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REVIEW ARTICLE

# AGRICULTURAL WATER MANAGEMENT THROUGH MAGNETIZATION OF IRRIGATION AND DRINKING WATER: A REVIEW

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**ABSTRACT**

Agricultural water management in arid and semi-arid countries such as Iran is of utmost importance. Alterations of water as a major component of each bio system through magnetization have been reviewed in this study. Magnetization process has been used as green technology in industry and agriculture with controversial results. Properties of water such as pH, hydrogen bonds, temperature, structure and its ions can be affected by an external magnetic field. Subsequent modifications have substantial impacts on water quality that is determined for optimum plant and animal production. There are some reports among numerous studies in agronomy, gardening and animal husbandry which claim fruitful influence of this treatment both qualitatively and quantitatively. Nevertheless, there are some controversial reports on the effects of magnetization. In conclusion, the response of organisms depends on magnetization time and intensity, water quality and plant or animal species. These variables should be taken into account for further studies regarding this mysteries process.

**Keywords:** Farm, Magnetization, Productive traits, Water quality

## INTRODUCTION

Water is a vital component for the foundation of every civilization and cultivation under all conditions. Water quality is of the utmost importance for potable and even recreational purposes. Water characteristics have a close relation towater's molecular structure and can be affected by external processing such as a magnetic field [1-2]. Water magnetization has been used in a wide variety of applications from concrete [3] to boilers [4] and broilers [5-6]. For instance, a 0.16 Tesla magnetizing treatment with 0.9 $dm^3/min$ flow rate was useful in precipitating calcium carbonate in hard water [7]. Some researches indicated that magnetized water as compared with ordinary water resulted in better efficiency in various fields of agriculture [8-9]. However, some reports can be misleading or demonstrate a lack of understanding of basic scientific principles. Hence, the objective of the current study was to elucidate the latest findings aboutvarious aspects of magnetization treatment of water in various fields of agriculture such as horticulture, aviculture and so on.

### Changes in magnetized water traits

The behavior of water molecules changes under the effect of a magnetic field. It has been revealed that the clustering structure of hydrogen-bonded chains and polarization effects of water molecules are intensified after magnetization [2]. It is suggested that the average size of water clusters became larger by magnetic treatments [10]. Moreover, the studies of Chang and Weng [11] showed that the structure of water is more stable and the ability of water molecules to form hydrogen bonds was improved after magnetization. It was found that the number of hydrogen bonds increases slightly (0.34%) as the strength of the magnetic field is raised from 1 to 10 T. This implies that the size of a water cluster can be controlled by the application of an external magnetic field [11]. Static magnetic effects have been shown to cause an increase in the ordered structure of water formed around hydrophobic molecules and colloids [12]. Furthermore, the calculations showed that an external electric field changes the number of hydrogen bonds, decreases the cluster sizes and increases the strength of the inter-cluster hydrogen bonds [13].

Pang *et al.* [14] and Pang and Deng [15] indicated that magnetic fields reduce the specific heat of water, increase the soaking degree and hydrophobicity of water to materials, reduce its surface tension force and viscosity and increase the refractive index and electric conductivity of water relative to those of pure water. In addition, boosting the refractive index with magnetic field (10 Tesla) has been attributed to strengthen in hydrogen bond [16]. Musa and Hamoshi [17] reported that magnetized solutions passing through field power of 450 gauss over 1 to 10 min which resulted in higher electrical conductivity values of sodium chloride and calcium chloride dihydrate

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as compared with non-magnetic solutions. Amiri and Dadkhah [18] showed that the surface tension of water is quite sensitive to experimental conditions. Thus, the surface tension of water is a reliable index for studying magnetized water. Meaningful changes in surface tension of a liquid sample after one day can be a reliable indicator for the presence of physical or chemical alterations in the solution.

Xu and Sun [19] demonstrated that magnetized water had higher pH as compared with ordinary drinking water. Also, the reductionof water viscosity up to 2% through magnetization has been observed by Kronenberg [20]. Moreover, Gilani *et al.* [21] indicated that the pH of some feed ingredients in magnetized water was significantly higher than in those non-magnetized water. However, Alimi *et al.* [7] reported that the pH of water was not influenced by magnetization treatment. Moreover, the freezing temperature increased with the enhancement of the magnetic field [22].

The effects of treatment with magnetic or electromagnetic fields, known as the magnetic memory of water, persist minutes or hours after the water treatment in the absence of heavy metals [23]. It has been reported that the internal seeding effect of the magnetic treatment lasts for up to two days. The relevant changes are the reduction of surface tension and viscosity by up to 2% and changes of the electro-optical values of the water [20]. Magnetic treatment devices that are physically designed to create additional turbulence by constricting or otherwise altering fluid flow may further enhance the anti-scaling effect by purely mechanical means [24]. Coey and Cass [4] indicated that magnetic memory can be preserved for 200 h. Therefore, it can be more effective in biological systems.

