

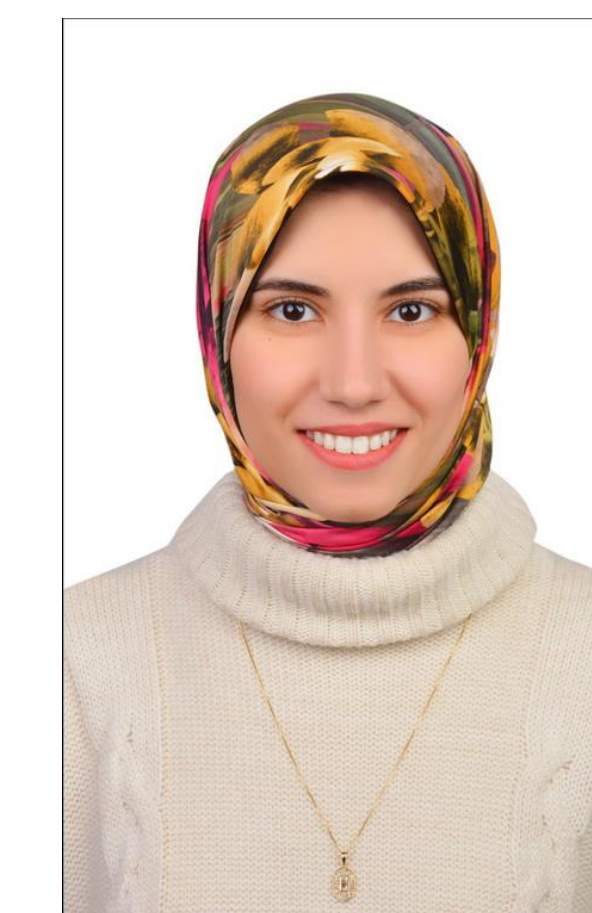
The influence of floating spheres on evaporation suppression under different climatic conditions

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water availability and evaporation:

Water is the most limiting resource for mankind in many parts of the world, due to **rapid population growth** and **climate change**. Increased rainfall variability is associated with **drought and flood risks**, increasing the need for **dams and reservoirs** to ensure water availability and stability.

However, In **arid and semi-arid zones**, up to **30-50%** of reservoirs' capacity is lost by **evaporation**, resulting in low overall water use efficiencies and affecting water availability and stability.

In **Egypt**, about 12.1 to 15.4 billion m³ (about **20%** of the country's Nile share) are lost annually by evaporation from lake Nasser.

Physical floating covers effectively decrease evaporation

Floating spheres to reduce evaporation losses:

- Reflect the incoming solar radiation.
- Act as physical barriers that hinder the escape of water.
- Allow for gas exchange and light penetration through gaps between spheres.
- Automatically rearranged and reinstalled after the water level changes or the wind-wave.

Research Gaps:

1. Seasonal comparisons between different color of floating covers in dissimilar environments are limited.
2. No study investigated the influence of covers on water ecology.

Objectives:

1. Comparing between spheres color (white, black, multicolor) to reduce evaporation rate (ER) into different climatic condition.
2. Investigating the influence of floating spheres on water ecology.

Exp. (1): evaporation suppression into different climatic conditions:

Class A Pans were covered with spheres in two locations (E. Awinat and Damanhour, representing Northern and Southern Egypt, respectively) over nine months (March to November-2019).

