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15 EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDSTREATED WATER INCREASE THE EFFICIENCY THE USAGE OF SOLONETZ-SOLONCHAK SOIL AND CROP YIELD

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There are large areas of the world that exist under sodic soils and need attention for efficient, inexpensive and environmentally feasible amelioration. Records nearly a century old reveal the use of water, crop, chemical amendment, electric current, and tillage as amelioration tools for such soils. Owing to gradual increases in amendment cost in some parts of the world during the last two decades, this amelioration strategy has become cost-intensive, particularly for the subsistence farmers in developing countries. The aim of the current work is to increase the usage efficiency of the sodic soil and crop yield. For this proposes chemical amelioration method was used: hydrochloric acid was used as ameliorant after which the soil was washed with 15 Hz extremely low frequency electromagnetic field (0.4 mT) treated water. The amelioration presses and the crop yield were more effective in case of irrigation with magnetized water than with non-treated water, suggesting the higher efficiency of the proposed method to increase the crop yield in the solonetz-solonchak lands.

***Key words**: amelioration; extremely low frequency electromagnetic field; magnetized water; sodic soil; solonetz-solonchak lands.*

Introduction

Sodic soils are characterized by the occurrence of excess sodium (Na+) to levels that can adversely affect soil structure and availability of some nutrients. Deterioration in these soils occurs through changes in the proportions of soil solution and exchangeable ions, soil pH as well as osmotic and specific ion effects (Oster et al., 1999). Structural problems in sodic soils created by certain physical processes (slaking, swelling and dispersion of clay minerals) and specific conditions (surface crusting and hardsetting) may affect water and air movement, plant available water-holding capacity, root penetration, seedling emergence, runoff, erosion and tillage and sowing operations (Shainberg and Letey, 1984; Gupta and Abrol, 1990; Sumner, 1993; Oster et al., 1999). In addition, serious imbalances in cation nutrition usually occur in such soils, which may range from deficiencies of several nutrients to high levels of Na+ (Naidu and Rengasamy, 1993). Such physical and chemical changes have a bearing on the activity of plant roots and soil microbes and ultimately on crop growth and yield (Naidu and Rengasamy, 1993).

Sodic soils exist mostly under arid and semiarid climates. Sodic soil amelioration needs replacement of excess exchangeable Na+ by more favourable calcium (Ca2+). The replaced Na+ is leached from the root zone through excessive irrigations. Thus, in addition to a source of Ca2+, adequate water movement into and through sodic soils is another key factor involved during the amelioration process.

Records nearly a century old of sodic soil amelioration research and practice reveal that several site-specific methods have been used to ameliorate a variety of sodic soils (de Sigmond, 1924; Kelley and Brown, 1934; Oster et al., 1999). These methods include (1) leaching without amendment application, generally applicable to ameliorate gypsiferous soils, (2) application of high electrolyte water containing divalent cations, high-salt-water dilution, (3) use of chemical amendments, both inorganic and organic, (4) soil profile modification through tillage, (5) horizontal flushing after amendment application to ameliorate low-permeability sodic soils where vertical leaching is not efficient, (6) electromelioration consisting of passing electrical current through the soils and (7) phytoremediation dealing with cultivation of certain plant species, tolerant to ambient soil salinity and

sodicity levels, without the application of an amendment. These methods or their suitable combinations have been used under specific conditions.

Armenia has 30,000 km2 area. Mountains make about 70% of the country's territory. The average altitude is 1,800 meters above sea level. About 90% of the territory is located above 1,000 meters. In general Armenia has 14 types of soils, including 27 subtypes, multiple families, varieties and species of soils. Saline-alkaline hydromorphic and solonetz-solonchaks soil type comprises about 31.000 ha (approx. 1.2 % of total area).

On the other hand it was shown that by non-ionizing radiation treated water have modulation effect on plant seed germination potential (Amyan and Ayrapetyan, 2004). It was shown also that extremely low frequency electromagnetic field (ELF EMF) and mechanical vibration at infrasound frequency (MV at IS frequency) had frequency-dependent character on plants seed's germination. In case of ELF EMF effect on germination potential of barley seeds the more effective frequency windows were 15 Hz (Amyan and Ayrapetyan, 2004). Our previous study has shown that a frequency-window effect of ELF-EMF on physicochemical properties of water depends on the chemical and physical compositions of the environment such as background radiation, light intensity, temperature, and gas composition (Baghdasaryan et al., 2013).

