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# Using Fe magnetic nanoparticles for reducing evaporation from water surface in small scale

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**ABSTRACT**

Evaporation, an important problem in hydrology and water resources engineering, has long been of great interest to many researchers. In this study, the magnetic nanoparticles dispersed in Jojoba plant oil were used to reduce the amount of water surface evaporation. The experiments were conducted in the city of Ardestan in the central part of Iran, using a completely randomized design with four treatments and three replications and taking advantage of $Fe_2O_3$ and $Fe_3O_4$ magnetic nanoparticles, dispersed in Jojoba plant oil. Conducted in two stages, it took into account the existing standards available in Class A standard evaporation pans and plastic pans. The results showed that there are significant differences between the treatments, i.e., the highest rate of evaporation reduction (25.4%) was observed when jojoba oil was mixed with 0.02 $Fe_2O_3$ in the Class A evaporation pan. It was also inferred that evaporation could drop by 32.6% provided that a jojoba oil solution containing $Fe_3O_4$ nanoparticle is used in plastic pans.

*Keywords:* Jojoba oil; Evaporation reduction; Reservoirs; Fe magnetic nanoparticles

## 1. Introduction

Considering the expansion of the arid and semi- arid areas of the world as well as its diminishing water resources, evaporation from these water reservoirs has led to irreversible water loss. However, water utilization can be increased by preventing water evaporation from such water reservoirs and using irrigation canals and other water resources available in these areas. The serious issue of evaporation control has been widely studied for decades by experts and scientists who have concerned the importance of this threat. More recently, numerous materials have also been used to provide a wide range of coverage for water surface, mostly resulting in satisfactory accomplishment.

It has long been known that monolayers at air–water interface can reduce water evaporation [1,2]; however, there are still many practical difficulties associated with the effective use of monolayers in open water storages. Monolayer films are vulnerable to be easily damaged not only by wind and wave action but also by water impurities and bacteria [3]. Hence, frequent replacement of the monolayer material is required. To reduce water evaporation, monolayers are needed to be easily applied and spread quickly across water surface. However, the choice of monolayer often involves a compromise between spreading rate and evaporation resistance. Rideal [2] first reported that monolayers reduce the rate of water evaporation, since they are able to form closely packed films and restrict the loss of water molecules. Subsequently, Langmuir and Schaefer [4] who made the first

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quantitative measurements of the evaporation resistance (*r*) of monolayers demonstrated an Arrhenius-type dependence of its resistance to permeation through evaporating water molecules with temperature. Since then, considerable attention has been directed towards effective suppression of water evaporation, especially from large open water bodies [5,6]. The principal compounds proved to be effective in case of monomolecular layers are hexadecanol, octadecanol, and ethylene glycol monooctadecyl ether [3,7]. In a study by Cooley and Myers, twenty different materials were used for evaporation reduction, so their efficiency was evaluated [8]. In another research conducted by Khan and Issa [9], a 20% reduction of evaporation was reported after using a single molecular layer. In India, Desai et al. [10], used 50 mg per square meter of fatty- acid- based emulsion (more cetyl alcohol and distilled alcohol) which could reduce evaporation by 30%. In 2005, Knights in Australia dispersed cetyl alcohol into several reservoirs and concluded that the evaporation rate can be reduced by about 20% [11]. In Canada, Brien mixed calcium hydroxide, hexa de canol, and a small amount of silica to produce a new substance for preventing evaporation. The results indicated the efficiency of such materials [12]. At the University of North Queensland, Barnes conducted a research on the effect of hexa de canol and octa de canol alcohols on evaporation reduction and concluded these materials were suitable for lowering evaporation in large reservoirs [13]. In addition, spraying a thin layer of $Cl_3(CH_2)$ $OH_{17}$ was recommended to increase the water resistance to evaporation [14]. Likewise, Liu et al. [15] studied the reduction of water evaporation and cracks made by monolayers on plastic concrete surface. Their results showed that the monolayers could effectively reduce water evaporation and improve concrete surface properties, mainly through inhibiting the formation of plastic-shrinkage cracking and crust. Christopher et al. [16] also studied the role of monolayers in retarding evaporation from water storage bodies and proposed an alternative mechanism for retardation of evaporation, which attributes with reduced evaporation and less surface roughness, and in turn, increases the effective vapor pressure of water above the surface.

