ANNALS OF FACULTY ENGINEERING HUNEDOARA
- INTERNATIONAL JOURNAL OF ENGINEERING
Tome IX (Year 2011). Fascicule 3. (ISSN 1584 - 2673)

[1.] Ala'a M. DARWISH, [2.] Wameedh G. ABDUL-HUSSEIN, [3.] Tala A. Al-KHATEEB

A THEORETICAL ATTEMPT TO INCREASE THE AMOUNT OF WATER FLOWING THROUGH THE NILE

[1.2.3.] BUILDING AND CONSTRUCTION ENGINEERING FACULTY, UNIVERSITY OF TECHNOLOGY, BAGHDAD, IRAQ

ABSTRACT: The Nile which is considered as the longest river in the world was known of its repetitive floods. Many dams had been built across its path to regulate its current around the year and to produce electricity. This process continued in the nine countries sharing the river. The result is a reduction in the amount of water flowing through its basin especially at the downstream countries like Egypt. Taking into account the increase of population and the Global climate change which are increasing factors for water demand the problem of water scarce is increasing day after day. In this research an experiment was done to measure the amount of water that can be saved by partially preventing the natural evaporation process. The idea consists of covering of 50% and 25% of the top surfaces of water in small laboratory pans. The weight of the evaporated water was monitored with time. Floating Styrofoam pieces having the size of 20x20x2mm have been used. Styrofoam material has the ability to float permanently to cover the water and to protect it from direct sunlight and heat. It was found that; covering of 50% of the top water surface might save 39% of the amount of water lost by evaporation. Lake Nasser which is situated at the entrance of the Nile to Egypt has an area of 5250 square kilometers. 10 km^3 of its fresh water is evaporated each year. The application of the result of this research by covering 50% of the top water surface of Lake Nasser by using 1000x1000x10mm Styrofoam pieces might save about 3.9 km^3 of fresh water annually which equals to an increase of 7% of Egypt's share of the annual flow of the Nile.
KEYWORDS: Evaporation, Natural water, Water saving, Styrofoam, Lake Nasser, Nile

❖ INTRODUCTION

The 6800 km long Nile is considered as the longest river in the world. It originates in the following African countries KENYA, TANZANIA, UGANDA, RWANDA, BURUNDI, ZAIRE and ETHIOPIA. Then it flows northwards through SUDAN and EGYPT and finally empties in the Mediterranean Sea. [1] The Nile's discharge is about 300 million cubic meters per day. This huge amount of fresh water is passing through a path of 8-11m deep and in an average width of 2800m (varying from 7500 to 350m). The upstream sources are located in humid regions, with an average rainfall of over 1000mm per year. The arid region starts in Sudan to only an average of 20mm per year in the north. Further north, in Egypt, precipitation falls to less than 20mm per year. While the Nile was known of its fluctuating discharge and its destructive floods through history, the increasing water demands and the construction of huge dams across its path reflect the situation to a water shortage dispute between the related countries.

Fig. 1. Lake Nasser in Egypt

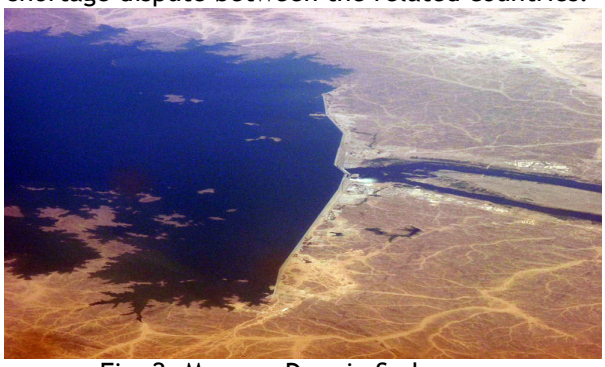


Fig. 2. Merowe Dam in Sudan

One of the greatest dams is the High dam (As'sad alaly) in Aswan, Egypt. [2]The High dam was constructed between 1960 and 1970. It aimed to enhance the country's economy by providing storage of water for agriculture and to generate 2.1 giga-watts of hydroelectricity. The 111m tall dam can hold 111 cubic kilometers of water, its reservoir (Lake Nasser, see Fig 1) is 550km long and 35km at it's widest with a surface area of 5250 square kilometers. [3]

Evaporation from Lake Nasser is estimated at 10 km^3 per year. The absolute amount of water lost to evaporation is enormous; it is estimated as 11% of the average volume stored in the Lake and 18% of Egypt's share of the annual flow of the Nile. While most of the water resources of Sudan and Egypt

originate outside their borders: 77% of Sudan's and more than 97% of Egypt's water resources are depending upon the Nile. [4]

Ethiopia, the source of 85% of Nile's flow, recently began construction of a massive hydropower project that will make it an energy exporter. [5] Three hydropower plants with a combined capacity of 1.18 GW were commissioned in 2009 and 2010 alone. The largest hydroelectric plant in Ethiopia, Beles, began initial operation in 2010. Contracts for five more large dams have been signed. Once completed, which is expected to be around 2015 the flow of the Nile could be reduced by 3km^3 per year, equivalent to about 5% of the current allocation of Egypt under the 1959 agreement. [6] It is in the delta, on some of the most fertile land in the world, that rice farmers have been ordered to plant fewer acres to conserve water as Ethiopia and other nations threaten to siphon away millions of gallons before the river reaches Egypt.