In our work, based in above mentioned phenomena, we focused on the same frequency window (15 Hz, 0.4 mT) where most positive effect on seed germination was shown. Therefore, the purpose of the present work is to increase the efficiency of the chemical amelioration method and crop yeald production in sodic soils. For this proposes as ameliorate the soil with hydrochloric acid HCl (30 %) and then washed it 15Hz EMF treated water.

Conflict settings

Five-hundred-gram soil samples were randomly collected from the upper 0-25 cm soil layer from Ararat valley (Armenia), placed in individual plastic bags, and stored in a cool, insulated box during transportation to the laboratory. The processing of abiotic analyses of the soil samples were done after two days of storage at 4°C.

The controlled generator and low-noise amplifier on a coil (manufactured by the Institute of Radiophysics and Electronics of National Academy of Sciences, Armenia) generated the ELF EMF. The Helmholtz coil had a cylindrical form with a dimension of 154 mm in diameter and 106 mm in height. Rings of Helmholtz were formed by two equal ring coils located coaxially and parallel. The distance between the coils was equal to their radius (77 mm). The magnetic field created by these rings had high homogeneity. Based on our previous finding that in case of ELF EMF the most effective frequency window was at 15 Hz (0.4 mT) for effective changes in physicochemical properties of DW for seed germination (Amyan and Ayrapetyan, 2004) we selected this frequency for ELF-EMF treatment in our current experiments.

A glass test tube (1) by 7 cm in diameter and 50 ml volume was placed in the coil (2) as ELF EMF source (Fig. 1). EMF was generated by the controlled generator (4) (GZ-118, Russia) and low-noise amplifier on the coil ((3), IRPhEA NAS, Armenia). Helmholtz coils generate a homogeneous magnetic field (0.4 mT) and are formed by two equal ring coils located coaxially and parallels. The harmonic voltage generated by generator (4) after being amplified by low-noise amplifier (3) passes to the Helmholz coils (2).

Water treatment and experimental setups. Distilled water (DW) was exposed to ELF EMF (15 Hz; 0.4 mT) for 30 minutes, whereas untreated DW that was placed in a non-activated coil for 30 minutes was used as control. Three experimental setups were done: (1) control, where no ameliorant was used and washed with regular or non EMF treated water. Due to the saturation of soil with water, only 20% of water amount calculated in field experiment was used (Papinyan et al., 2009). (2) Soil ameliorated with HCl (30%) and washed with non-treatedwater. (3) Soil ameliorated with HCl (30%) and washed with 15 Hz (0.4 mT) ELF EMF treated water. To check the efficiency of amelioration

vegetative experiments were performed. Half a kg solonetz-solonchak soil is placed in polyethylene tubes and fifteen seeds of winter wheat were germinated in each polyethylene tubes.

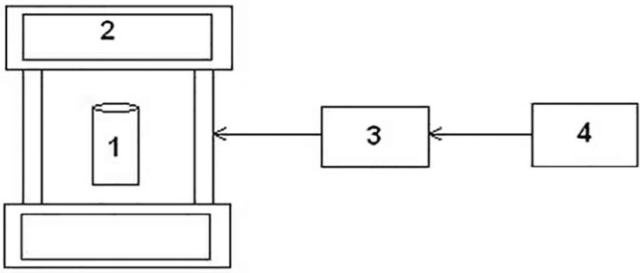

Figure 1. The schematic diagram of a device for EMF treatments. (1) glass test tube with diameter 7 cm and volume 50 ml, (2) Helmholtz coils, (3) the low-noise amplifier, (4) the generator of a harmonic field.

Chemical analysis. Soil pH was determined with a pH electrode in the filtered supernatant after an overnight incubation period at room temperature of a mixture containing 20 g soil and 40 ml distilled water (DW) (1:2 soil:water ratio), followed by shaking for 10 min (160 rpm) and incubation overnight at room temperature.

