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# MAGNETIZED WATER TREATMENT: REVIEWING THE ENVIRONMENTAL APPLICATIONS

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**Abstract**

Magnetic water treatment (MWT) is an old idea which has been recently introduced into different fields including medical, environmental, and industrial applications. Magnetized water (MW), water that has been exposed to magnetic field, possesses unique physical and chemical characteristics making it a multi-purpose compound with interesting applications in environmental and industrial fields. This paper aims to comprehensively review the recent advances in MWT and its applications in environmental fields. We searched the PubMed, EMBASE, CINAHL, Web of Science, Google scholar, BIOSIS Previews, and additional sources for published and unpublished papers using the relevant keywords. Our main focus was applications of MW in agriculture, farming, and food processing. Exposing water to magnetic field induces different physical and chemical alterations in the water which some of them persist some minutes to several days. Improvements of the quality and quantity of irrigation water, crop yields and quality, soil improvement, and water saving are some of the reported benefits of MWT in agriculture and farming. In addition, magnetic field treatments have shown beneficial effects on the germination of seeds, plant growth and development, the ripening and yield of field crops. Despite the substantial advances in the MW technology, the main challenge in applications of MW in agriculture and farming is integration of irrigation components, designing suitable pumps and water irrigation network compatible with technical and field requirements of MWT systems.

**Keywords:** Magnetic Water Treatment, Magnetic Water, Advances, Environmental Applications, Agriculture, Farming.

## 1. Introduction

Magnetic or magnetized water (MW) is water that has been exposed to a magnetic field. Magnetic water treatment (MWT) is the process of exposing usual water by magnetic fields to induce some physical or chemical alteration in water. MWT is usually an environmental friendly, low installation cost and no energy requirement process. Although the idea of magnetic modulation of water is as old as modern sciences, the scientific development and applications of MWT date back the recent decades. MWT has been used in different fields including medicine, agricultural, industrial, and environmental applications (1-3). MW can be used to increase crop yield, induce seed germination, benefit the health of livestock, etc. In different countries including Australia, Bulgaria, China, England, Japan, Poland, Portugal, Russia, Turkey and the United States some companies and individuals are using MWT in different stages and levels of agricultural and farming activities (4-6). Some studies have shown that MW used for irrigation can improve water productivity(7). Magnetic water has also been found to be effective at preventing and removing scale deposits in pipes and water containing structures. MW also can increase the levels of CO2 and H+ in soils comparable to the addition of fertilizers. Cleaning agents when combined with the power of MW have an increased effectiveness, and one-third to one-fourth can reduce the amount of cleaner used (8). Agricultural sciences have shown great interest on MWT not only in the common and valued crop farming factors, but also in those less expensive and generally underestimated such as ionizing, laser or ultra violet radiation and electric and magnetic field. The magnetic technology has been investigated since the turn of the $19^{th}$ century. The water treated by the magnetic field or passed through a magnetic device has been called MW. In irrigation, industry, home use, medicine and… have been successful used by MW. For studying the biological effects of magnetic fields plants became more an attractive model system (9). A biostimulation on the initial growth stages was produced by 125 and 250 mT magnetic fields and increased the germination rate of several seeds such as rice (10, 11), wheat (12, 13), and barley have been reported (12, 13). MW prevents harmful metals such as lead and nickel from uptake by roots and reaching fruits and roots. It increases the%age of nutrient elements like phosphorus, potassium and zinc in plants (14). The stimulating effect requires availability of rich experimental material to figure it out (15). When water is magnetized, some physical and chemical properties changed that may be causing changes in plant characteristics, growth and production. To have a pronounced effect on plants productivity has been found by MWT (16) who suggested that there are possibly some beneficial effects of the magnetic treatment of irrigation water for the plant yield and water

