Magnetized Water: Science or Fraud?

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Although the magnetic treatment of household and industrial water to avoid scaling has raised much scientific debate for more than 50 years *(1–7),* commercially available water magnetizers have grown substantially in number and variety over this same period of time. Magnetizers are sold in a variety of forms under different trade names depending on the particular country—interested readers can search "magnetized water" using any search engine. Basically, water magnetizers are magnets that are placed around water pipes. As advertised, these devices prevent scaling inside pipes and in heating coils of household appliances. According to the technical specifications *(8)*, the device provides the following benefits:

- Pipes and appliances are kept deposit-free and last longer.
- Corrosion is delayed.
- Water acidity is reduced and surface tension decreased.
- Clothes wash better with less detergent and fabrics last longer.
- Bathtubs and toilet bowls are less easily stained.
- Water and steam diffusers remain clog-free over long periods.
- Heating systems perform optimally for years.
- Plant and crop growth and strength are markedly improved.
- Soaps produce more foam and leave hair and skin cleaner, softer, and shinier.

Some of the alleged effects of commercial magnetizers are closely related to the total hardness of water (viz., the total concentration of free Ca^{2+} and Mg^{2+} ions), which is a measure of the quality of drinking water. This parameter is important for industries and homes since both cations form carbonate precipitates—especially in hot water—that leave unwanted deposits in containers, pipes, and heating coils. In addition, Ca^{2+} and Mg^{2+} ions cause soaps to precipitate by forming insoluble salts that leave deposits on washing basins and bathtubs and result in poor washing. Water acidity (pH), which, according to some magnetizer dealers, is altered by magnetizers, can also have strong effects on the cleaning efficiency of soaps and detergents and ultimately add to the corrosive effect of water in combination with other chemical agents.

The effects of magnetizers have been ascribed to the increase in the aragonite/calcite ratio in $CaCO_3$ deposits in magnetically treated water relative to untreated water *(9–11)*. While calcite is a hard crystalline solid, aragonite is softer and less prone to forming persistent deposits. Although the mechanism by which the aragonite/calcite ratio is increased has not been clarified, the phenomenon may account in part for the alleged usefulness of these devices; in fact, such an easily understood argument is among the most widely used in their commercial advertising. However, some tests have shown that the action of magnetizers can vary widely depending on the pH of the water, so much so that a very slightly alkaline pH can favor the formation of calcite *(12)*. Also, whether the magnetic treatment can actually alter the composition of water with regards to the quantity of the free cations is controversial; thus, while some authors *(13)* have found a decreased concentration of Ca^{2+} following magnetic treatment of water, others *(14, 15)* have reported no substantial change in the free Ca^{2+} and Mg^{2+} quantities upon treatment. Clarifying this point is essential with a view to establishing whether magnetizers can improve the action of soaps and detergents and also the properties of water for personal hygiene (e.g., whether they can help avoid shower itch).

We addressed this scientific debate by designing a straightforward laboratory experiment to measure various properties of drinking water (viz., total hardness, surface tension, and pH) prior to and after subjection to the magnetic field produced by a commercial household magnetizer to check its efficiency. The experiment uses inexpensive reagents, materials, and instrumentation that are usually available in chemical laboratories. The experiment can be completed in six hours distributed in three work sessions. Students become acquainted with Tate's law for determining surface tension, laboratory measurements with simple instruments (a pH meter and a conductimeter), and the use of classical, but still popular techniques such complexometric titrations with EDTA for the determination of water hardness. Once the measurements are made, the students can use statistical computations to reject outliers based on Dixon's *Q* criterion, calculate mean values, and compare them via Student's *t* test. The outcome is used to check the manufacturer's claims of a typical household device for magnetizing water.

Encouraging students to engage in skeptical thinking is an essential part of scientific education. Chemistry, applied to magnetic treatments of water, provide a good opportunity to help university and secondary students develop educated skepticism against claims made about some products.

Chemicals and Equipment

- Analytical reagent-grade chemicals that include $Na_2EDTA{\cdot}2H_2O$ from Scharlau and, NH_4Cl, NH_3, and Eriochrome Black T from Panreac
- Grade A volumetric glassware
- Consort C-830 pH meter–conductimeter
- Commercial magnetizer[1]

Experimental Procedure

Treatment of Flowing Water

The commercial magnetic device was attached to the middle of a 1.5 m long copper pipe with a 20 mm i.d. (Figure 1). A stream of drinking water flowed by gravity through the copper pipe at a rate of 65.5 mL s^{-1}. The flow rate is comparable to a mean flow obtained from the tap (either lab or home). The water was recirculated 5 times to strengthen the claimed effect of the magnetic field and 10 samples were collected for measurement. The results were checked against those obtained by passing a stream of drinking water at a flow rate of 65.5 mL s^{-1} through the same copper pipe in the absence of the magnetizer. All analyses were performed in the same work session to avoid attenuation of the claimed effects of the magnetic field on the water.

Influence of Treatment Time

The influence of time on the potential magnetizing effect on drinking water was also examined. The water was initially held in the tube for 4 h and then poured into a vessel from which ten samples were withdrawn for measurement. Subsequently, fresh drinking water was held in the tube for 16 h and processed as before. All analyses in both experiments were performed in the same work session to avoid attenuation of the claimed effects of the magnetic field on the water. The results were also checked against those obtained by passing a stream of drinking water at a flow rate of 65.5 mL s^{-1} through the same copper pipe in the absence of the magnetizer.