The past two decades has witnessed a sudden explosion in nanoscience and its diverse emerging applications [17]. Iron is the fourth most abundant element in the earth crust that can be found in different forms in nature and has a great variety of geological localities with a wide range of technological applications. Its availability and ease of synthesis have introduced Fe oxide nanoparticles as an affordable absorbent used to absorb toxic metals. Since Fe is an eco-friendly element, its oxides can be pumped into contaminated areas, with no risk of secondary pollution [18]. Both Ferrous and ferric iron oxides exist in seven crystalline phases, but the most common ones are Magnetite and Maghemite. Meanwhile, a number of different forms of magnetic materials, used for various applications in human daily life, have been regarded by many researchers [19–22].

Since the advent of studies on nanoparticles, especially magnetic nanoparticles, it has been indicated that they have a high surface to volume ratio, with a strong tendency to stick to each other and become cloyed. Moreover, their dispersion and stability can be increased because of their disparity in an oily environment. Jojoba oil, liquid at room temperature, is a taste-less, golden, and incorruptible essence that chemically has a unique molecular form. This oil is a combination of a fatty acid with 18–36 carbon unsaturated direct chains and an alcohol (97% of ester). Jojoba fluid is composed of two types of esters (mixture of acid and alcohol): one with 30% of carbon atoms and the other with 50% of carbon atoms [23].

Therefore, due to presence of heavy alcohol, it is the best Fe nanoparticle solvent, for it not only makes iron nanoparticles stable, but it keeps them afloat on the surface of water and prevents the penetration of nanoparticles into water. A review of previous studies showed that no research has been conducted on the use of magnetic dispersed nanoparticles in jojoba oil and its possible effects on reducing evaporation. Considering the increasing importance of evaporation from reservoirs plus the properties of magnetic nanoparticles of iron such as being non-toxic and chemically stable and having varying colors and low price [24], this research was performed to use such materials in reducing evaporation from reservoirs.

## 2. Materials and methods

### *2.1. The study area*

Ardestan, with a population of about 46,000 people and an area of 11,591 sq km, is an ancient historic city in the vast region of Isfahan Province. This city is located on the eastern slopes of Markazi Mountains on the outskirts of the desert with an elevation of 1,200 m above sea level between 32°50′ to 25° north latitude and 51°55′ to 53°15′ east longitude Greenwich meridian. In other words, it is located exactly in the center of Iran. Ardestan City is among the first areas in Iran that were introduced as the “Forbidden Plains” in the early 1990’s. Despite the average rainfall of 250 mm in Iran, it is 110 mm in Ardestan, i.e., less than half the average rate of the whole country. Fig. 1 shows the location of Ardestan city in Iran.


Fig. 1. A general map of Iran illustrating the location of the study area (Ardestan city).

### 2.2. Materials

The materials required for the experiment included jojoba plant oil, $Fe_3O_4$, and $Fe_2O_3$ magnetic nanoparticles. Firstly, to produce the needed material, four samples, weighed 0.2, 0.02, 0.002, and 0.0002 g, respectively on a digital scale (with an accuracy of 0.0001), were separately poured into a volumetric flask. Next, jojoba plant oil was poured in a Burt and 2 mm oil was added to each flask. It was then properly shaken to mix oil and nanoparticles. After mixing the nanoparticles with oil, each sample was poured in a separate test tube. To make the solution uniform, it was transferred to an ultrasonic bath for 30 min.

### 2.3. Method

To determine the best concentrations of $Fe_3O_4$ and $Fe_2O_3$ nanoparticles to be mixed with jojoba oil, two tests were performed. It was followed by implementing the final phase of the tests, that is, using a completely randomized design with three replications and four treatments.

### 2.4. Procedures of nanoparticles concentration determination

To determine the best concentrations of $Fe_3O_4$ and $Fe_2O_3$ nanoparticles, a completely randomized design with three replications and 4 treatments (i.e., 0.2, 0.02, 0.002, and 0.0002) was used and the water level of each pan was measured for 7 d. Then, the SPSS software and Duncan's test were used to determine the best concentration at the 5% level.

The final phase of the tests was implemented using a completely randomized design with three replications and four treatments (i.e., experimental treatments including Control (pure water), jojoba oil, $Fe_3O_4$ with a concentration of 0.2 mixed with jojoba oil, and 0.02 concentration of $Fe_2O_3$ mixed with jojoba oil). This 35 d experiment started on August 15, 2014 and continued until September 18, 2014. Finally, the obtained data were analyzed with the SPSS 19 software and Duncan's test at the 5% level of significance. Furthermore, the experimental treatments were compared with each other. ANOVA software was also used to compare the mean treatments.