productivity. Moreover, MW has been recommended for irrigation to enhance and increasing water use efficiency (WUE) and water productivity (WP) (17, 18). Speed of germination are increased by irrigation with MW (19). Magnetic treatment of irrigation water and magnetic treatment of seeds had the potential to improve the early seedling growth and nutrient contents of seedlings were. Irrigation of common bean plants in compared with control plants with MW increased the growth characteristics, potassium, GA3, kinetin, nucleic acids (RNA and DNA), photosynthetic pigments, photosynthetic activity and translocation productivity of photoassimilates as (20). Magnetic field exposure can increase the germinating energy, germination, fresh weight and shoot length of maize (14, 15, 21). MW has shown different medical benefits such as for diabetic patients, increasing the rate of fertility, preventing calculus accumulation in periodontal patients, increasing the activity of glutamate decarboxylase, increasing enzymatic activity, decreasing blood viscosity, reducing acidity. Furthermore, the alkalizing effect of MW can normalize the pH of the blood, body tissues and can reduce cholesterol and triglycerides. Drinking MW has reportedly beneficial effects on bladder problems, stroke recovery, arthritis pain, and on reducing blood pressure.

**2- Agricultural and Farming applications of MW**

Water is the most important factor for plant growth. MW has reportedly shown different potential applications in agriculture and farming.

**2-1. Crop Yield**

An increase in crop yield, size and sugar content of melon grown with magnetized irrigation water in South Africa was shown by Lin and Yotvat (22). Statistically significant increases in the yield and water productivity of snow peas and celery, but no significant effect on the yield or productivity of peas was reported by Maheshwari and Grewal (16). Harari and Lin (1989) showed the size of muskmelons, the number of fruits and their sugar content were significantly greater when irrigated with MW. Lentils irrigated with MW showed significant increase growth, the stimulation in growth is thought to be attributed to an effect of MW on the induction of cell metabolism and mitosis(6). MW has been stated to triple seedling advent of wheat(23). Reina et al. reported a significant increase in the rate of water adsorption and an increase in total mass of lettuce when treated with MW was reported by (24). Chickpea plants irrigated with MW grew taller and heavier than plants irrigated with tap water (6). Stimulation cause an increase in photosynthetic pigments, where the MW induces cell metabolism and mitosis meristematic cells in pea, lentil and flax (25). New protein bands are

formed in plants are treated with MW, and these proteins are responsible for increased growth(6). MW has been linked to increases in photosynthetic pigments, endogenous promotors, total phenol and protein biosynthesis in plants (6, 26).

**2-2. Germination**

The application of a magnetic field has been shown to induce seed germination, and increase the percent age of germinated seeds. Carbonell *et al*. reported an increase in the germination rate and percent age of rice seeds treated with a magnetic field (27). Moon and Chung cured tomato seeds with a magnetic field then figured out germination rates were accelerated about 1.1–2.8 times in compared with the control seeds(28). Pinus tropicalis showed about 50% increase in the germination rate, when the seeds were treated with MW and germination occurred in 70-81% of the seeds (29, 30). Germination of the broad bean seeds was found to take place 2-3 days earlier when seeds underwent magnetic treatment (Podleoney *et al*., 2004). However, Govoroon *et al*. observed no effect of magnetic treatment on the growth of pea, flax, and lentil seeds(31).

**2-3. Livestock**

Dairy cows that drink MW have shown an increase in milk production with the same amount of milk fat as present in cows drinking ordinary water. They also have a longer lactation period with fewer non-productive days and overall health is better (22). Young male cattle watered with MW rised their dry feed intake, while improving their digestion and nitrogen retention were demonstrated by Levy *et al.* (32). Piglets watered with MW drank twice as much water, and grew 12.5% larger than the control group (8). Chickens watered with MW grew larger, with an increase in the meat to fat ratio, and experienced reduced mortality rates (33). In addition, poultry have showed an increase in egg production when watered with MW (22). (22). (32).

**3- Environmental Applications**

The Italian chemist Giorgio Piccardi was among the pioneers who documented the capability of magnetic fields to alter the physical and chemical characteristics of water. Subtle changes in the Earth's geomagnetic field can modify the phase-change rate of water thus properties of water. Liburkin et al. (1986) found that magnetic fields affect the structure of gypsum (calcium sulfate) (34). Gypsum particles formed in magnetically treated water were found to be larger and more regularly oriented. Similarly, magnetic fields alter the mode of calcium carbonate precipitation such circular disc-shaped particles are formed rather than the dendritic particles observed in non-treated water (35). In addition, magnetic fields

