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Design of magnetic flux and its effect of pH groundwater

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ABSTRACT

Water scarcity is a worldwide problem, where more than 40% of the world's population is suffering from water shortages and a severe deterioration of water quality. Magnetic water treatments may improve water quality to reduce the water crisis. In the current study, 20 magnetic bars were arranged and positioned adjacent to different sized-glass and galvanized iron cuboids and rectangular cuboids. This positioning was reliable to quantify the relation between magnetic forces and water properties, such as pH. Results generally showed that the averaged magnetic fluxes (ϕ_B) inside the galvanized iron cuboid and rectangular cuboid had values lower than the glass ones. Magnetic treated water (MTW) had higher pH than non-magnetic treated water. The averaged pH of MTW of exposure time (24 and 12 h) were 8.18 and 8.11, while non-magnetic treated water had a lowered average (7.72). One way analysis of variance (ANOVA) test of pH analytical values indicated that the significant effect of the magnetic forces (105.98 μW) on groundwater pH. In addition, the validation of ANOVA was tested by calculation of the partial Eta^2 (η_2). Eta^2 (η_2) had the value of 0.46 to refer that the groups (treatments) explain 46.6% of the variance from the average. Tukey's honestly significant difference referred to the significant (at 90% and 99%), differences between the means of the pairwise treatments; T_1:T_2, T_1:T_3, where; T_1 (non-magnetic treated groundwater or blank), T_2 (magnetic-treated groundwater with an exposure time of 12 h), and T_3 (magnetic-treated groundwater with an exposure time of 24 h). Contrary, the difference between the means of the pairwise T_2 and T_3 was non-significant.

Keywords: Groundwater; Magnetic fields; Magnetic intensity; Magnetic fluxes; pH; Eta^2 (η_2); Tukey's honestly significant difference

1. Introduction

Water is the main factor limiting crop production in the world and plays an important role in food security [1]. Irrigation can greatly enhance crop yields, but the local availability of freshwater resources limits the ability to increase food production [2]. Agriculture is the most water-demanding, requiring more than 85% of human water consumption. Irrigated agriculture represents 20% of the total cultivated land and accounts for 40% of global food production. It is generally accepted that water is the most critical and valuable resource for human life from survival purposes to an increase in wealth. A vast number of regions are subject to water rarity issues; therefore, a considerable number of researchers recognize the global trend of increasing water demand and decreasing water availability [3]. Egypt is facing an annual water deficit of around seven billion cubic meters and the country could run out of water by 2025 [4]. However, water availability in Egypt puts it below the World Bank's water scarcity limit of renewable water available (1,000 m^3/capita/y) [5].

New approaches were recently introduced such as magnetic fluxes, electrodialysis, and reverse osmosis, to

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raise groundwater quality [6]. The magnetization of water solutions is one of the interesting methods of non-chemical water treatment. There are many examples of effective application of magnetic water treatment in such industries as chemical, mining, metallurgical, production of construction materials. There were attempts to use water magnetization in agriculture, and medicine. In several cases, a stable positive effect was reported, in others no effect of magnetic treatment. The design of the simplest magnetic device has shown that the greatest effect occurs in the case of certain chemical water compositions [7].

A bar magnet is a rectangular piece of an object made up of iron, steel, or any other ferromagnetic substance or ferromagnetic composite, that shows permanent magnetic properties. It has two poles, a north and a south pole. There are simple shapes of bar magnet: (a) cylindrical bar magnet, and (b) rectangular bar magnet [8]. Permanent magnets are uniformly magnetized. It has two well-defined poles [9].

The magnetic field may be created by other permanent magnets, or by currently flowing in coils. Basic problems of permanent magnet design revolve around estimating the distribution of magnetic flux in a magnetic circuit, which may include permanent magnets, air gaps, high permeability conduction elements, and electrical currents [10].

Magnetized water has more hydroxyl (OH^-) ions that form alkaline molecules which reduce the acidity. Normal tap water has a pH of about 7. Magnetized water is more alkaline and can have a pH as high as 9.2 [11]. The pH slightly increases; it means the absorption of H^+ ions and the increase of the number of OH^- ions in the water. The pH increases by 5.6%. Treatment of distilled water using permanent bar magnets induced greatest changes of water properties as compared to using permanent ring magnets, with pH increase of 0.08 [12].

The study aimed to:

(1) Present a design that may be reliable for upcoming laboratory researches of (a) improving quality of irrigation water, (b) magnetic exposure time, and (c) water magnetic retentivity (water magnetic memory).
(2) Produce varied magnetic forces to quantify the relation between the different positions of the magnetic bars and the resulting magnetic forces.
(3) Study the effect of exposure time of the magnetic flux on groundwater pH.

2. Materials and methods

Twenty rectangular magnetic bars were arranged adjacent to different sized-glass and galvanized iron cuboids and rectangular cuboids. The cuboids (squared base: 4 cm × 4 cm) and rectangular cuboids (rectangular base: 2.5 cm × 4 cm) represented the first and second studied cases, correspondingly. The bars were positioned in three organizations to produce varied-intensities horizontal and vertical magnetic fluxes. Magnets were organized in 10 × 10 bar, 5 × 5 bar, and 5 × 5 × 5 × 5 bar. All magnetic bars were organized in unlike poles (attract position) to increase forcing by minimizing the scattering of the magnetic lines. It was noticeably that pre-experiments indicated that vertical magnetic fields had generally so low magnetic intensities than that of the horizontal ones, to be eliminated from the study.

The selection of the glass and galvanized iron materials are based on the following facts:

(1) Materials that are not attracted to a magnet like air, wood, plastic, brass, etc., have permeability equal to 1. There is no magnetism induced in them by an external magnetic field.
(2) Ferrous, nickel, and cobalt alloys have high permeability (μ), and thereby, magnetic fields can be induced in them when exposed to an external magnetic field [13].

The work was elaborated in two phases: (I) preparation of the magnetic environment, (II) assessment the effect of magnetic force on groundwater pH.