## Magnetization in plant production

It is hardly surprising that there are controversial results in agronomy and horticulture about the effectiveness of magnetizing processes. For instance, magnetic treatment of water has been claimed to improve the yield and quality of muskmelons [25]. Also,Vashisth and Nagarajan [26] exposed sunflower (*Helianthus annuus L.*) seeds to different static magnetic fields (0 to 250 mT in steps of 50 mT for 1-4 h in steps of 1 h) and found that these magnetic fields improved the germination speed, seedling length and dry weight under laboratory germination tests. In germinating seeds, enzyme activities of alpha amylase, dehydrogenase and protease were significantly higher in treated seeds as compared with controls. The higher enzyme activity in magnetic field–treated sunflower seeds could lead to fast germination and early vigor in seedlings. Aladjadjiyan [27] stated that the positive effect of magnetic treatment may be due to paramagnetic properties of some atoms in plant cells and pigments, such as chloroplasts. In consistent, Buyukuslu *et al.* [28] indicated that the activity of superoxide dismutase increased when exposed to magnetic field.

The effects of pre-sowing magnetic treatments on growth and yield of tomato were investigated by De Souza *et al.* [29]. Tomato seeds were exposed to full-wave rectified sinusoidal non-uniform magnetic fields induced by an electromagnet at 100mT for 10 min and at 170 mT for 3 min. In the vegetative stage, the treatments led to a significant increase in leaf area, leaf dry weight, and specific leaf area per plant. In general, pre-sowing magnetic treatments would enhance the growth and yield of tomato crop. In another research effort, exposing tomato seeds to 3 mT continuous magnetic field and 25 mT for 5 min increased root length by 29 and 25 percent, respectively, in comparison with control. Additionally, the longest shoot length, seedling length and vigor index were obtained in 3 mT continuous magnetic field and 25 mT for 5 min [30]. Furthermore, lower salt concentration in soil and better soil conditions for plant growth in magnetized irrigation water compared with non-magnetized irrigation has been reported by Mostafazadeh-Fard *et al.* [9]. However, Maheshwari and Grewal [31] indicated that there was no beneficial effect of magnetically treated irrigation water on the yield and water productivity of peas. Table 1 presents the magnetization impacts on some fruits and vegetables. All in all, it seems that plant species' responses to magnetic fields are unpredictable. Their response depends on magnetization time and intensity, seed species and priming procedures [32].

## Magnetization in animal production

In animal husbandry, Lin and Yotvat [33] reported that magnetized drinking water caused higher production of milk, mutton and wool in sheep, added weight gain in geese and more persistency of egg production and more hatchability in turkey. Moreover, Patterson and Chestnutt [34] concluded that electromagnetized drinking water containing a relatively high total hardness with slow flow rate increased the depth of subcutaneous fat and lipid concentration in the carcass of lambs. They did not find any improvements in performance or carcass composition of finishing lambs. Also, Garg *et al.* [35] evaluated the exposure time magnetically restructured water on liver of a fish *Clarias batrachus* for 1, 3, 5, and 8 h at 0.297 T. They found different changes of hepatic cell density, size, and nuclear diameter. More recently, Lee and Kang [36] indicated that the 8-week intake of magnetized water through a 0.9-1.3 Tmagnetic field diminished the concentrations of blood glucose and glycated hemoglobin levels,and damages of DNA in the blood and liver of diabetic rats. However, the authors found no differences in total cholesterol, HDL-cholesterol, and LDL-cholesterol among treated and non-treated rats. Abdi *et al.* [37] demonstrated which magnetic flux densities of 0.25 and 0.5 mT decreased, and magnetic flux densities of 3 and 4 mT increased, the zeta potential and low density lipoprotein oxidation in comparison with the control samples. Thus, the static magnetic fieldsmay influence the metabolism of lipoproteins and their interaction with other molecules such as apolipoproteins, enzymes and receptors through the change in low density lipoprotein. Furthermore, size changes of internal organs in rodents drank with conditionedwater was observed in some works that is maybe because of an osmotic effect on cell membrane permeability [38]. Also, weak electromagnetic fields on showed promoting impact on bone healing [39] and activation of gene expression in tissue cultures [40] which may be due to more calcium uptake through cell membrane, although there is no anecdotal evidence to support this hypothesis, yet.