To clarify the relationship between distribution of mixture of Jojoba oil and Nano- particle on the surface of the pan, in this study, the plastic pans with an identical surface and volume of the class A standard evaporation pan were mutinously used with the raised iterations and treatments.

Ultimately, a sample of control treatment, a water sample of $Fe_2O_3$ pan, and a water sample of $Fe_3O_4$ pan were analyzed using Atomic absorption spectroscopy (AAS). In addition, the atomic absorption rate and the influence of iron nanoparticles in water were determined. The flowchart of the methodology used in this study is presented in Fig. 2.

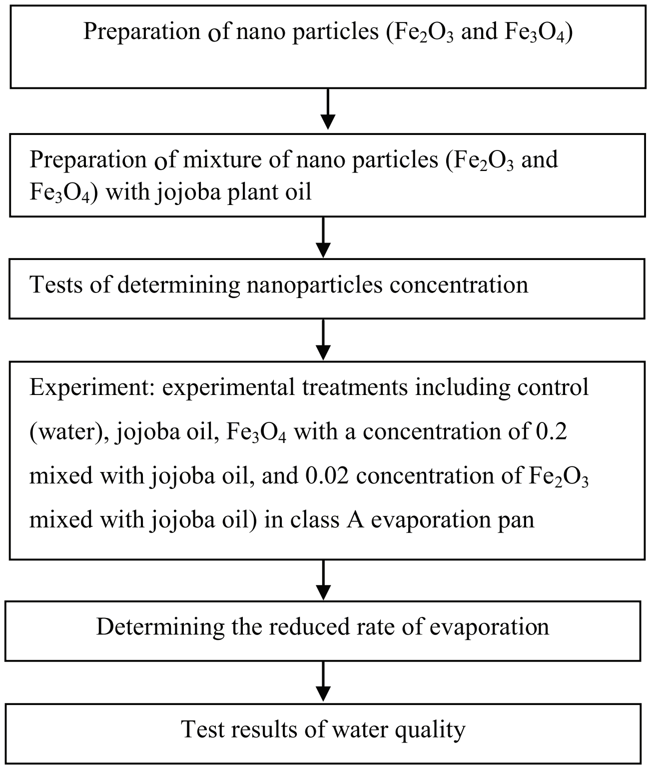


Fig. 2. The flowchart of the methodology.

## 3. Results and discussion

### 3.1. Nanoparticle size distribution and chemical composition

TEM images of $Fe_2O_3$ and $Fe_3O_4$ nanoparticles are shown in Figs. 3(a),(b),(d) and (e), respectively. The images show an agglomeration of nanoparticles which results from the applied aqueous route suffering from less-uniform sizes. Likewise, due to the agglomeration, size distributions were induced by the existence of surface hydroxyls [25]. The size distributions for $Fe_2O_3$ and $Fe_3O_4$ samples are shown in Figs. 3(c) and (f), respectively. It is observed that the nanoparticles size for $Fe_2O_3$ sample ranges from 2 to 10 nm and the average size obtained from the size distribution diagram is 8 nm. On the other hand, for $Fe_3O_4$ sample, the size of nanoparticles ranks in size within the range of 10–26 nm with an average of 18 nm. For both, the sample particles are spherical in shape and their size distribution diagram shows a highly uniform particle size.

The chemical composition in both types of nanoparticles is characterized by using XRD and FT-IR spectroscopy. The XRD patterns of $Fe_3O_4$ and $Fe_2O_3$ nanoparticles are shown in Figs. 4(a) and (b), respectively. For both samples, similar diffraction peaks are observed which are well indexed to either $Fe_2O_3$ or $Fe_3O_4$ cubic phase. Since the XRD patterns in both samples were similar, FT-IR spectroscopy was chosen to determine the exact phase of the samples. Figs. 5(a) and (b) show the FT-IR spectroscopy of $Fe_3O_4$ and $Fe_2O_3$ nanoparticles, respectively. Previously, Namduri and Nasrazadani [26] had showed that the FT-IR spectra of iron oxides were easily distinguishable.