2.1. Phase (I): preparation of the magnetic environment

The magnetic environment was prepared to produce magnetic fields through the following steps: (1) determination the pole (N-S) of the magnetite, (2) design the suitable containers of groundwater and solutions, (3) producing varied intensities–horizontal magnetic fields, and (4) measurements of the magnetic intensity and calculating the magnetic fluxes.

2.1.1. Determination of the pole (N-S) of the magnetite

The north and south poles were not indicated on the magnetic bars, so we had to identify and marked them by magnetic compass [14].

2.1.2. Design containers of groundwater

The containers that had the shapes cuboids and rectangular cuboids were made of glass and galvanized iron materials. They had an 8 cm height, and 0.3 cm fine thicknesses to provide maximal magmatic permeability [15]. The glass cuboid and rectangular cuboid were made to have a 4 cm² × 4 cm² base and rectangular base (2.5 cm × 4 cm inside) (Fig. 1).

2.1.3. Producing varied intensities–horizontal magnetic fields

20 magnetic bars were differently organized to produce varied intensities–horizontal magnetic fields (Fig. 2). The number of magnetic bars was chosen to produce an adequate varied-magnetic intensity that is located within the range of similar studies of the effect of the magnetic force on properties of irrigation water [16]. Hence the magnetic strength decreases as magnetite distance increases, in all cases and all positions, the magnets were ever placed adjacent to the rectangle to provide the power of magnets [17]. The magnetic intensities (Fig. 3) were measured in the vertical direction of the magnetic fields.

2.1.4. Measuring the magnetic intensity and calculating magnetic fluxes

The magnetic intensity varies through the magnetic field [18,19], therefore it was determined at different positions, by

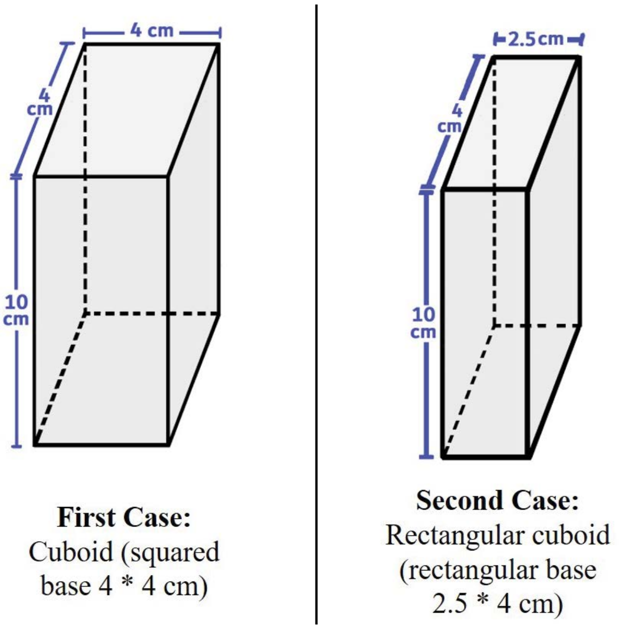


Fig. 1. Containers of groundwater and solutions.

using Teslameter-4060.50. Magnetic flux (ϕ_B) was online calculated [20], by applying the following formula [21]:

$$\phi_B = (B)_G \times A \quad (1)$$

where the magnetic field (G) is at a 90° angle; perpendicular, has magnetic intensity $(B)_G$ and an area of (A) (Fig. 4).

2.2. Phase (II): assessment magnetic force on groundwater pH

Thirty-eight groundwater samples were collected from the wells of Wadi El-Natroun, Egypt (Fig. 5), to assess the effect of the magnetic force on groundwater pH. They were exposed to the magnetic field (101.64 μW) for the time of 0, 12, 24 h, and then pH was determined by pH meter. Analysis of variance (ANOVA) was run determine to test the significance of the effect of magnetic force on pH groundwater is significant [22]. The validation of ANOVA was tested by calculation of the partial η_2 that is a proportion of variance accounted for by some effect (η_2 is like R^2 in the linear regression). η_2 had the value of 0.46 [22].

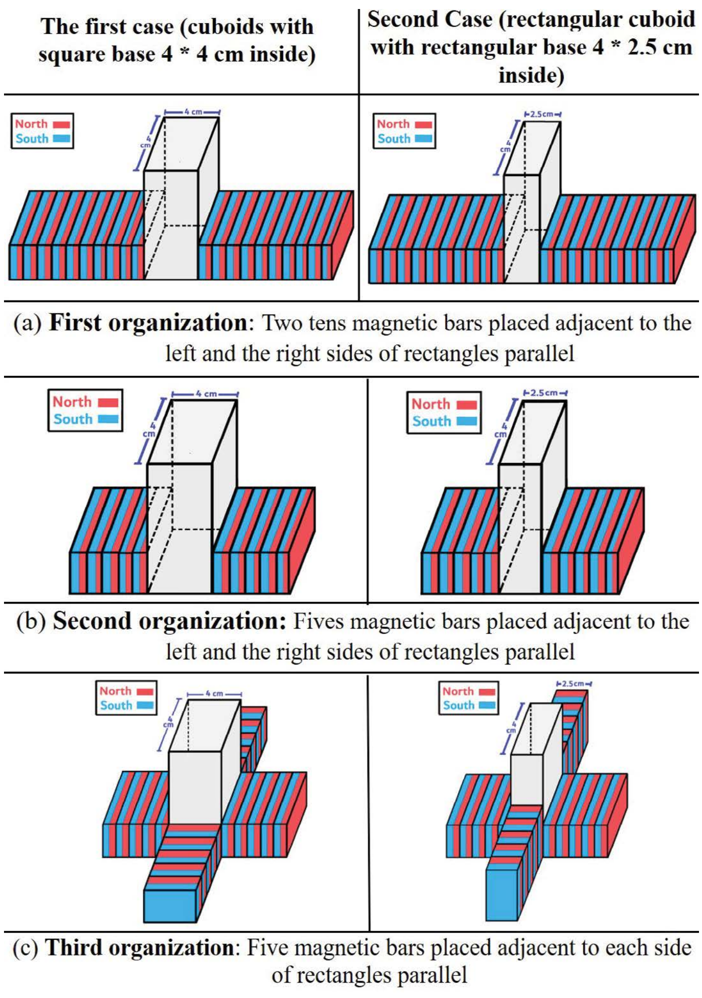


Fig. 2. Organizations of the first case (cuboids with square base; 4 cm × 4 cm inside), and second case (rectangular cuboid with rectangular base; 4 cm × 2.5 cm inside).