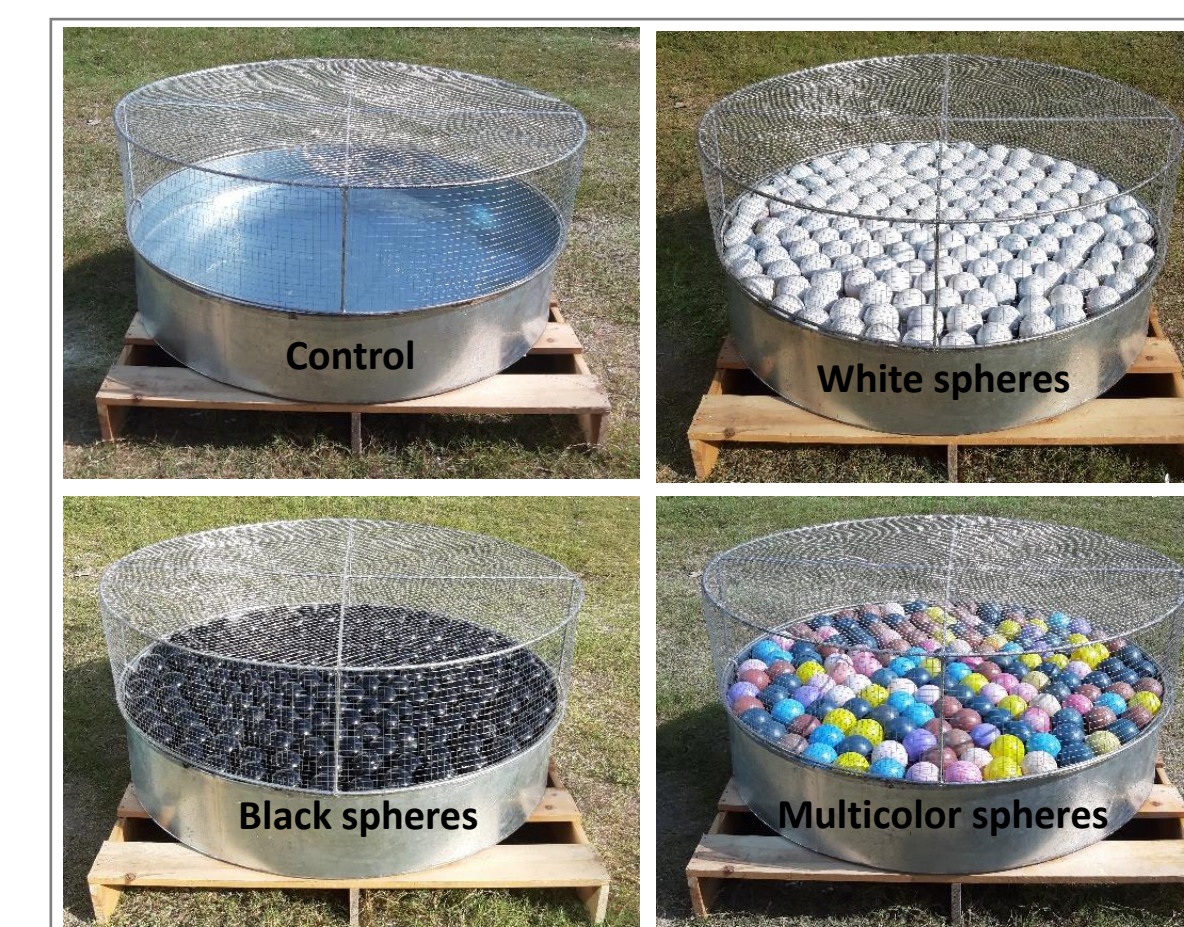


Figure (2): Class-A pans experiments in outdoor setting.

Climate:

Climate is typically arid Mediterranean in Damanhour and arid in E. Awinat.

Measurement:

The measurements of ER (evaporation rates) were collected within three consecutive days, resulting in ten measurements every month.

Results:

- Floating spheres reduced ER (especially in **summer months**) in both locations with white spheres possessed the greatest effect.
- The average saved water in E. Awinat were almost twice higher than Damanhour. And it was 5.17, 4.43, and 4.58 mm d⁻¹ for white, black, and multicolor spheres, respectively in E. Awinat. And in Damanhour, they were 3.02, 2.63, and 2.73 mm d⁻¹.
- The evaporation suppression efficiency (ESE) in Damanhour was nearly 1.35 times of E. Awinat. It was in Damanhour 63.38, 54.8 and 58.13% for white, black and multicolor spheres, respectively and by 48, 41.6 and 42.5% in E. Awinat.