The FTIR spectrum of magnetite ($Fe_3O_4$) exhibits two strong infrared absorption bands at 570 $cm^{-1}$ and 390 $cm^{-1}$ [26]. Maghemite ($\gamma$- $Fe_2O_3$), a defective form of magnetite, has some absorption bands at 630, 590, and 430 $cm^{-1}$. In Fig. 5(a), it can be seen that two peaks, observed at 575 and 400 $cm^{-1}$, correspond with Fe-O vibration of magnetite nanoparticles, whereas, in Fig. 5(b), two distinct peaks at 580 and 450 are representative of maghemite phase.

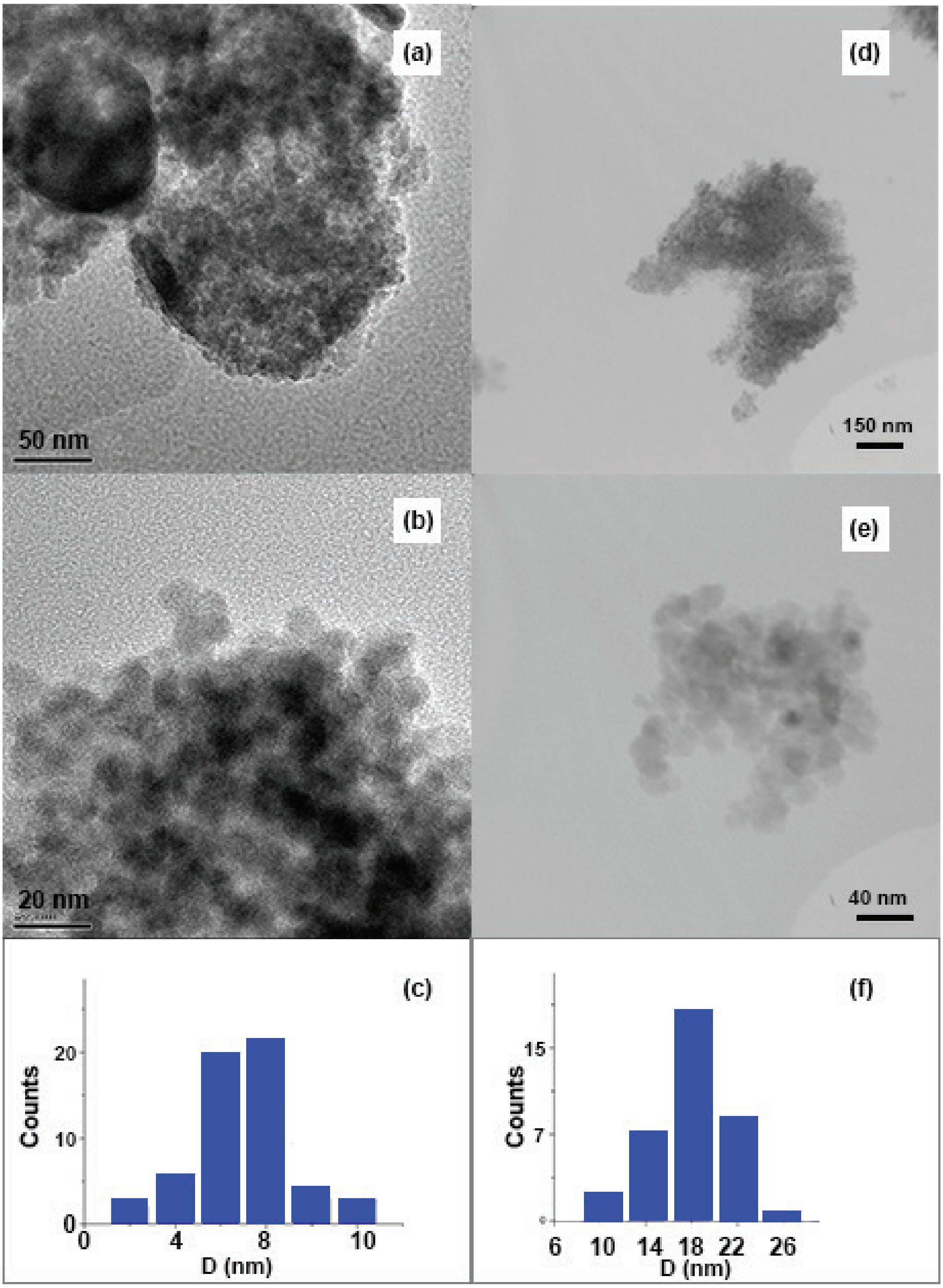


Fig. 3. TEM images of (a) and (b) $Fe_2O_3$, (d) and (e) $Fe_3O_4$ nanoparticles. (c) and (f): size distribution diagrams of $Fe_2O_3$ and $Fe_3O_4$ nanoparticles.