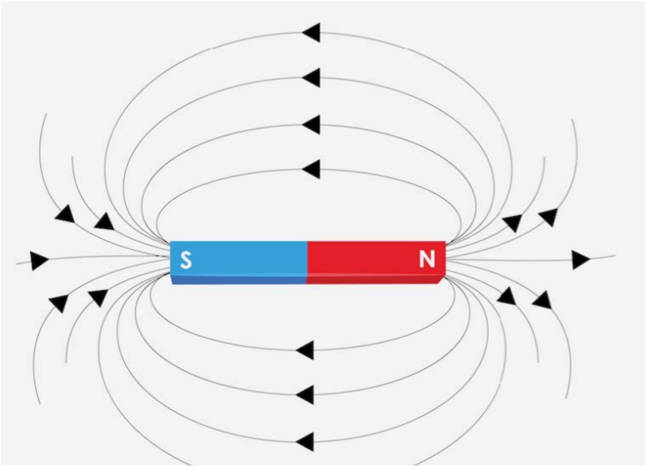
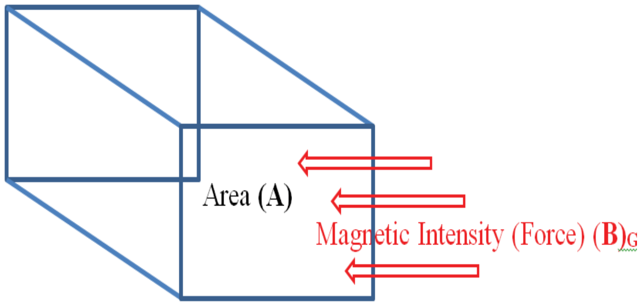


Fig. 3. Measuring magnetic intensity by Teslameter [22].



$$(\varphi_B) = (B)_G * A$$

Fig. 4. Magnetic flux (ϕ_B) and intensity $(B)_G$ of the magnetic field (G).

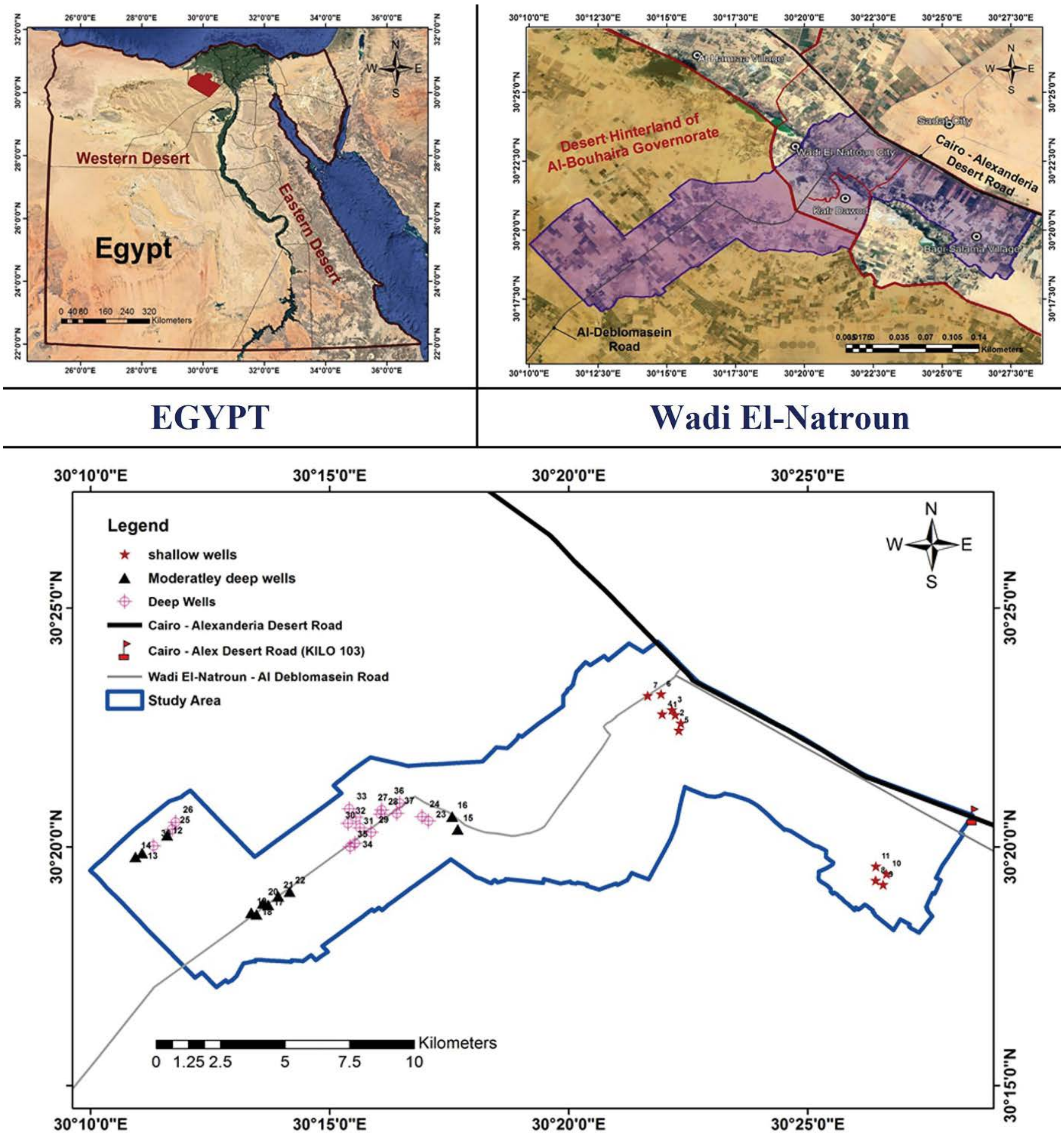


Fig. 5. Location of studied groundwater wells, Wadi El-Natroun (Egypt).