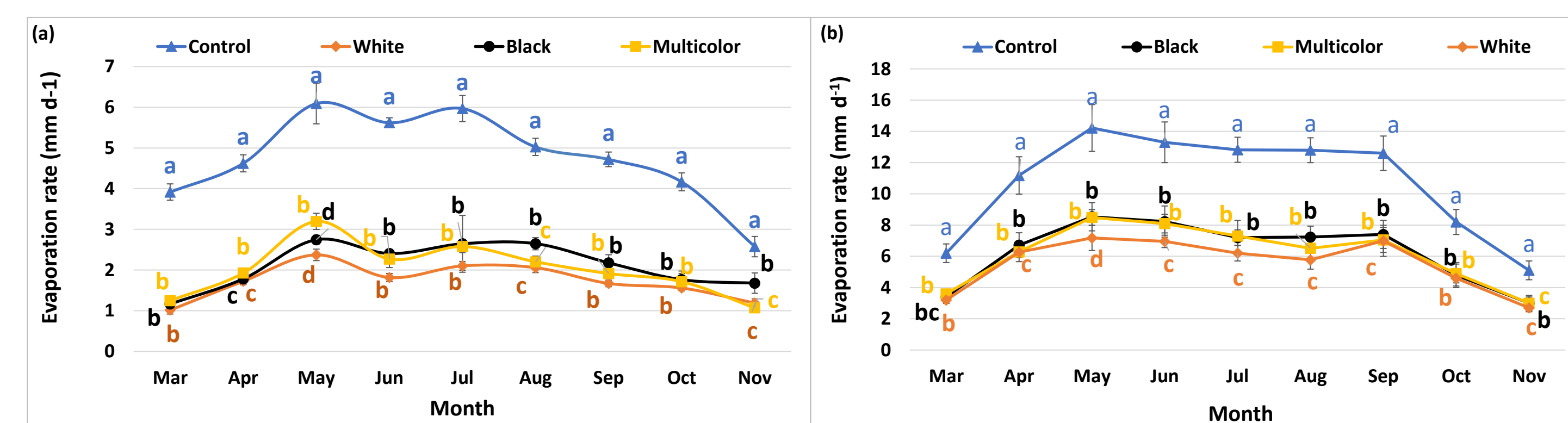


Figure (3): Monthly average evaporation rate (ER) for white, black and multicolor spheres, in (a) Damanhour and (b) E. Awinat.

Exp. (2): Impacts of floating spheres on the water ecology:

The effect of floating spheres on the water ecology was estimated by monitoring the growth of microalgae (*Chlorella Vulgaris*, micro-green algae, freshwater) in Damanhour only.

After 16 days of incubation, microalgae was inoculated in a fixed water depth (20 cm) in each pan. After that, pans were covered by spheres.

Measurement:

After five days (on the **6th day** of microalgal inoculation), a water sample was collected from each pan, and microalgae growth was estimated by measuring optical density (OD) at **680 nm** using the UV visible **spectrophotometer**.

Results:

Unexpectedly, Spheres enriched microalgae growth by 27.2, 31.8 and 27.2% for black, multicolor and white balls, respectively, relative to the control.

