INTRODUCTION

One has to understand the basic process of evaporation, the factors affecting the evaporation before one thinks about the evaporation control. Evaporation is the process by which the water is transferred from its liquid (or solid) state to the gaseous state through the transfer of heat energy. This heat energy is received from the sun in the form of solar radiations. On being absorbed at the surface of earth the earthly objects get heated up. Nearly two-third pan of the earth is covered by water. Water is present in the big oceans, seas, lakes, reservoirs, ponds, rivers, soils etc. Because of the transfer of heat energy the top mono-layer of water surface gets warmed up. The molecules forming the layer get energized but they remain in the main water body because of the cohesive forces of surface tension. When these energized molecules receive sufficient energy to overcome the cohesive forces, they eject out of the water body and join the atmosphere close to the vicinity of the water body. The atmosphere already consists of molecules of gases like Nitrogen, Oxygen and Carbon-di-oxide etc. along with water molecules already evaporated earlier. Some of the newly evaporated water molecules collide with the molecules of air and on being rebounded join back the water body. Thus, a two way traffic of water molecules being ejected out. and, on being rebounded back their joining the water body continues. The net loss of water molecules from the water body causes the "loss" of water due to evaporation. This in turn is gain of water in its gaseous state by the atmosphere. During the process of ejection of water molecules and its rejoining back the water body it interacts with the atmospheric losses. It gets enriched in its oxygen content. It transfers its heat energy to atmosphere and thus causes cooling of the water surface on joining back the water body.

Loss of Water Due to Evaporation

Water is present in nature in three basic physical forms i.e. solid (viz. Snow ice), liquid (viz water) and vapor (viz atmospheric moisture). The communities (i.e. flora and fauna) can make use of water only when it is in liquid form. Its transfer to vapor state due to evaporation is termed as "loss" as the evaporated water has no local economic worth and is not usable (i.e. for the purpose of drinking, irrigation or power generation etc.). Speaking in terms of hydrology it is not a loss. Water remains a part of hydrologic cycle. The process of evaporation is essential and basic necessity. It supplies moisture to atmosphere and causes humidity to it. This humidity is responsible for the precipitation to occur which is the source of water on the surface of earth.
Factors Affecting Evaporation

Relevant to the coverage and scope of this course, the following factors are important for the basic process of evaporation.

(a) Saturation deficit.
(b) Wind transport,
(c) Quality of water, and
(d) Physical factors like nature of surface, temperature etc.

A brief discussion of these factors is as follows:

The Saturation Deficit

Among all the physical parameters this is the most important one. Rather one can say that evaporation continues so long saturation deficit exists. Other physical parameters may influence the proceeds of evaporation in positive or negative manner. The saturation deficit is to exist so long the number of water molecules leaving the water body are more than the number of water molecules joining back to it (i.e. water body). It is measured in term of vapor pressure which is a function of temperature.

Vapor Pressure (or Water vapor pressure)

Every liquid is subjected to the process of evaporation. According to Dalton's law of partial pressure since the air is a mixture of gases, therefore, the total pressure exerted by it is the sum of pressures exerted by all the component gases of the atmosphere. For this purpose, the water vapors present in the atmosphere act like the "component gas" of the atmosphere.

Total pressure exerted = Pressure exerted by dry atmosphere + Water vapor pressure
By the atmosphere

Thus, the atmospheric pressure is more or less depending upon the water vapor pressure.

Saturation Conditions, Saturation Vapor Pressure

Saturation conditions are said to exist when the atmosphere can no longer accept more water vapors due to the process of evaporation. This means the number of water molecules leaving the water body equal the number of molecules joining back the water body. The pressure exerted under saturation conditions is called the saturation vapor pressure and is denoted by e_s. Thus, the saturation vapor pressure (e_s) is the sum of pressure of dry air and water vapor pressure at saturation conditions. The saturation
deficit is the difference between the saturation vapor pressure ($e_s$) at the given temperature and the existing vapor pressure of air ($e_a$)

Saturation deficit $\alpha (e_s - e_a)$

Saturation vapor pressure of mono layer of water body is termed as ($e_w$). and therefore

$E$ (Evaporation) $\alpha$ Saturation deficit $a (e_w - e_a)$

$E \alpha (e_w - e_a)$ where $e_a$ is vapor pressure of air.

Standard tables are available where saturation vapor pressure ($e_s$) are given for different temperatures ($°C$). In order to determine ($e_w$), the temperature of water body at its surface ($t_w$) is measured and from the tables corresponding to it the saturation vapor pressure is determined (i.e. $e_s$ at $t_w = e_w$). The air temperature ($t_a$) is also measured and corresponding to it the saturation vapor pressure (i.e. at air temperature. $t_a$) is determined. The relative humidity (R.H.) is experimentally obtained

$e_a$ (vapor pressure at $t_a$) = [(e_s)] at $t_a$ * R.H.