Tukey's honestly significant difference (HSD) was applied for pairwise comparisons; T_1:T_2, T_1:T_3, and T_2:T_3, where; T_1 (non-magnetic treated groundwater or blank), T_2 (magnetic-treated groundwater with an exposure time of 12 h), and T_3 (magnetic-treated groundwater with an exposure time of 24 h). Tukey's honestly significant difference (HSD) was calculated online [23] from the following formula:

$$\text{HSD} = Q \times \frac{\sqrt{\text{MSwithin}}}{n} \tag{2}$$

MS is the mean square within, and n is the samples number in the group or treatment. HSD results were confirmed by calculation of studentized range (Q) that is the difference between the largest and smallest data point in a sample, measured in terms of sample standard deviations [23]. Q was online calculated, [24]. Also, it can be derived from the next equation:

$$Q = \frac{M_a - M_b}{\sqrt{\text{MSwithin}} / n} \tag{3}$$

where (M_a – M_b) are pairs difference means of the treatments (or groups) of (a) and (b). Finally, the calculated Q was compared to standard (tabulated) Q to confirm the test of (HSD) [25].

3. Results and discussion

The work included (1) determination of the pole (N-S) of the magnetite, (2) building varied intensities–horizontal and vertical magnetic fields, (3) determination of the magnetic intensities of magnetic fields, and (4) determination of the magnetic fluxes of magnetic fields.

3.1. Determination of the pole (N-S) of the magnet: (locate the pole (N-S) of the magnet)

The poles "N" and "S" of the magnetic bars were not marked; therefore, they were determined by a compass. The north pole of the compass needle magnet is attracted to the south pole of the magnetic bar.

3.2. Building varied intensities–horizontal magnetic fields

The magnets that were arranged, around the glass and iron, galvanized cuboids and rectangular cuboids in different organizations produced varied intensities–horizontal and vertical magnetic fields. It was notable that all the organizations of magnetic bars took the positions of unlike poles (attract) (Figs. 6 and 7). These positions lead to bars attraction and minimizing the scattering of the magnetic lines. This effect which is easily remembered by the famous expression of "opposites attract" produced the

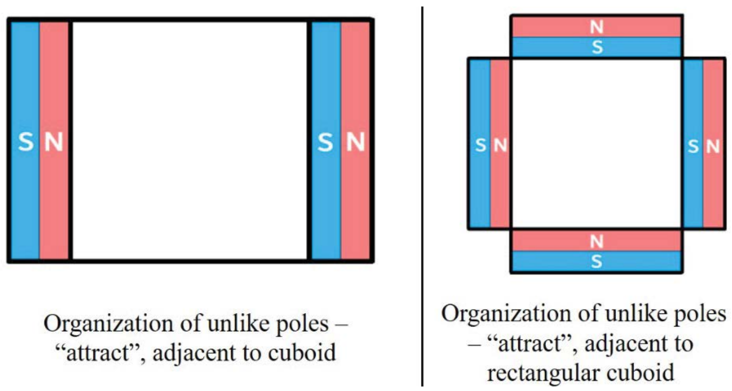


Fig. 6. Unlike poles – "attract" position of magnetic bars.

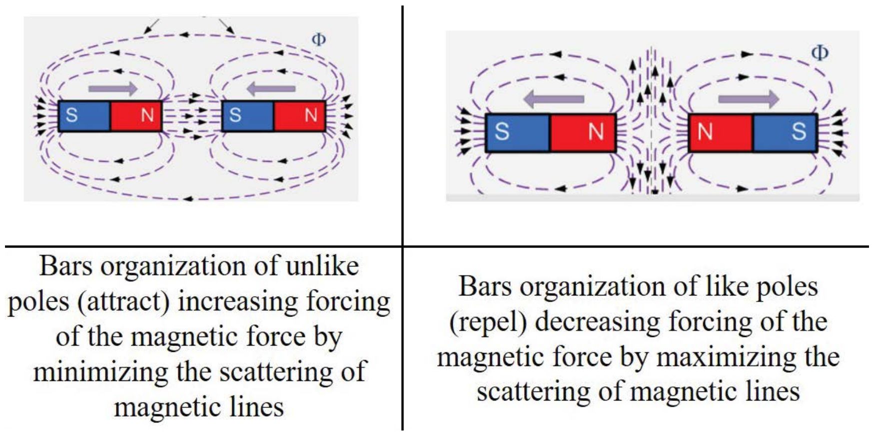


Fig. 7. Organizations of unlike poles – "attract" and like poles – "repel" [27].

possible maximum magnetic power. Also, these organizations were conducted to more decreasing the values of total soluble solids, electrical conductivity, total hardness, calcium and magnesium hardness, chloride and sodium ion, high pH, high potassium ion concentrations, and increasing the readiness of nutrients for soil and plants [26].

3.3. Determination magnetic intensities of horizontal magnetic fields

Magnetic intensity (force) varied through the magnetic fields, of the same case and same arrangement, because of the measurement of the different locations (Tables 1 and 2). So, it was measured, inside the glass and galvanized iron cuboids and rectangular cuboids at five positions (Figs. 8 and 9). For example, the magnetic intensity had five values: 830; 983; 805; 1,255 and 1,209 (gauss/m^2), at the five locations measurement of the glass rectangular cuboid (First organization). Therefore, the means of the magnetic intensity were calculated to correctly express the force of magnetic fields. These variations of magnetic intensity are owing to the measurement of the location are because pulling force is strongest at the two poles of a magnet and thus the distance weakens the force, that is, magnetic strength decreases as distance increases [17].