affect the structure of subsequently precipitated solids (36). As scale formation takes in precipitation and crystallization, these studies indicate MW fields is likely to have an effect on the formation of scale. Some researchers hypothesize that magnetic fields influence the nature of hydrogen bonds between water molecules. Changes in water properties such as light absorbance, surface tension, and pH have been reported in different studies (37-39). However, later investigators have not always found these effects (40). Further, the characteristic relaxation time of hydrogen bonds between water molecules is approximated to be too fast and the applied magnetic field strengths too small for any such lasting effects, so it is unlikely that MW fields affects water molecules (41). The application of a magnetic field affects the electrical charges on calcium carbonate particles (42). Furthermore, the magnitude of the change in particle charge increases as the strength of the applied magnetic field increases. Magnetic fields affect the quantity of suspended and dissolved calcium sulfate (43). A very strong magnetic field generated by a nuclear magnetic resonance spectrometer was used to test identical calcium sulfate suspensions with very high hardness. Exposure to two minutes of magnetic fields decreased the dissolved calcium concentration by about 10% and the average particle charge by about 23%(44, 45).

The success or failure of MWT highly depends on the environmental conditions (46-49). Because of the varied conditions of the previous studies it is unclear whether the positive reports are due solely to magnetic fields or to other conditions that have not been controlled during the trial. Some commercial devices have been subjected to tests under controlled conditions. Unfortunately, the results are mixed (50) (41). Busch et al. (1997) measured the scale formed by the distillation of hard water with and without magnetic fields (51). Using laboratory-prepared hard water, a 22% reduction in scale formation was observed when the magnetic fields were used instead of a straight pipe section. However, a 17% reduction in scaling was found when an un-magnetized, but otherwise identical, device was installed. Fluid turbulence inside the device may be the reason of the 17% reduction, with the magnetic field effect responsible for the additional 5% (51). River water was subjected to similar tests, but no difference in scale formation was found with and without the magnetic treatment device installed. An explanation for this negative result was not found. Under the technical care of the device supplier, the device was tested to find out its ability to prevent the accumulation of calcium carbonate scale in a pipe. Very hard water was pumped through a cast-iron pipe, and periodically inspecting the pipe's interior determined the rate of scale accumulation inside the pipe. Much of the available laboratory test data imply magnetic water field devices are ineffective , yet reports of positive outcomes in industrial settings persist (52, 53). The contradictory reports imply if a

MW field effect for scale prevention exists, then it is effective under some of the conditions encountered in industry. Currently, there does not seem to be a defensible guideline for finding out when the desired effect can or cannot be expected. One of the claims made for residential magnetic field devices is less soap and detergent will be required for washing. Compared to the claim to suppress scale formation, this claim has received little direct attention in the literature. To decrease soap and detergent consumption, the concentration of dissolved hardness minerals must be decreased. An experimental study reported an about 10% decrease in dissolved mineral concentration after MWT (43).

There is a lack of peer-reviewed laboratory data, mechanistic explanations and documented field studies and erroneous conclusions about their efficacy are based on applications with uncontrolled variables , (54-56).

There are, however, some studies which have claimed significant effects and proposed possible mechanisms for the observed decrease in water scale (57). Some studies have shown a statistically significant reduction in calculus formation on the teeth when exposed to magnetically treated water (as compared to normal water) with an oral irrigator (58, 59).

MWT can be used to improve the performance of soaps, detergents and other cleaning agents, providing even greater cost savings. Magnetic technologies can also be used for improving fuel consumption. These fields can prevent scale formation inside fuel tanks and networks with no adverse effects as hydrocarbon fuels have no appreciable electrical resistivity and conductivity and are not susceptible to magnetic attraction.

**Conclusion**

Current evidence indicates that exposure to magnetic fields can alter the physical and chemical properties of water and the polarity of the magnetic fields defines the types and extent of the altered properties. Exposing water to magnetic field induces different physical and chemical alterations in the water which some of them persist some minutes to several days. Improvements of the quality and quantity of irrigation water, crop yields and quality, soil improvement, and water saving are some of the reported benefits of MWT in agriculture and farming. In addition, magnetic field treatments have shown beneficial effects on the germination of seeds, plant growth and development, the ripening and yield of field crops. Despite the substantial advances in the MW technology, the main challenge in applications of MW in agriculture and farming is integration of irrigation components, designing suitable pumps and water irrigation network compatible with technical and field requirements of MWT systems.

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