Measurement of pH and Conductivity

The pH and electrical conductivity of all samples were measured with a Consort C-830 pH meter–conductimeter.

Determination of Surface Tension

The surface tension of the treated and untreated water samples was determined by using Tate's law and distilled water as reference.

Determination of Total Hardness

The total hardness of the samples was determined according to the WHO (World Health Organization) standard method for calcium and magnesium in drinking water *(16)* with grade A volumetric glassware and analytical reagent-grade chemicals that included $Na_2EDTA \cdot 2H_2O$ and Eriochrome Black T.

Hazards

Na_2EDTA is slightly hazardous in case of skin contact (irritant), of eye contact (irritant), and of ingestion. Eriochrome Black T is an eye, skin, and respiratory irritant.

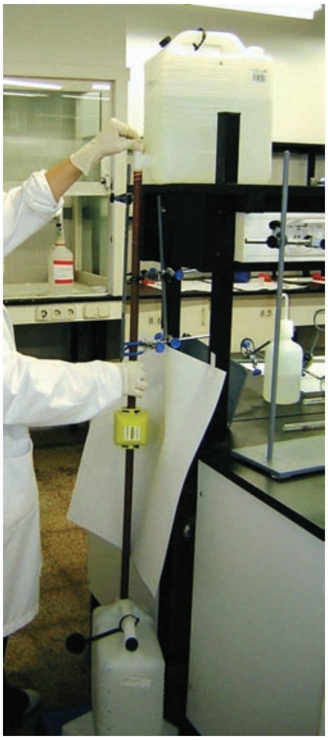

Figure 1. Recirculation of water by gravity flow through a copper pipe bearing the commercial magnetizer.

Table 1. Mean Values and Standard Deviations of the Parameters Determined in Magnetized and Untreated Water

Parameter	Untreated Drinking Water	Treated Drinking Water		
		t = 0 h	*t* = 4 h	*t* = 16 h
pH	8.08 ± 0.03	8.07± 0.04	8.11 ± 0.04	8.10 ± 0.03
Conductivity/(mS cm^{-1})	2.00 ± 0.07	1.99± 0.07	2.07 ± 0.08	2.06 ± 0.06
Total hardness/(g L^{-1}, $CaCO_3$)	0.873 ± 0.006	0.878± 0.006	0.877 ± 0.004	0.879 ±0.007
Surface tension/(dyn cm^{-1})	75.4 ± 0.6	75.2± 0.6	75.3 ± 0.6	75.6 ± 0.6

NOTE: *N* = 10.

Results and Discussion

The experimental work was performed by two undergraduate students under the supervision of a professor. The students worked jointly at every stage of the experimental procedure. One student conducted all pH measurements and the necessary measurements to determine the total hardness for the 40 water samples.[2] The other student carried out all conductivity measurements and the necessary measurements to determine the surface tension for the 40 water samples.

Mean values plus their respective standard deviations were calculated. Application of Dixon's Q criterion to the data revealed no outliers. The results, which were rounded according to standard criteria, are shown in Table 1. Although the data were very similar, they were compared via a statistical procedure based on Student's t test. No significant differences at the $p < 0.05$ level were detected. As can be seen from Table 1, the pH, conductivity, total hardness, and surface tension values exhibited no significant differences between treated and untreated drinking water, irrespective of the length of time during which the water was exposed to the magnetic field.

Based on the results generated by such a simple experiment, which was conducted under the recommended conditions for use of the magnetizer, the studied parameters are insignificantly altered by the device. Therefore, contrary to what is advertised, no improvement in the washing properties of water treated with the magnetic device is to be expected.

Conclusions

The results obtained in this simple experiment do not support the claims that the magnetizer acts on the pH, conductivity, surface tension, and total hardness of water and, hence, that the magnetic device softens drinking water. However, only a limited number of measurements ($N = 10$) for each parameter were made to compare the treated water with the untreated water. We recommend that when this procedure is carried out by the students in the laboratory, they should make their own conclusion based on the experimental results and the number of measurements. Considering that the benefits declared by the magnetic device manufacturer are related with the experimentally determined parameters, the experimental results will generate an interesting discussion with the students.

Although some studies suggest that magnetic fields can alter the morphology and adherence of calcium carbonate deposits *(9)* and specific properties of aqueous solutions, the mechanism remains unclear *(17, 18)*. The efficiency of the magnetizers must depend of a large number of physicochemical parameters, so additional studies are required to examine the influence of other factors such as temperature, pH, the ionic composition of water, the intensity of the magnetic field, the flow rate at which the water is passed through the pipe, the pipe material (copper, PVC), and other, as yet unknown variables potentially affecting the claimed effects of magnetic fields on the properties of water *(6, 18)*.

Notes

1. The commercial device was purchased from MASICAL. It is advertised on national radio channels in Spain and is well-known in the country. The unit studied in this work was purchased for €93.
2. The 40 water samples are 10 replicate samples of untreated water, 10 replicate samples of treated water, 10 replicate samples of treated water (4 hours), and 10 replicate samples of treated water (16 hours).

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