wu, L., 2016. Observation study on complementary relationship between pan evaporation and actual evapotranspiration and its variation with pan type. Agric.For.Meteorol.222,1–9.

3) Sajeena, S., V. Amrutha Gayathry and Sharmina, V.K. 2017. Estimation of Pan Evaporation Using Artificial NeuralNetworks – A Case Study.Int.J.Curr.Microbiol.App.Sci.6(9): 3052- 3065.

4) Edward T.Linacre, 1994. Estimating U.S Class A evaporation from few climatic data. Water International, 19 (1994) 5-14

5) Cahoon, J.E., T.A- Costello, and J.A. Rrguson, Estimating Pan Evaporation using Limited Meteorological Observations, Agricultural and Forest Meteorology. Vol. 55, 1991, pp. 181-190.

6) Kohler, M.A., TJ. Nordenson, and WE. Fox, "Evaporation from Pans and Lakes," Research hper 38, U.S. Lkpartment of Commerce, Weather Bureau, Washington D.C., 1955, 21 PP.