### *3.2. Determination of $Fe_2O_3$ and $Fe_3O_4$ concentrations*

Observations showed that after spraying the material on the surface of the evaporation pan in the early days, the materials were spread on the pan surface as clusters, and after a week, they covered the surface fully; hence, more diffusion of the materials was observed in the plastic pans. Moreover, these observations showed that mixed with jojoba oil, $Fe_3O_4$ nanoparticles diffused more frequently than $Fe_2O_3$

nanoparticles. In addition, it was concluded that as a result of their magnetic properties, Fe nanoparticles, mixed jojoba oil, would have more tendency to be attracted to the walls of the evaporation pan, made of galvanized Fe, especially $Fe_3O_4$ magnetic nanoparticleswith more magnetic force than $Fe_2O_3$.

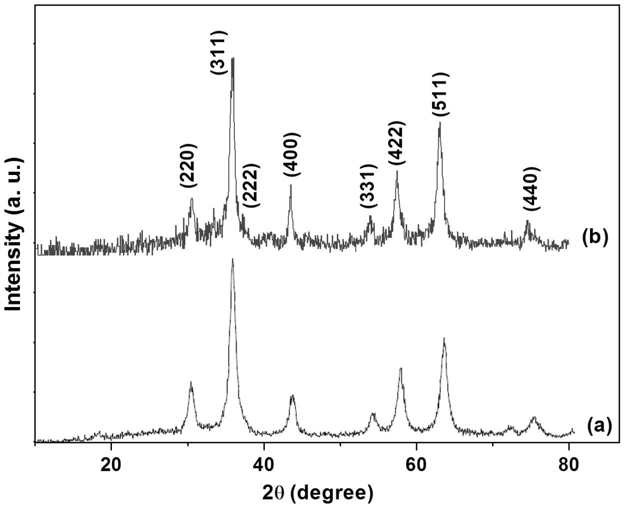


Fig. 4. XRD pattern of (a) $Fe_3O_4$ and (b) $Fe_2O_3$ nanoparticles.

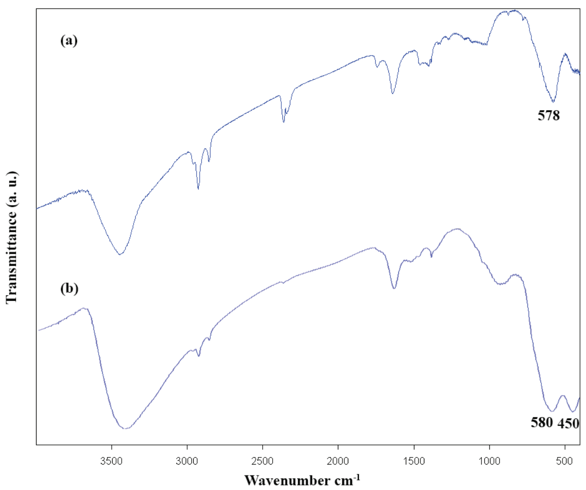


Fig. 5. FT-IR spectroscopy of (a) $Fe_3O_4$ and (b) $Fe_2O_3$ nanoparticles.

While testing the materials resulting from the mixture of $Fe_2O_3$ and $Fe_3O_4$ nanoparticles and jojoba oil with different concentrations, SPSS software was used to compare the mean of evaporation read from the surfaces of the pans. Tables 1 and 2, respectively, compared the average evaporation rates read from the surfaces of the tested pans having various concentrations of nanoparticles.

In comparison with Tables of means, the two columns of confidence interval, 95% and Sig, were used to infer the equal or unequal conditions of the means.

The results of comparing the means of the experimental data showed that there is a significant effect of nanoparticles on the experimental treatments. The obtained results are provided in Tables 1 and 2.

Comparing the means, Table 1 shows significant differences between the treatments, where the minimum and maximum amounts of evaporation were, respectively, related to the concentrations of 0.02, 17.2 and 0.0002, 18.2. Given that the least amount of evaporation is 0.02 g/ml, this treatment was selected in the final test as the best concentration for the mixture of jojoba oil and $Fe_2O_3$ nanoparticles.