Another factor affecting the magnetic intensity $(B)_G$ was the organization of the magnetic bars adjacent to the glass and galvanized iron cuboids and rectangular cuboids. In the case of glass cuboids, the mean of $(B)_G$ ranged from 561.8 (Second organization) to 643 (gauss/m^2) (First organization). The mean magnetic intensity $(B)_G$, inside galvanized iron cuboid, had the values of 21.2, 17.0, and 38.6 (gauss/m^2) for first, second, and third organization, respectively. These variations of magnetic intensity were due to the fact each magnet's organization produced its force. These variations of the mean $(B)_G$ that were due to the different organizations were confirmed by the results of the second case (glass and galvanized iron rectangular cuboids). The means $(B)_G$ values, of the second case, followed the same order. The minimal and maximal $(B)_G$ were recorded for the second and first organizations of glass rectangular cuboids. The third organization represented intermediate mean $(B)_G$. The means of $(B)_G$, of the three organizations, had the values 1,016.4; 915.2 and 954.8 (glass rectangular cuboids), and 20.4, 19.2, and 19.6 gauss/m^2 (galvanized iron rectangular cuboids).

In addition, these results indicated that the mean $(B)_G$ varied according to the material of the cuboids and rectangular cuboids (glass or galvanized iron). Generally, the means $(B)_G$ magnetic intensities, inside of glass cuboids and rectangular cuboids, were higher than that of the inside of

Table 1
Means of magnetic intensity $(B)_G$ and flux (ϕ_B) of the horizontal magnetic fields
First case: cuboids with square base: 4 cm × 4 cm

Glass cuboid						Galvanized iron cuboid					
First horizontal organization (10 bars on left side and other 10 bars on right)											
Loc.*	1	2	3	4	5	Loc.*	1	2	3	4	5
$(B)_G$	807	561	560	472	815	$(B)_G$	24	19	17	17	29
Mean $(B)_G$	643					Mean $(B)_G$	21.2				
$(B)_W$	64,300					$(B)_W$	2,120				
ϕ_B	64,300 × 16 × (10^{-4}) = 102.88					ϕ_B	2,120 × 16 × (10^{-4}) = 3.392				
Second horizontal organization (5 bars on left side and other 5 bars on right)											
Loc.*	1	2	3	4	5	Loc.*	1	2	3	4	5
$(B)_G$	697	561	508	442	696	$(B)_G$	21	12	12	12	28
Mean $(B)_G$	561.8					Mean $(B)_G$	17				
$(B)_W$	56,180					$(B)_W$	1,700				
ϕ_B	56,180 × 16 × (10^{-4}) = 89.89					ϕ_B	1,700 × 16 × (10^{-4}) = 2.72				
Third horizontal organization (5 bars on each side)											
Loc.*	1	2	3	4	5	Loc.*	1	2	3	4	5
$(B)_G$	818	597	571	456	870	$(B)_G$	40	37	34	26	56
Mean $(B)_G$	662.4					Mean $(B)_G$	38.6				
$(B)_W$	66,240					$(B)_W$	3,860				
ϕ_B	66,240 × 16 × (10^{-4}) = 105.98					ϕ_B	3,860 × 16 × (10^{-4}) = 6.176				

Loc.*: measurement locations of magnetic intensity (force);
$(B)_G$: magnetic intensity (force), gauss/m^2;
Mean $(B)_G$: mean magnetic intensity (gauss/m^2);
$(B)_W$: mean magnetic intensity (microweber: μWb);
(ϕ_B): mean magnetic flux density = $(B)_W \times A$;
A: area of the base of the cuboid = 4 cm × 4 cm = 16 cm^2 = 16 × (10^{-4}) m^2;
Note: One Gauss (G/m^2) = 0.1 Millweber (mWb·t) = 100 Microweber (μWb).

Table 2
Means of magnetic intensity $(B)_G$ and flux (ϕ_B) of the horizontal magnetic fields
Second case: rectangular cuboids with rectangular base: 2.5 cm × 4 cm

Glass rectangular cuboid						Galvanized iron rectangular cuboid					
First horizontal organization (10 bars on left side and other 10 bars on right)											
Loc.*	1	2	3	4	5	Loc.*	1	2	3	4	5
$(B)_G$	830	983	805	1,255	1,209	$(B)_G$	13	14	16	29	30
Mean $(B)_G$			1,016.4			Mean $(B)_G$			20.4		
$(B)_W$			101,640			$(B)_W$			2,040		
ϕ_B			101,640 × 10 × (10^{-4}) = 101.64			ϕ_B			2,040 × 10 × (10^{-4}) = 2.04		
Second horizontal organization (5 bars on left side and other 5 bars on right)											
Loc.*	1	2	3	4	5	Loc.*	1	2	3	4	5
$(B)_G$	829	909	691	1,063	1,084	$(B)_G$	12	15	15	26	28
Mean $(B)_G$			915.2			Mean $(B)_G$			19.2		
$(B)_W$			91,520			$(B)_W$			1,920		
ϕ_B			91,520 × 10 × (10^{-4}) = 91.52			ϕ_B			1,920 × 10 × (10^{-4}) = 1.92		
Third horizontal organization (5 bars on each side)											
Loc.*	1	2	3	4	5	Loc.*	1	2	3	4	5
$(B)_G$	672	915	793	1,184	1,210	$(B)_G$	29	34	30	46	64
Mean $(B)_G$			954.8			Mean $(B)_G$			19.6		
$(B)_W$			95,480			$(B)_W$			1,960		
ϕ_B			95,480 × 10 × (10^{-4}) = 95.48			ϕ_B			1,960 × 10 × (10^{-4}) = 1.960		

Loc.*: Measurement locations of magnetic intensity (force);
$(B)_G$: magnetic intensity (force), gauss/m^2;
Mean $(B)_G$: mean magnetic intensity (gauss/m^2);
$(B)_W$: mean magnetic intensity (microweber: μWb);
(ϕ_B): mean magnetic flux density = $(B)_W \times A$;
A: area of the base of the cuboid = 2.5 cm × 4 cm = 10 cm^2 = 10 × (10^{-4}) m^2;
Note: One Gauss (G/m^2) = 0.1 Millweber (mWb·t) = 100 Microweber (μWb).

galvanized iron ones. For example, the means $(B)_G$ of the glass and galvanized iron cuboids were 643.0 and 21.2 gauss/m^2, while these of the rectangular cuboid ones were 1,016.4 and 20.4 gauss/m^2. This type of $(B)_G$ variation is owing to the magnetic arrangement. This idea of the molecular alignment of magnetic materials is known as "Weber's Theory" which refers to the fact that all atoms have magnetic properties due to the spinning action of the atom's electrons. Any magnetic material will produce a magnetic field itself, which depends on the degree of alignment of magnetic domains in the material set up by orbital and spinning electrons [27].

