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Evaporation losses control in water surface by chemicals

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Abstract – The extremely high rate of Evaporation from water surfaces day by day is reducing the optimal utilization of water reservoirs. The work presented in this study aims to investing the use of Chemical films as Evapo retardars for reduction of evaporation from the open water surface so as to increase the storage efficiency. Particular emphasis will be on practical procedures and techniques that professionals can use to estimate and/or to suppress evaporation from shallow water bodies. The natural evaporation loss taking place from pan evaporimeters of two or more chemicals were observed and compared. The important meteorological factors affecting the natural evaporation such as Temperature, Relative Humidity, Wind Velocity, Sunshine Hours, etc. were also observed. Cetyl and Stearyl Alcohols were selected to reduce the evaporation during the study period in Newasa Phata Ahmednagar region with Class-A evaporation pan.

1. Introduction

Evaporation is a type of vaporization that occurs on the surface of a liquid as it changes into the gas phase when it reaches its boiling point. The surrounding gas must not be saturated with the evaporating substance. When the molecules of the liquid collide, they transfer energy to each other based on how they collide. When a molecule near the surface absorbs enough energy to overcome the vapor pressure, it will "escape" and enter the surrounding air as a gas. When evaporation occurs, the energy removed from the vaporized liquid will reduce the temperature of the liquid, resulting in evaporative cooling. On average, only a fraction of the molecules in a liquid have enough heat energy to escape from the liquid. The evaporation will continue until equilibrium is reached when the evaporation of the liquid is the equal to its condensation. In an enclosed environment, a liquid will evaporate until the surrounding air is saturated. Evaporation is an essential part of the water cycle. The sun (solar energy) drives evaporation of water from oceans, lakes, moisture in the soil, and other sources of water. In hydrology, evaporation and transpiration (which involves evaporation within plant stomata) are collectively termed evapotranspiration. Evaporation of water occurs when the surface of the liquid is exposed, allowing molecules to escape and form water vapor; this vapor can then rise up and form clouds. With sufficient energy, the liquid will turn into vapor.

2. Factors affecting the evaporation of Water Surface

Evaporation is a surface phenomenon and the quantity lost through evaporation from water stored, therefore, depends directly on the extent of its surface exposed to the atmosphere.

I. Temperature

The temperature of water and the air above it affect the rate of evaporation. The rate of emission of molecules from liquid water is a function of temperature. The higher the temperature, greater is the rate of evaporation.

II. Vapour Pressure Difference

The rate at which molecules leave the surface depends on the vapour pressure of the liquid. Similarly, the rate at which molecules enter the water depends on the vapour pressure of the air. The rate of evaporation therefore depends on the difference between saturation vapour pressure at the water temperature and at the dew point of the air. Higher the difference, more the evaporation.

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III. Wind Effect

The greater the movement of air above the water, greater is the loss of water vapour. Experimental studies on the relationship between wind speed and evaporation show direct relationship upto a certain value of wind velocity beyond which perhaps the relationship does not hold good. Factors like surface roughness and dimension of the water body are reported to have an important role to play.

IV. Atmospheric Pressure

Atmospheric pressure is very much related to other factors affecting evaporation. It is, therefore, difficult to assess its effect separately. The number of air molecules per unit volume increases with pressure. Consequently with high pressure, there is more chance that vapour molecules escaping from the water surface will collide with an air molecule and rebound into the liquid. Hence evaporation is likely to decrease with increasing pressure.

V. Quality of Water

The salt content in water affects the rate of evaporation. Experimental studies show that the rate of evaporation decreases with increase in salt content in water. In the case of sea water, the evaporation is 2 to 3% less as compared to fresh water, when other conditions are same.

3. Methods to reduce rate of evaporation

Although evaporation losses in the country are quite substantial, the evaporation retardant methods perhaps cannot be employed to all open surface water bodies, irrespective of their size and shape. In view of this, water conservation management by control of evaporation has so far been limited generally to drought prone and scarcity areas under specified wind speed and temperature conditions of the water bodies.

The methods of evaporation control can be grouped under two broad categories :

(i) Short term measures.
(ii) Long term measures.

A number of approaches have either been applied or considered by Engineers and Scientists in their attempt to Reduce evaporation losses from surface of water bodies.Since the basic meteorological factors affecting evaporation cannot be controlled undenormal conditions, efforts have so far been restricted to managing the suppression or inhibition of evaporation from water surfaces by physical or chemical means. The methods generally used or being tried are broadly listed below:

(i) Wind breakers
(ii) Covering the water surface
(iii) Reduction of exposed water surface
(iv) Underground storage of water
(v) Integrated operation of reservoirs
(vi) Treatment with chemical Water Evapo Retardants (WER).