As seen in Table 2, the evaporation and concentration had a reverse relationship. The highest evaporation rate belonged to the concentration of 0.0002 g/ml, because these magnetic nanoparticles were attracted to the iron frame of the pan reducing the concentration of nanoparticles available on the pan surface. Hence, in case of the class A pan, it seems necessary to take a higher concentration of this material to obtain a more $Fe_3O_4$ coat. Since the magnetic nanoparticles are absorbed to the iron pan to reduce the concentration of nanoparticles in the lower basin, it is necessary to choose a greater concentration of this substance to achieve a greater impact. Since the least amount of evaporation was 0.2 g/ml, this treatment was selected as the best concentration for the mixture of jojoba oil and $Fe_3O_4$ nanoparticles for the final test.

The evaporation rates of water from American class A and the plastic pan were compared and the results were shown in Tables 3 and 4.

As indicated in Table 3, the mean comparison at the 5% level showed a significant difference between all treatments and the control. The Jojoba oil treatment and the mixture of jojoba oil and $Fe_3O_4$ treatment were both at a meaningful level, whereas, the mixture jojoba oil and $Fe_2O_3$ treatment was

Table 1
A comparison of the average evaporation read (mm/day) from the surface of the tested pans (mixed jojoba oil with $Fe_2O_3$) using the SPSS software

| Test | $Fe_2O_3$ concentration | Replication | Number of evaporation read | $\alpha$ = 0.05 | | | |
|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 |
| Duncan test (5% level) | 0.02 | 3 | 21 | 17.2 | | | |
| | 0.002 | 3 | 21 | | 17.5 | | |
| | 0.2 | 3 | 21 | | | 17.8 | |
| | 0.0002 | 3 | 21 | | | | 18.2 |
| | Sig. | | | 1.0 | 1.0 | 1.0 | 1.0 |

Sig. = *p* Value.

Table 2
A comparison of the average evaporation read (mm/day) from the surface of the tested pans (mixed jojoba oil with $Fe_3O_4$) using the SPSS software

| Test | $Fe_3O_4$ concentration | Replication | Number of evaporation read | $\alpha$ = 0.05 | | | |
|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 |
| Duncan test (5% level) | 0.2 | 3 | 21 | 13.4 | | | |
| | 0.02 | 3 | 21 | | 13.8 | | |
| | 0.002 | 3 | 21 | | | 14.1 | |
| | 0.0002 | 3 | 21 | | | | 14.4 |
| | Sig. | | | 1.0 | 1.0 | 1.0 | 1.0 |

Sig. = *p* Value.

Table 3
A comparison of the average American class A evaporation pan read (mm/day), using the SPSS software

| Test | Treatments | Replication | Number of evaporation read | $\alpha$ = 0.05 | | |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| Duncan test (5% level) | Mixture jojoba oil and $Fe_2O_3$ | 3 | 105 | 11.5 | | |
| | Mixture jojoba oil and $Fe_3O_4$ | 3 | 105 | | 12.3 | |
| | Jojoba oil | 3 | 105 | | 13.1 | |
| | Pure Water | 3 | 105 | | | 15.4 |
| | Sig. | | | 1.0 | 0.1 | 1.0 |

Sig. = *p* Value.

Table 4
A comparison of the average the plastic pan read (mm/day), using the SPSS software

| Test | Treatments | Replication | Number of evaporation read | $\alpha$ = 0.05 | | |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| Duncan test (5% level) | Mixture jojoba oil and $Fe_2O_3$ | 3 | 105 | 10.4 | | |
| | Mixture jojoba oil and $Fe_3O_4$ | 3 | 105 | | 11.4 | |
| | Jojoba oil | 3 | 105 | | 12.1 | |
| | Pure Water | 3 | 105 | | | 14.5 |
| | Sig. | | | 1.0 | 0.147 | 1.0 |

Sig. = *p* Value.

in another significant level. The results showed that $Fe_2O_3$ treatment could reduce evaporation significantly. In Table 3, the control treatment had the maximum amount of evaporation. The subsequent treatments were respectively allocated to jojoba oil, mixture jojoba oil and $Fe_3O_4$, and mixture jojoba oil and $Fe_2O_3$. The mean comparison in Table 4 revealed that $Fe_3O_4$ had a significant difference with other treatments at the 5% level, whereas, there was no significant difference between Jojoba oil and its mixture with $Fe_2O_3$ treatment, yet both treatments had a significant difference with the control. It was concluded that the highest rate of evaporation belonged to the control and its lowest was that of the mixture of jojoba oil and $Fe_3O_4$. Table 4 illustrates the falling trend of the control, the Jojoba oil treatment, the mixture of jojoba oil, $Fe_2O_3$, the mixture of jojoba oil, and $Fe_3O_4$, respectively.