Briefly, the three factors affecting $(B)_G$ can be arranged, ascending order, as follows; locations measurement, magnets positions, and absorbing materials (in which magnetic force passes).

3.4. Determination of the magnetic fluxes of magnetic fields

The magnetic intensity expresses the magnetic force, only for a point, while magnetic flux is the magnetic force through an area, that is, magnetic flux is a measurement of the total magnetic field which passes through a given area [28]. So, the mean magnetic flux (ϕ_B) was calculated by the online technique [20] to determine the more effective magnetic field (Table 3). The table generally showed that (ϕ_B) values, inside the galvanized iron cuboid and rectangular cuboid, were so lower to be not concerned by the study. (ϕ_B) values of glass cuboid and rectangular cuboid ranged from 89.89 (Third organization, case of the cuboid) to 105.98 μWb (Second organization, cuboid). It was obvious that the later organization of the glass cuboid represented the more ideal magnetic environment to study groundwater pH.

In the natural environment, soil pH has an enormous influence on soil biogeochemical processes. Soil pH is, therefore, described as the "master soil variable" that influences myriads of soil biological, chemical, and physical properties and processes that affect plant growth and biomass yield. pH impacts on plant nutrition and soil remediation (bioremediation and physicochemical remediation) [29,30]. For this reason, groundwater pH was selected for as matter for assessing the impact of magnetic flux. pH analytical data showed generally that magnetic treated water (MTW) had higher pH values than non-magnetic treated water. pH values were arranged in descending order; the averaged pH of MTW of exposure time (24 and 12 h) were 8.18 and 8.11, while and non-magnetic treated water had the lowered averaged of 7.72 (Table 4). ANOVA test, using F distribution, was carried out to determine

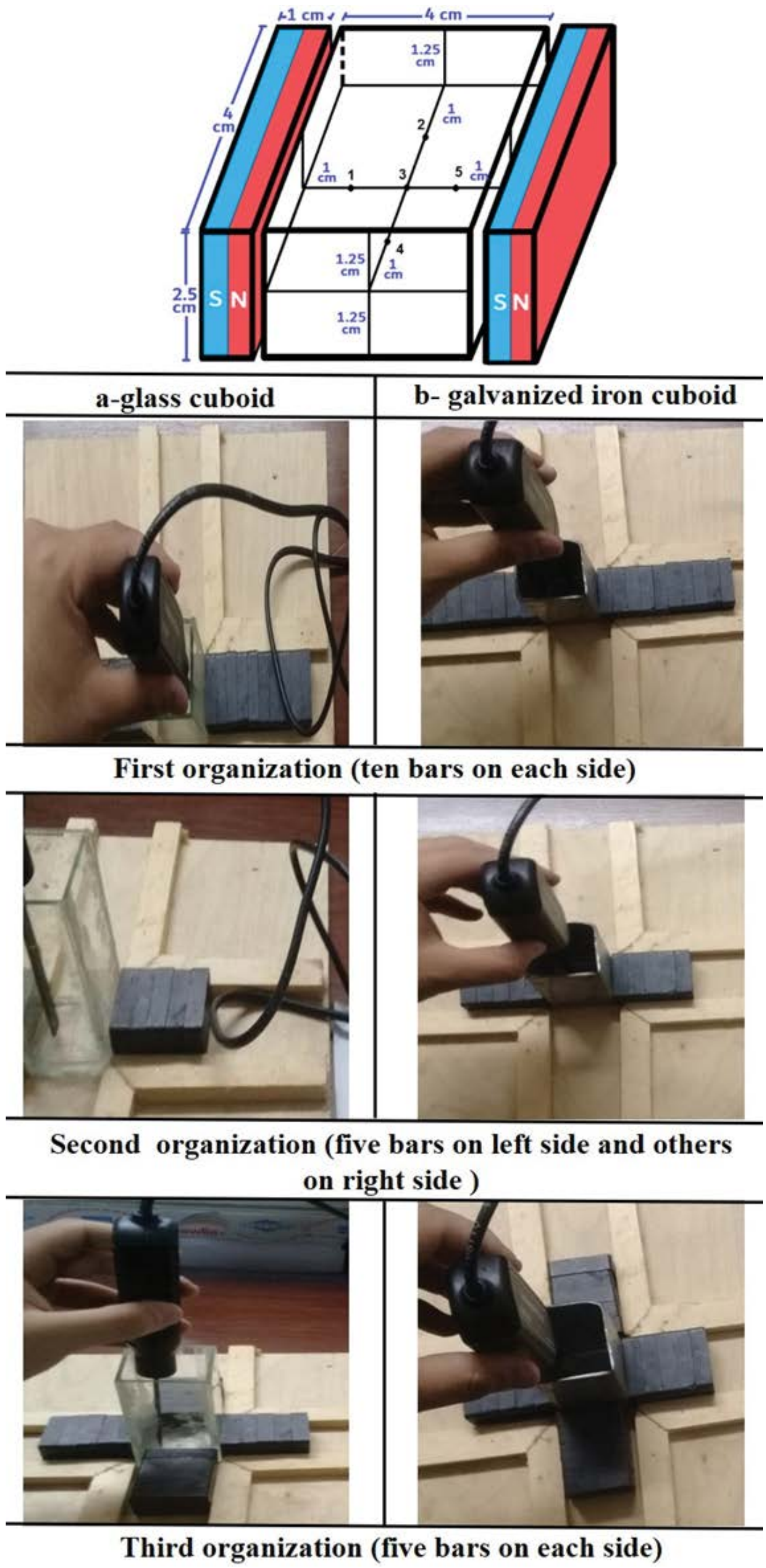


Fig. 8. Measurement locations of the magnetic intensity of horizontal magnetic field (first case: cuboid with square base: 4 cm × 4 cm).