[7], [8] the fast increase of populations from 1950 to 2011in Egypt (21- 82 million) and in Sudan (9- 41 million) shows the great increase in water demand. Adding the fact of Global climate change in those dry countries, serious water scarce will certainly arise and augment year after year.

Sudan has inaugurated Merowe Dam on March 3, 2009, see Fig 2. A dam which is situated 350 km north of the capital Khartoum having a storage capacity of 12.5 km^3, or about 20% of the Nile's annual flow. The reservoir lake is planned to extend 174 km upstream.[9]

Regarding water lack, it is obvious that Egypt will be the most suffering country. Politicians, journalists and media are alerting that; [10] the next war among countries will not be for oil or territorial borders, but only for the problem of water. International organizations are figuring out the problem but with no decisive solution. [11] In 1998, the UN identified lack of freshwater as one of the major problems facing humanity. There have been various efforts to bring co-operations among the Nile counties but there has been little to no success.

This theoretical research is an engineering attempt to assess the amount of water that can be saved by preventing its evaporation with the use of partial covering to the top surface of Lake Nassir- the reservoir of Al-Sad Alaly in Egypt. The expected saved water might be added to the existing Nile discharge to reduce the problems between neighboring countries due to water lack. One of the physical phenomena stated that; the evaporation process is increased by the increase of three factors; Temperature degree, wind velocity and surface area. While the first two natural factors are difficult to be changed, the surface area is considered as the only factor that can be adapted to reduce water loss by evaporation. The surface area of water is decisive regarding evaporation. Whatever the quantity of water was, if it sprayed over an infinite area will require no time to be evaporated while the same water quantity could be totally saved if it flows through a sealed pipe.

❖ MATERIALS USED

The following materials and tools were used to perform the test:

1- Three tapered plastic pans having the following dimensions: Upper diameter is 25cm; Lower diameter is 15cm and a depth of 12cm.
2- 20 x 20 x 2mm pieces of Styrofoam sheets having a density of 100kg/m^3.
3- Thermometer.
4- Scale.

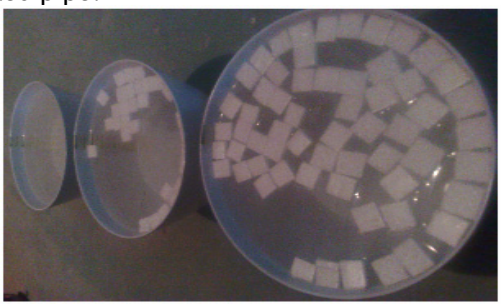


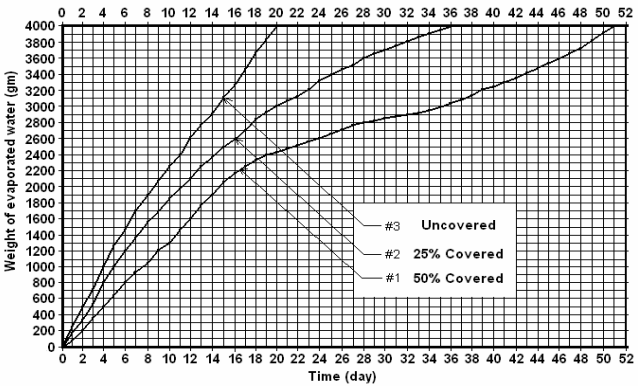
Fig. 3. The three pans after three days

❖ TESTING PROCEDURE

Each of the three plastic pans was filled with 4kg of water. Pieces of Styrofoam having the size of 20 x 20 x 2mm were floated to cover an area of 245.5cm^2 which was equal to 50% of the top surface area of pan#1. With similar pieces of Styrofoam only 25% or 122.75cm^2 of the top surface area of pan#2 was covered. Pan#3 was uncovered to be as a reference for free evaporation. All other circumstances, wind, temperature degrees and water temperature were the same for the three pans. See Fig 3.