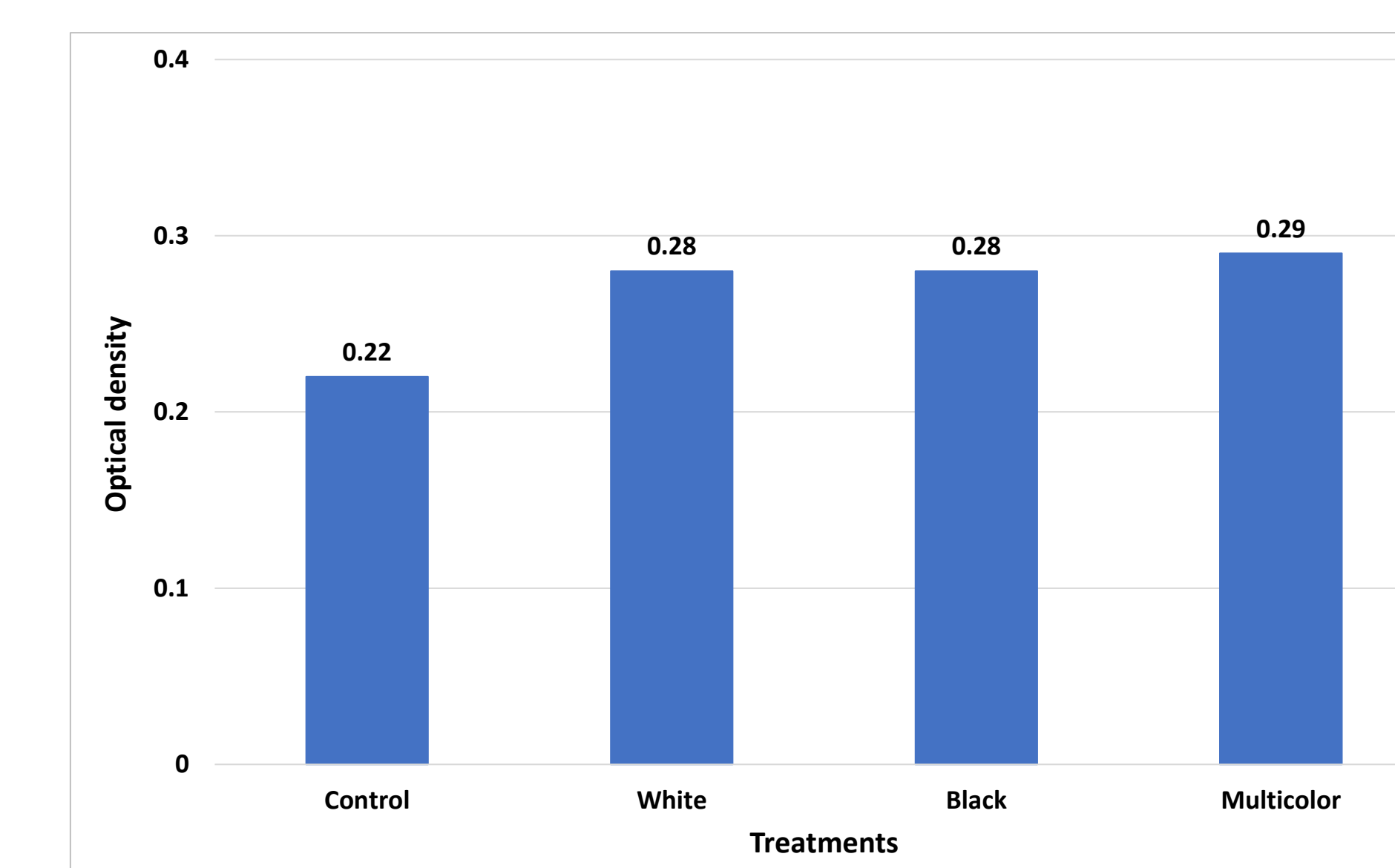


Figure (4): The growth of *Chlorella Vulgaris* microalgae (optical density)

Conclusions

- 1) The white spheres having the greatest ESE (63% in Damanhour and 48% in E. Awinat).
- 2) The low ESE in E. Awinat could be because evaporation is mainly driven by a very low RH.
- 3) Spheres effective to reduce ER without any impact on water ecology.

Future Work

- 1) Further studies at reservoirs' scale are needed.
- 2) Future studies must include the measurement of several aquatic organisms.
- 3) Further investigations should include water quality measurements (especially DO), covers stability and durability.
- 4) Stable Covers with low water footprint must be developed/ Engineered to ensure covers' feasibility and stability.