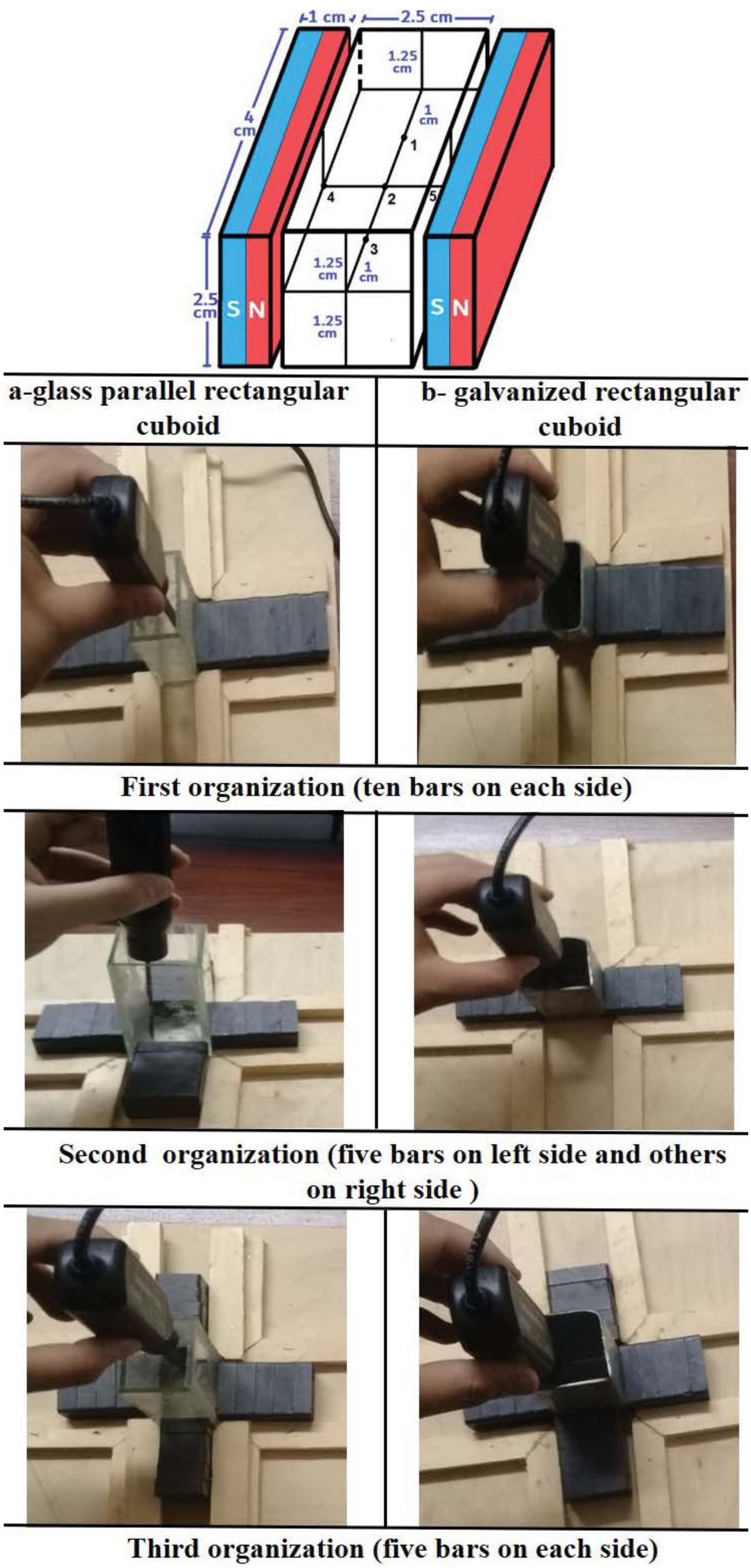


Fig. 9. Measurement locations of the magnetic intensity of horizontal magnetic field (second case: rectangular cuboid with rectangular base: 2.5 cm × 4 cm)

Table 3
Descending order of the mean magnetic flux (ϕ_B) at the different organizations of magnetic bars

Organization (Arrangement)	Magnetic flux (microweber)	Descending order
First case (cuboid with square base: 4 cm × 4 cm)		
Third (5 × 5 × 5 × 5 bars)	105.98	4
First (10 × 10 bars)	102.88	5
Second (5 × 5 bars)	89.89	6
Second case (rectangular cuboid with rectangular base: 2.5 cm × 4 cm)		
First (10 × 10 bars)	101.64	1
Third (5 × 5 × 5 × 5 bars)	95.48	2
Second (5 × 5 bars)	91.52	3

Table 4
pH of groundwater (Wadi El-Natroun wells) exposed to the magnetic field (101.64 μW)

Well No.	Exposure time: ExT (h)			Well No.	Exposure time: ExT (h)		
	Blank	T_1	T_2		Blank	T_1	T_2
	0	12	24		0	12	24
1	8.13	8.36	8.22	20	8.13	8.00	8.27
2	7.62	7.88	7.73	21	7.91	8.31	8.31
3	7.49	7.87	7.77	22	7.14	8.08	8.23
4	7.79	7.87	8.06	23	7.37	8.13	8.40
5	7.78	8.09	8.04	24	7.59	8.23	8.28
6	7.70	8.00	7.80	25	7.46	8.21	8.37
7	7.82	7.84	8.73	26	7.68	8.32	8.40
8	7.79	8.11	8.18	27	7.15	8.08	8.13
9	7.96	7.99	8.11	28	7.42	8.19	8.14
10	7.65	8.08	8.25	29	7.80	8.20	8.24
11	7.94	8.36	8.40	30	7.37	8.02	7.82
12	7.63	7.94	7.99	31	7.67	8.25	8.14
13	7.60	7.87	7.99	32	7.6	8.1	8.3
14	7.63	7.75	7.86	33	8.0	8.4	8.4
15	7.63	7.79	8.05	34	7.7	8.2	8.5
16	7.67	7.99	7.99	35	8.1	8.7	8.7
17	8.05	7.91	7.98	36	8.3	8.7	8.8
18	7.70	7.77	7.92	37	8.0	8.3	8.3
19	7.45	7.95	7.83	38	8.0	8.3	8.3
Mean	7.72	8.11	8.18				

pH was measured at room temperature, then the reading was compensated to 25 to have pH of the standard temperature of (°C).

the significance of pH variation. The obtained results of the one-way ANOVA test, using F distribution df (2,111), referred that F had the value of 36.54** which is greater than the critical values for the F distribution at the probability of 95% and 99%. This indicated the significant effect of the magnetic forces (105.98 μW) on pH groundwater (Table 5).