4. Treatment with Chemical Water Evapo-Retarders (WER)

Chemicals capable of forming a thin mono-molecular film have been found to be effective for reducing evaporation loss from water surface. The film so formed reflects energy inputs from atmosphere, as a result of which evaporation loss is reduced. The film allows enough passage of air through it and hence, aquatic life is not affected. The film developed by using fatty alcohols of different grades has been found most useful for control of evaporation. These materials form a film of mono-molecular layer when applied on water surface which works as a barrier between water body and the atmospheric conditions. These fatty alcohols used for evaporation control are generally termed as chemical water evapo-retardants (WERs) and these are available in the form of powder, solution or emulsion.These chemical water evapo-retardants have the disadvantage of high cost of application. However, when adopted in scarcity period, drought, etc. the quantity of water saved by this method would work out cheaper than alternate means of bringing water from far off places by manual or mechanical transport. The economics of WERs application may however vary from site to site depending on local factors. The chemical water evapo-retardants have another limitation of the mono-layer breaking at high wind velocities. Following chemicals are generally used for water evaporation retardation:

(i) Cetyl Alcohol
(ii) Stearyl Alcohol
(iii) Ethoxylated Alcohols
(iv) Aquatain
(v) Cetyl Stearyl Alcohol

5. Experimental Setup

- Placing of evaporation pan.
- Filling, the tank with water upto 20cm
- Leave it from 8AM to 5PM
- Measure the level of water
- Take the reading and calculate Evaporation in mm
- Refill the tank upto the top face of stilling well with micometer
- Spread the chemical on the surface of water
- Take the reading and calculate evaporation in mm
- Calculate % of reduction in evaporation loss

6. Experimental Analysis

Properties of Chemicals:
An ideal material which can spread over water the surface and act as a sealant should possess the following properties:

- Tasteless, odorless, non-toxic and nonflammable.
- Form a compact mono-molecular film and develop a surface pressure of more than 20 dynes to prevent water molecules from escaping.

- Pervious to oxygen and carbon dioxide but tight enough to prevent the escape of water molecules. It should not resist the passage of sunlight: in other words, it should not affect the aquatic life.
- Economical and relatively stable.

7. Quantity of material

I. Application of cetyl alcohol @ 10 mg/sq. m. for every day. Surface area of pan having diameter 1.207. m is 1.144 sq.m. Therefore the quantity of cetyl alcohol to be used is 1.144*10 = 11.44 mg. Same amount of Stearyl alcohol and Cetyl Stearyl alcohol.

II. Application of Aquatain @ 50 ml/sq. m. for every day. Surface area of the pan is 1.144 sq. m. Therefore the quantity of aquatain used is 57.2 ml. Same amount of Ethoxylated alcohol

8. Experimental Observation

Chemical Used	Evaporation without chemical (mm)	Evaporation with Chemicals (mm)	Evaporation E = Kp*e (mm)	% Reduction
-	8	-	5.6	-
Cetyl Alcohol	-	6.5	4.5	18.75
-	8.5	-	5.95	-
Ethoxylated Alcohol	-	6.5	4.23	28.82
-	8.7	-	6.09	-
Stearyl Alcohol	-	6.025	4.21	30.74
-	8.4	-	5.88	-
Cetyl Stearyl Alcohol	-	6.05	4.23	27.97
-	9	-	6.3	-
Aquatain	-	5.37	3.76	40.31

- Atmospheric temp = 35-37 °C
- Wind Velocity = 8 m/sec
- Surface temperature of water = 27 °C
- Rate of evaporation = Initial volume of water- final volume of water

9. Experimental Calculations

For the class A evaporation pan, the K pan varies between 0.35 to 0.85.Average K pan = 0.7.

1. Cetyl Alcohol

- Evaporation without chemical = Kp*e
  = 0.7*8
  = 5.6 mm
- Evaporation with chemical = Kp*e
  = 0.7*6.5
  = 4.5 mm
- Percentage of redaction in Evaporation
  = 100-[(4.55/5.6)*100]
  = 18.75 %

2. Ethoxylated Alcohol

- Evaporation without chemical = Kp*e
  = 0.7*8.5
  = 5.9 mm
- Evaporation with chemical = Kp*e
  = 0.7*6.05
  = 4.235 mm
- Percentage of redaction in Evaporation =100-[(4.235/5.95)*100]
  = 28.82 %

3. Stearyl Alcohol

- Evaporation without chemical = Kp*e
  = 0.7*8.7
  = 6.09 mm
- Evaporation with chemical = Kp*e
  = 0.7*6.025
  = 4.21 mm
- Percentage of redaction in Evaporation = 100-[(4.21/6.09)*100]
  = 30.74 %

4. Cetyl Stearyl Alcohol

- Evaporation without chemical = Kp*e
  = 0.7*8.4
  = 5.88 mm
- Evaporation with chemical = Kp*e
  = 0.7*6.05
  = 4.235 mm
- Percentage of redaction in Evaporation =100-[(4.235/5.88)*100]
  = 27.97 %

5. Aquatain

- Evaporation without chemical = Kp*e
  = 0.7*9
  = 6.3 mm
- Evaporation with chemical = Kp*e
  = 0.7*5.375
  = 3.76 mm

- Percentage of redaction in Evaporation = 100-[(3.76/6.3)*100]
  = 40.31 %

10. Experiment Result

- The rate of redaction of evaporation by using Cetyl Alcohol is 18.75 %
- The rate of redaction of evaporation by using Ethoxylated Alcohol is 28.82 %
- The rate of redaction of evaporation by using Stearyl Alcoholis is 30.74 %
- The rate of redaction of evaporation by using Cetyl Stearyl Alcoholis is 27.97 %
- The rate of redaction of evaporation by using Aquatain is 40.31 %

11. Disadvantages of Chemical

- The chemical water evaporetardants have another limitation of the mono-layer breaking at high wind velocities.
- The chemicals which have to used is slight costly.
- In rainy season,Pan reading measurement is difficult.

12. Conclusion

Observing above results we conclude that Chemical films such as Aquatain are one of most feasible and cost effective evaporation retardants which reduce evaporation significantly.

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