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ORIGINAL ARTICLE

Use of palm fronds as shaded cover for evaporation reduction to improve water storage efficiency

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Abstract Water bodies in arid surroundings can be subject to high evaporation losses due to oasis effect. Evaporation raises the storage requirements of water bodies and lowers the yield. Covering of water bodies can help in reducing evaporation. The work presented in this study aims at investigating the use of palm fronds as shaded cover for the reduction of evaporation from the open water surface so as to increase the storage efficiency. The material used for cover was locally available palm fronds which are a massive agricultural waste and environmental friendly by-product in Saudi Arabia. Pan evaporimeters were used in the present study. One pan was covered like a shade made of palm fronds, which were tied up on mesh wiring while the other was kept without any cover. Initially a single layer of cover was used as shaded cover which was replaced by a cover of two layers of palm fronds in order to see the effect of thickness of cover on overall evaporation. It was observed that the average reduction in evaporation in the covered pan (with single layer of cover) was about 47% as compared to the evaporation from the open pan. However, the average reduction in evaporation in the covered pan (with double layer of cover) was about 58% as compared to the evaporation from the open pan.

1. Introduction

Water is the most precious natural resource in the world, especially in Saudi Arabia with arid climate and limited resources of surface water. Evaporation losses from small reservoirs affect their water storage efficiency. Evaporation from open water bodies such as wetlands, reservoirs and lakes often represents the largest loss in their local hydrological budget, yet its quantification still continues to be a theoretical and practical challenge in surface hydrology. Water bodies in arid surroundings can be subject to high evaporation losses due to the oasis effect. These high rates are due to energy advection, or extra energy input from the dry surroundings. Evaporation raises the storage requirements of water bodies and lowers the yield. Rate of evaporation from open water surfaces varies with the temperature or vapour pressure of the water and the air in contact with it, and further more the wind speed, barometric pressure and water quality. The annual rate of evaporation in Saudi Arabia is 3000 mm. Natural evaporation takes place by the exchange of water molecules between air and a free water surface (Ikweiri et al., 2008). This water surface could be a lake, pond or river. In the present study a Pan evaporimeter was used as a water surface. A Pan evaporimeter is a stan-

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dard evaporation pan based on the US Class A pan, originally developed by the US Weather Bureau.

Covering of water bodies can help in reducing evaporation. There are many materials; chemicals and physical covers which can effectively and efficiently reduce the evaporation from open water bodies. Such types of materials are used to suit the local climatic conditions and availability as well. There has been an increased focus on evaporation control techniques which can be applied to water storage due to severe drought conditions in many parts of the world (Anonymous, 2003). In a similar study Barnes (1993) found that monolayer is potentially most effective in conditions where the rate of evaporation is high. The study by Alvarez et al. (2006) on different types of shading meshes reveals that the shading of pan induced a significant decrease of the daily evaporation rate, ranging from 50% for the aluminized screen to near 80% for the coloured-polyethylene meshes.

Craig et al. (2007) observed that the use of physical cover was able to reduce evaporation substantially, they suggested that these types of covers would be more effective with small reservoirs (less than 10 ha in size). However the physical covers can also be used for large reservoirs but it could be uneconomical.

Recent study done by Al-Hassoun et al. (2009) on impounding reservoirs found that the average reduction in evaporation using the floating cover made up of palm leaves was 63% for the fully covered pool while for the half covered pool it was 26% only.

Palm tree is considered to be one of the most important commercial crops widely distributed across the Saudi Arabia capable of withstanding extremely hot weather conditions of the arid region (Al-Juruf et al., 1988). The number of trees in the Kingdom is estimated to be over 21 million. These trees are estimated to yield about 210,000 tons of fronds (Al Gassim Dates Factory, 2011). Every year many palm trees have to be pruned (about three million trees a year), moreover this amount is evenly distributed all over the country which makes it particularly attractive for its use in the development or control project which benefits every part of the country. After pruning, fronds are considered as disposed waste.

Present study proposes the use of Palm fronds as shaded cover for the reduction of evaporation from the open water surface.

2. Materials and methods

2.1. Experimental setup

Pan evaporimeters were used in the present study. One advantage of evaporation pan is that they incorporate all possible physical effects (Roderick et al., 2007). A Pan evaporimeter is a standard evaporation pan based on the US Class A pan, originally developed by the US Weather Bureau. A US Class A pan is a circular tub of 1210 mm internal diameter; 250 mm deep and is constructed of one millimetre thick galvanised steel sheet. The evaporation pan was installed, set and leveled on the roof of the department of Civil Engineering building, King Saud University, away from any obstacles which may obstruct a natural air flow around the pan, thus representing open water in an open area. Pans were always covered with open mesh wiring to stop animals and birds from drinking or using water.

2.2. Material of pan cover

The material used for cover was locally available palm fronds which are a massive agriculture waste and environmental friendly by-product in Saudi Arabia One pan was covered like a shade made of palm fronds (Fig. 1), which were tied up on mesh wiring while the other was kept without any cover (Fig. 2). Shaded cover reduces the energy available for evaporation; reduces wind action over the water surface and traps humid air under the cover, all factors that contribute to evaporation. Initially a single layer of cover (1.9 mm thick) made of palm frond was used as shaded cover which was replaced by a cover of two layers of palm fronds (3.8 mm thickness) after three months in order to see the effect of thickness of cover on overall evaporation.

2.3. Recording of data

Evaporation was measured by measuring changes in water level in the pan. This was done manually with point gauge. The data were recorded at 9:30 am and 2:30 pm daily except weekends (Thursday and Friday). The amount of evaporation is a

Figure 1 Evaporation pan covered with palm fronds.

Figure 2 Evaporation pan without cover.