Many authors postulated the mechanisms of pH increasing under the effect magnetic. Hydrogen bonding between water molecules was enhanced when exposed to a magnetic field (B = 0.5T). This was attributed to the effect of the Lorentz force on protons and promoting their bonding to water to form hydronium (H_3O^+). pH increased significantly and proton concentration decreased when water passed through the magnetic field (B ¼ 1:350 T) [31]. Higher pH of irrigation water reduces the acidity of the soil solution, so higher pH of irrigation water improves the quality of acidic soils solution (like European soils). Contrary, higher pH of irrigation water reduces the quality of alkaline soils solution (such as soils of arid and semi-arid regions) by increases the alkalinity. The above-mentioned opposite effect of higher pH of irrigation water on soil solution is due to the inverse relationship between pH and solubility and availability of plant micronutrients (Fe, Zn, …).

Table 5
Comparing the means of the three treatments (0, 12, and 24 h) simultaneously by one way ANOVA test

Source	DF	Sum of square	Mean square (MSG = SSG/DFG)	F-statistic
Groups (between groups)	2	4.658434	2.329217	36.539318
Error (within groups)	111	7.075750	0.0637455	
Total	113	11.734185	0.103842	

DFG = number of groups – 1 = 3–1 = 2 = number of treatments;
DF (within groups) = N – number of groups = 114–3 = 111;
Sum of square (SSG) = 4.658434;
MSE = root mean square error;
F = MSG/MSE = 2.329217/0.0637455 = 36.54**

In addition, the validation of ANOVA was tested by calculation of the partial η_2 that is a proportion of variance accounted for by some effect (η_2 is like R^2 in the linear regression). η_2 had the value of 0.46 [23]. It means that the groups (treatments) explain 46.6% of the variance from the average.

The F statistic (above) indicated that there is an overall difference between groundwater pH means. Therefore, Tukey's HSD procedure was elaborated to facilitate pairwise comparisons within the obtained ANOVA results to determine between which of the various pairs of means – if any of them – there is a significant difference (Table 6). The table showed that HSD mean of M_1:M_2, M_1:M_3 and M_2:M_3 had values of 0.39, 0.56, and 0.07 (M_1, M_2 and M_3 are the means of treatments T_1, T_2 and T_3, respectively). Consequently, the values of HSD of M_1:M_2, and M_1:M_3 were higher than the standard of HSD.05 (0.139) and HSD.01 (0.172) to indicate the significant differences between the pairs means of M_1:M_2 and M_1:M_3. This simply means that the exposure time of 12 and 24 h of magnetic flux (105.98 μW) of significantly increases the groundwater pH. Contrary, the HSD of M_2:M_3 had a value of 0.07 which was low than the standard HSD of the probability of 95% and 99%. This was conducted to the conclusion that there is no significant difference between the exposure time of 12 and 24 h of magnetic flux (105.98 μW) on the groundwater pH. These results were confirmed by comparing the tabulated $Q_{0.05}$ (3.360) and $Q_{0.01}$ (4.207) by the calculated $Q_{M1,2}$ (9.52), $Q_{M1,3}$ (13.67), and $Q_{M2,3}$ (1.71).

Table 6
Means pairwise comparisons (M_1, M_2, and M_3)

Pairwise comparisons		$HSD_{0.05}$ = 0.138 $HSD_{0.01}$ = 0.172	$Q_{0.05}$ = 3.360 $Q_{0.01}$ = 4.207
T_1:T_2	M_1 = 7.72 M_2 = 8.11	0.39	$Q_{M1,2}$ = 9.52
T_1:T_3	M_1 = 7.72 M_3 = 8.18	0.46	$Q_{M1,3}$ = 13.67
T_2:T_3	M_2 = 8.11 M_3 = 8.18	0.07	$Q_{M2,3}$ = 1.71

4. Conclusion

More attention must be paid to study the effect of magnetic fluxes on the quality of groundwater and soil extracts for better crop growth. The research conducted to conclude that (1) magnetic bars organization of unlike poles "attract" increasing forcing the magnetic force by minimizing the scattering of the magnetic line; Contrary, magnetic bars organization of like poles "repel" decreasing forcing the magnetic force by the scattering of the magnetic lines (2) horizontal magnetic fields have stronger intensities than the vertical ones (3) the intensities differ widely through the magnetic plane, therefore, the mean of the magnetic intensity must be calculated to express correctly the force of magnetic fields (4). The magnetic intensity varied according to (a) locations measurement (b) magnetite arrangement (organization), and (c) the material of the rectangles parallel (glass or galvanized iron), and (5) magnetic intensity expresses the magnetic force, only for a point, while magnetic flux is the magnetic force through an area. So, magnetic flux must be considered in all magnetic studies. Generally, the produced magnetic intensities varied according to location measurement of the magnetic force, and the materials (glass or galvanized iron) of the containers. Besides, magnetic intensities, inside of glass cuboids and rectangular cuboids, were higher than that produced interior the galvanized iron ones.

The magnetic treated groundwater (MTW) has higher pH values than non-magnetic treated water. ANOVA test that is reliable to study the significant effect of the magnetic forces (105.98 μW) on pH groundwater must be validated by partial η_2. HSD values conducted to conclude that there is no significant difference between the effect of exposure time of 12 and 24 h of magnetic flux (105.98 μW) on the groundwater pH.

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