Alternatively: In an experimental set up the air temperature is lowered to determine the dew point

$e_a = (e_s)$ at dew point temperature ($t_d$) of air.

It may be remarked that all these conditions which tend to increase the saturation deficit will increase the loss of water from the water body.

**WIND TRANSPORT**

Wind provides a transport for the water molecules evaporated from the water body. Thus, it helps in maintaining the "saturation deficit". In the absence of winds, the air in the vicinity of water surface of water body will attain saturation conditions early. The saturation deficit will keep decreasing, and consequently, the evaporation will continuously decrease. Thus, water bodies surrounded with wind barriers (i.e. high mountains) are subjected to less "evaporation loss".

**Quality- of Water:** Impounded water rich in dissolved ionic salts have larger surface tensions and thus the evaporation losses are smaller. Due to this fact the evaporation from sea waters and brakish and saline water lakes is less than those from the fresh Water bodies.

**Nature of Surface:** A significant amount of moisture in atmosphere comes through evaporation from soils. The heat budget of dark colored soils, loose soils, sandy soils and upward convex soils is more and. therefore, the evaporation from them is also more.
EVAPORATION CONTROL MEASURES

All those factors which are either responsible for the evaporation or tend to promote the evaporation, if restricted, will tend to control the evaporation from the water bodies. These measures can be put and discussed under the following two main subheads.

(a) Measures to be Taken at Planning Stages.

The following measure if taken at the planning stages of reservoirs will reduce the loss of water due to evaporation.

(i) Minimum Surface Area: Water is evaporated through the surface which interacts with the atmosphere. All factors remaining to be the same, if choice is available between two possible sites for a reservoir, site in deep gorge, where for the same volume of storage, the surface area open to atmosphere is much less, is always preferable compared to the one in plain areas where open surfaces are large. This will considerably reduce the total water loss.

(ii) Altitude of Reservoir Site: Reservoir in mountainous gorges at higher altitudes are preferable. Firstly, the air and water surface temperatures will be low and in close vicinity. Therefore, the saturation deficit will be less and evaporation rate from the water body will be less. This will reduce the total evaporation loss from the reservoir. Secondly, the surrounding high mountains act as wind barriers. Air in the absence of an efficient wind transport, gets saturated with evaporated moisture in the near vicinity of water surface. This reduces the rate of evaporation and eventually the total water loss due to evaporation is reduced. Contrary to it, in plain areas temperature are expectedly more in tropical conditions and accordingly wind activity is intense. This promotes the evaporation rates and total loss of water due to evaporation.

(iii) Planning or Underground Reservoir: If impounding of huge volumes are not involved, as in case of municipal reservoirs, it may be desirable to plan ground water storage reservoirs. For these reservoirs interaction with open atmosphere is curtailed. No wind transport is available. Hardly any saturation deficit exists as the reservoir surface water temperature and temperature of small air above it remains same and air remains completely saturated with moisture. Loss of water due to evaporation is thus negligible.

(b) Measures of Evaporation Control for Constructed Water Projects

Effectiveness of such measures mostly depends on how effectively interaction between the water surface and the atmosphere is curtailed. The following methods have been tried.

(i) Mechanical Covers: At the surface of water mechanical covers are provided which serve the purpose of a barrier between the water surface and the atmosphere. A wooden mesh or a mesh made out of interwoven bamboos have reportedly given good results. Near ten to fifteen percent cut in evaporation loss has been reported through the use of such covers.
(ii) **Thin Film of Oils**: Among all methods, use of thin film of oil has been found to be the most effective method in checking the loss due to evaporation. If the film of oil remains without break, the evaporation loss can be fully curtailed. However, desirability of its use is highly questionable.

(iii) **Use of Mono molecular Layers**: Under this head comes application of mono molecular layer of fatty acids and cetyl alcohol. The higher series of alcohols are found in solid state. When crushed and powered they attain very small particle size almost close to molecular sized particles. Through special techniques when spread over the water surface, the powdered cetyle alcohol provides a near monolayer on the surface of water and provides a complete barrier between the water surface and the atmosphere. Practical difficulty lies with the problem that the wind and wave action does not permit the spread and it accumulates in pockets of reservoir. This was tried in the case of AJI Lake in Gujarat and success was to the tune of 15 to 30 percent reduction in loss due to evaporation.

**ENVIRONMENTAL CONSTRAINTS**

Any methodology, in whatever manner is applied for the check of evaporation, beyond doubt, is an interference into the natural process. Therefore, it has negative impact on the environment. Effectiveness of checking evaporation loss depends on how effective is curtailment of interaction of water surface with the atmosphere. This reduced interaction with the atmosphere eventually results into loss or reduction of oxygen of water body. This causes danger to entire aquatic life. If oxygen at the bottom of water body is fully curtailed, pathagenic bacteria start developing and septic conditions start developing. Thus, the quality of water becomes unsafe for the entire community of fauna for whose benefits the projects are envisaged.