To determine the reduced rate of evaporation in treatments used in this study, it is required to compare each of them with the mean evaporation of the control. Tables 5 and 6 show the reduced rates of evaporation from both the Class A pan and the plastic pan.

The results of Tables 5 and 6 show that the effects of nanoparticles on evaporation reduction largely depend on the type of tank or pan material. According to these observations, in the plastic pan where uptake of nanoparticles to the walls was lower, more particles remained on the water surface and to a greater extent, they prevented evaporation more than the galvanized pan. In the plastic pans, the highest rate of evaporation loss was recorded by the $Fe_3O_4$ nanoparticles, whereas in the Class A evaporation pans made of galvanized iron, $Fe_2O_3$ treatment had

Table 5
Reduced rate of evaporation in the Class A evaporation pan (mm/day)

| Class A evaporation pan (mm/day) | | |
|---|---|---|
| Treatments | Mean of evaporation | Reduction rates |
| Pure water | 15.4 | – |
| Jojoba oil | 13 | 15.1 |
| Mixture jojoba oil and $Fe_2O_3$ | 11.5 | 25.4 |
| Mixture jojoba oil and $Fe_3O_4$ | 12.3 | 19.8 |

Table 6
Reduced rate of evaporation in the plastic pan (mm/day)

| Plastic pan | | |
|---|---|---|
| Treatments | Mean of evaporation | Reduction rates |
| Pure water | 15.4 | – |
| Jojoba oil | 12.1 | 21.4 |
| Mixture jojoba oil and $Fe_2O_3$ | 11.4 | 25.5 |
| Mixture jojoba oil and $Fe_3O_4$ | 10.4 | 32.6 |

less magnetic properties, resulting in greater evaporation reduction.

Results also showed that the percentage of evaporation loss in case of jojoba oil treatment in the plastic pan was about 21.4%, while in the class A evaporation pan, it was 15.1%, indicating the direct effect of type of pan walls on heat and evaporation absorption. In the plastic pan, the pan's surface was coated with oil to prevent heat transfer from the water surface. Since the walls were also made of plastic, less heat was transferred to the water; hence, the oil played a significant role in reducing evaporation. On the other hand, in case of evaporation pans made of galvanized iron, the walls absorbed more heat, leading to an increased evaporation rate. Moreover, the analysis of the results in Tables 5 and 6 showed that the evaporation loss rates in the mixed treatment of jojoba oil with $Fe_2O_3$ nanoparticles were identical in both plastic and class A evaporation pans. Of course, in case of the plastic pan, the evaporation rate was about 0.1% higher. In India, Desai et al. [10] extracted a fatty-acid-based emulsion (more cetyl alcohol and distilled alcohol) from oil plants, which was scattered in different sites of the lake dam. Using 50 mg per $m^2$ of the material, they observed an approximate 30% reduction in the rate of evaporation.

To determine the water quality of the pan, the UNICAM 919AA Atomic absorption spectrometry was used. Table 7 shows the absorption rates of Fe nanoparticles concentration in the tested samples.

According to Table 7, the concentration of Fe nanoparticles in the tested samples was less than the limited ones (0.3) indicating that jojoba plant oil is a more proper solvent for keeping the nanoparticles on the water surface. The influence of meteorological parameters on the rate of evaporation in both trials is shown in Table 8. In this table, temperature is in C, wind speed is in m/s, relative humidity is in %, and the amount of evaporation is in mm/day. In Fig. 6, the evaporation changes of each treatment are shown during the test period.

According to Table 8 and Fig. 6, on the 5th (May 19, 2014) and 31st days (August 15, 2014) of the test, there was a sudden evaporation increase. Analyses of the measured meteorological parameters showed that on the fifth day of the experiment, the wind speed was 14 m/s less than the previous day, whereas compared to its previous day, the minimum temperature increased. This factor itself was the cause of increased evaporation. During this day, relative humidity did not change significantly and the only factor leading to the increased evaporation was temperature. The same was observed on September 15, 2014 when due to an increase in the minimum and maximum temperatures, (in comparison with the previous days), reduced wind speed, and increased humidity were recorded indicating the fact that temperature was the single factor that could affect the evaporation rate. Also, according to Table 8, in spite of the wind speed of 17 m/s (61.2 kph), reported as the maximum wind speed during the test covering the entire area, the final coating material remained resistant. Hence, it was predicted that at speeds above 17 m/s, its strength and coating property could be maintained.