**Table 1: A summary of magnetization impacts on some plants**

| Species | Intensity of magnetization | Effects | References |
|---|---|---|---|
| Muskmelon | Not reported | Yield and quality improved | Harari and Lin [25] |
| Pea | 0.136 T | No beneficial effect | Maheshwari and Grewal [31] |
| Tomato | 0.10 T for 10 min<br>0.17 T for 3 min | Leaf area and dry weight increased | De Suza *et al.* [29] |
| Tomato | 0.025 T for 5 min | Shoot length and seedling vigor index increased | Feizi *et al.* [30] |
| Sunflower | 0.25 T for 1-4 h | Germination speed, seedling length and its dry weight increased | Vashisth and Nagarajan [26] |

**Table 2: A summary of magnetization impacts on some animals**

| Species | Intensity of magnetization | Effects | References |
|---|---|---|---|
| Sheep | Not reported | Higher milk, wool, and mutton | Lin and Yotvat [33] |
| Sheep (lamb) | Not reported | Subcutaneous fat and lipid in carcass increased | Petterson and Chestnutt [34] |
| Lactating goat | 0.36 T | No effect on milk and blood components | Sargolzehi *et al.* [45] |
| Rat | 0.9-1.3 T | Blood glucose decreased | Lee and Kang [36] |
| Guinea fowl | Not reported | No effect on performance and blood components | Beata *et al.* [44] |
| Broiler chicken | 0.5 T | No effect on performance and immune response | Al-Mufarrej *et al.* [41] |
| Broiler chicken | 0.5 T for 5-15 min | No effect on performance | Al-hassani *et al.* [5] |
| Broiler chicken | 0.65 T for 3 h | More feed and water intake and weight gain during starter phase, but not in overall trial.<br>Villus height and muscularis thickness of jejunum improved | Gilani *et al.* [42, 43] |

Al-Mufarrej *et al.* [41] observed that the exposure of tap water to a magnetic field of approximately 500 gaussreduced water consumption, but did not significantly influence the performance, carcass composition and immune system of broiler chickens. Moreover, Gilani *et al.* [42-43] indicated that magnetization of drinking water with 0.65 T (6500 gauss) for 3 h caused more water consumption throughout the trial; however, feed intake and body weight gain were significantly increased in chickens that drank magnetized water in the starter phase. However, feed conversion ratio, mortality, European Production Efficiency Factor and Bioeconomic Index were not affected by magnetized water.

Nevertheless, Beata *et al.* [44] pointed out that magnetized drinking water did not influence blood constituents such as potasssium and chloride and the performance of guineafowl. Furtheremore, Alhassani and Amin [5] reported that 500 gauss magnetization with durations of 5, 10, and 15 min on 10 liters of drinking water did not significantly affect the performance of broiler chickens. Moreover, consumption of magnetized water through a 3600 gauss by Saanen lactating goatsdid not significantly alter blood components such as urea, $Na^+$, $K^+$, $Mg^{++}$, and $P^-$ and milk composition includingfat, protein, lactose, and solids-not-fat [45]. Coey and Cass [4] mentioned that drawing water through a static magnetic increases the aragonite/calcite ratio in the deposit tank. It is noteworthy that aragonite calcium has low bioavailability for farm animals [46]. Magnetization effects on some animal species are summerised in table 2.

**Modes of action**

The magnetic field showed to influence ion, solvent and ligand [47]. Rai [48] mentioned that nonionizing electromagnetic radiation (NER) produces biological effects which have been found to depend on field strength, frequency, pulse shape, type of modulation, magnetic intensity, and length of exposure. Furthermore, time-dependent variable water structures produced by two poles of 0.297 T have different effects on the activities of the photosystems of *Chlorella vulgaris* [49]. Magnetization also can improve the solubility of minerals for prevention and removal of mineral deposits in milk pipelines [50]. Water and water solutions passed through the magnetic field obtain finer and more homogeneous structures [51]. This increases the fluidity and dissolving capability for various constituents like minerals and vitamins [20, 52]. Consequently, the biological activity of solutions improves, positively influencing the performance of human, animal and plants [53]. Furthermore, the diffusion of magnetized water through the cell walls can be better than non-magnetized water [54]. Another mode of action is that magnetized water can prevent aging and fatigue through boosting cell membrane permeability [55]. Goldworthy *et al.* [56] found a biologically-active agent that had been produced by the conditioning process which remained in the culture medium for long enough to a yeast cell multiplication. The peak at 15–30 s of conditioning suggests that there is an optimum concentration for this agent, but 2-min conditioning period showed a marked inhibition compared with the unconditioned control. On the other hand, strongly conditioned water could bring about a more lethal disruption of the membrane structure and inhibit cell multiplication, especially in microorganisms where virtually all of their external membranes are exposed to it.

## Conclusion and future scope

It is worth noting that research focused on the cellular level, which shows that electromagnetic fields have no direct mutagenic effects on DNA, but also modify the cellular metabolism and arrangement [57]. Albeit the principle of magnetic water treatment is still not well understood and various contradictory hypotheses were proposed, but from the microscopic viewpoint, the magnetic field was purported to influence significantly the zeta potential and size distribution of the particles formed in solution. It is reported that magnetizing apparatus, volume, rate and quality of water and even water temperature are determining the intensity of changes in magnetized water [33, 58].

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