Table 1. Weight of evaporated water with time

Time(day)	Weight of evaporated water (gm)			Time(day)	Weight of evaporated water (gm)		
	50% covered	25% covered	0% covered		50% covered	25% covered	0% covered
1	90	180	225	27	2770	3520	
3	360	525	720	29	2825	3650	
5	625	1000	1280	31	2880	3760	
7	930	1380	1700	33	2920	3880	
9	1210	1700	2080	35	3000	3950	
11	1470	1980	2410	37	3090	4000	
13	1760	2250	2770	39	3210		
15	2050	2500	3100	41	3300		
17	2260	2700	3480	43	3410		
19	2400	2930	3840	45	3540		
21	2490	3080	4000	47	3670		
23	2570	3210		49	3840		
25	2660	3400		51	4000		



Graph1. Water evaporation with time

During the test the air temperature was ranging from 32 to 42 °C with an average of 36 °C. The weight of the evaporated water was recorded daily for each pan as shown in table 1. The experiment took 51 days to be terminated after the complete water evaporation in pan#1. It should be noted that the uncovered pan#3 had lost its water rapidly after 21 days, while pan#2 which was partially covered had lost its 4kg of water after 37days.

Test results were drawn in Graph 1 to show the daily evaporation of water in each pan. It can be seen that after 20 days the covering of 50% of the top water surface might save 1550x100/4000= 39% of the evaporated water and 1000x100/4000= 25% of the evaporated water if only 25% of the top surface was covered. The Graph also shows that the inclination of the curve of the uncovered pan#3 is approximately straight during all the period of 20days that was required to evaporate all the water in that pan while the inclinations of the other pans#2 and #3 started to be approximately straight during the first two weeks then flattened with time. That was because of the tapering of the pans which might simulate the real shape of actual lakes and water reservoirs. The Styrofoam pieces started to cover 50% and 25% and finished to cover 140% and 70% of the top water surfaces of pan#2 and pan#3 respectively.

❖ DISCUSSION

It is clear that there is a direct relation between the amount of the evaporated water and its top surface area. Covering part of the top water surface with a floating waterproofing material will reduce the surface area then will reduce the rate of evaporation. The low thermal conductivity of the Styrofoam will protect the water from being heated by direct sunlight; that will also be reflected in a further retardation in evaporation process because that; the decrease in water temperature means a reduction in its evaporation rate. Moreover, the white color of the Styrofoam will successfully reflect sunlight and therefore it will keep the water cooler and more inert regarding evaporation. This experiment might give an initial indication of how to protect natural water from excessive evaporation. The experimental size of Styrofoam pieces of 20 x 20 x 2mm might be enlarged 50 times to be 1000x1000x100mm for actual use.

Reducing the amount of evaporated water will not only save water but will improve its quality due to the reduction of water salinity concentration.

It should be mentioned that actual wind, waves and water currents will have a noticeable effects in practical application. Some losses should be expected due to the mentioned factors which will create a percentage of overlapping of the Styrofoam pieces which means a reduction in the covered area and a decrease of the fine results that had been reached in the laboratory. Anyway, it is worth trying for its low cost and great expected results for saving valuable natural pure water.

If 50% of the top surface of Lake Nassir (5250/2= 2625 square kilometers) covered with Styrofoam pieces of 1000x1000x100mm, then 39% of the estimated 10 km^3 of the annual evaporated water can be saved. That is 3.9 km^3 of fresh water which equals an increase of (3.9/10x18 %=) 7% of Egypt's share of the annual flow of the Nile.

Also, if 25% of the top surface of Lake Nassir (5250/4= 1312 square kilometers) covered with Styrofoam pieces of 1000x1000x100mm, then 25% of the estimated 10 km^3 of the annual evaporated water can be saved. That is 2.5 km^3 of fresh water which equals an increase of (2.5/10x18 %=) 4.5% of Egypt's share of the annual flow of the Nile.

❖ CONCLUSIONS

The following conclusions can be derived:

- Reducing the top surface area of a lake or a water reservoir will reduce the amount of the lost evaporated water.
- Floating Styrofoam pieces can be used to partially cover the top surface of water.
- Covering of 50% of a top water surface will save 39% of the evaporated water, while covering of 25% of it will save 25% of the lost water.
- Using of 1000x1000x100mm Floating Styrofoam pieces can reflect the direct sun light keeping water cooler and more inert to be evaporated.
- Reducing the quantity of evaporated water will improve water quality by reducing its salinity concentration.
- The saved amount of water can be added to the existing water.

- It is expected that this result can be applied in a large scale as in the case of Lake Nassir in Egypt to save about 3.9 km^3 of fresh water annually which equals to an increase of 7% of Egypt's share of the annual flow of the Nile.
- More researches are required to be done to study the effects of Winds, Waves and overlapping of Styrofoam pieces in actual cases compared to the laboratory results.

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