Table 7
Fe concentration in the tested samples

| Treatments | Fe concentration (ppm) |
|---|---|
| Pure water | 0.002594 |
| Mixture jojoba oil and $Fe_2O_3$ | 0.01556 |
| Mixture jojoba oil and $Fe_3O_4$ | 0.02248 |

Table 8
Measured meteorological parameters during the test

| Meteorological parameters | Maximum | Minimum | Mean |
|---|---|---|---|
| Mean of temperature (°C) | 37.14 | 24.33 | 30.74 |
| Relative humidity (%) | 20.15 | 10.08 | 15.3 |
| Wind speed (m/s) | 17 | 5 | 9.71 |
| Evaporation (mm/d) | 23.6 | 12 | 15.41 |

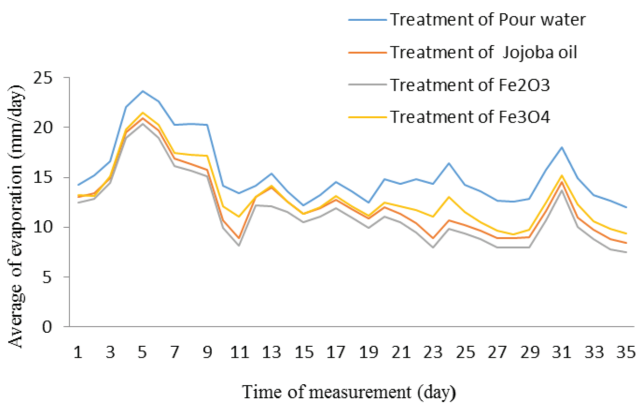


Fig. 6. Graph of evaporation changes of each treatment during the experiment.

## 4. Conclusion

In this study, jojoba oil and the produced material, including magnetic nanoparticles solvable in jojoba oil, were used to reduce water evaporation from the reservoirs on a small scale. Therefore, in a completely randomized design with three replications and four treatments including control (pure water), 0.5 cc jojoba oil with 0.02 $Fe_2O_3$, 0.5 cc jojoba oil with 0.2 $Fe_3O_4$ and 0.5 cc jojoba oil were conducted in both the Class A evaporation pan and the plastic pan. The results showed reduced rates of evaporation in the class A evaporation pan in treatments of jojoba oil, mixture of jojoba oil with nano $Fe_2O_3$, and $Fe_3O_4$ nanoparticles which were 15.1, 25.4, and 19.8%, respectively. In case of the plastic pan, however, they were 21.4, 25.5, and 32.6%, respectively.

The results showed that the impact of nanoparticles depends largely on the kind of reservoir. Combining jojoba plant oil with nanoparticles equipped the final material with high durability, so the sprayed material would float on the water till there is water in the reservoir. Although it is performed just once during the experimental period, it is economically cost-effective. Moreover, as shown in the atomic absorption test results, this produced material will remain floating and water- proof on the water surface. On the other hand, it will not affect soil fertility and plant growth adversely. Yet, it will prevent the growth of algae. In addition, the performed atomic absorption verified the non-toxic and healthful properties of the material.

Nanoparticles are equipped with a large specific surface that absorbs energy from the environment in the form of heat. In addition, nanoparticles have high thermal resistance which enables them to absorb heat from the sun and their environment. In fact, due to their high thermal resistance prevents heat transmission to water. Nevertheless, the most critical issue is that nanoparticles simply penetrate water. In this case, it seems impossible to reduce water temperature, so that it is necessary to find material capable of holding nanoparticles on water surface with no harm for drinking and agriculture uses. The solution is found in Jojoba plant oil, a taste-less, golden, and incorruptible essence, which is liquid at room temperature. In terms of chemical structure, it has a unique molecular form. This oil is a combination of a fatty acid with 18 -36 carbon unsaturated direct chain and an alcohol (97% of ester). As a fluid, it is comprised of two types of esters (mixture of acid and alcohol): one with 30% of carbon atoms and the other with 50% of carbon atoms [23]. On the other hand, Jojoba oil's repellency deter polar solvents will dissolve it [27]. The optimal composition was determined based on the reservoir material. If the material of reservoir is Nonmagnetic, the jojoba oil mixed with 0.2 concentration $Fe_3O_4$ will be the best composition and if it is magnetic, the most appropriate composition will be jojoba oil mixed with 0.02 $Fe_2O_3$.

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