The elemental analyses of Ca, Na, K, Mg by done in the filtered supernatant by flame photometry. The filtered supernatant was prepared in this structure soil:double-distilled water, 1:10, followed by shaking for 30 min (160 rpm) and overnight incubation at room temperature.

The rest of chemical analysis was done by standard laboratory methods of soil analysis (Alban and Kellogg, 1959).

Statistical analysis. Statistical analyses were conducted using SPSS software (release 17). The means of measures in two groups were compared by independent T test. Data were expressed as means. All experiments were repeated at least three times.

Research results. The efficiency of chemiacal amelioration of solonetz-solonchak soilwas investigated using 15 Hz ELF EMF treated water after using HCl (30 %)amalorant. Chemical composition of soil in water solution and indicators of exchangeable Na^+ and $K^+$are shown in Table 1.

Papinyan et al. (2009) in the field experiment have calculated that the required amounts of ameliorant and irrigation water for 1 ha soil is 240 tons of 30% HCl and 56.8 thousand m^3 irrigation water, respectively. In ourlab experimentsonly half of required ameliorant was used, total 10 ml of 30% HCl and 2.1 l of water for 0.5 kg of soil amelioration.

During the three experimental setups filtrates periodicaly were taken and chemical analysis were performed. It has been shown the use ofelectromagnetically treated water has advantages: in the filtrate the concentration of Na is higher 4,2% than in non-treated water used experiments (Table 2).

The efficiency Na^+ removal from soil is aboout 5 % with treated water used. It has been shown that using the EMF treated water both the amount of amelorant and washing water can be decreased by 20-25 %. For ameloration of 1 ha instead of estimated 240 tons of HCl (Papinyan et al., 2009) only 190 tons is required if using EMF treated water, saving 50 tons of HCl per ha of soil ameliorated. With the cost of 1 tons of 30 % HCl of 50 $ (USA), it is possible to save 250 $ in this method by decreasing amount of amelorant: at the same time the decraese of amount of water can also be advantageous: 10,000 m^3 x 0.03 $ (USA) = 300 $, thus using this method overall we can save 280 $.

Table 1

The chemical composition of investigated soil water solution and the indicators of exchangeable Na^+ and + K^+.

Soil laye, cm	pH	Σ of salt, %	mg-ekv/100gsoil									
			Total CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	$Na^+ + K^+$	Na^+	exchangeable Na^+, K^+	
0-25	9,8	1.57	3.59	5.00	7.05	10.47	0.50	0.08	21.94	21.8	18.3	1.8

Table 2

Chemical composition of the washed filtrate. Twenty percent of the amount of washing water (from 2.1 l) was used.

N	Exp. setups	pH	Σ of salts g/l	mg-ekv/l							Water (l)	Filtrate (l)	Total removed Na %
				CO_3^{2-}	Total HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	$Na^+ + K^+$			
1	Control		No filtrate observed		-	-	-	-	-	-	0,4	No	-
2	HCl + non-treated water	6.8	11.7	No	10,0	129,6	50,8	50,0	12,8	127,6	0,4	0,3	15,8
3	HCl + treated water	7.0	12.8	No	10,0	144,4	68,4	48,0	12,8	162,0	0,4	0,3	20,0

Table 3

The chemical analysis of the investogated soils water solution and exchangeable $Na^+$and K^+.

N	The experimental setups	pH	Salts %	mg-ekv/l									
				CO_3^{2-}	Total HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	$Na^+ + K^+$	Na^+	Exchang. Na^+	K^+
1	Control	9.8	1.6	3.6	5.00	7.1	10.5	0.55	0.1	21.9	21.8	18.3	1.8
2	HCl + non-treated water	9.0	0.1	0.07	1,25	0.3	0.07	0.10	0.04	1.43	1.38	4.50	1.8
3	HCl + EMF treated water	8.8	0.1	0.05	1.16	0.3	0.12	0.15	0.16	1.32	1.27	3.80	1.7

The soils chemical analysis of the hypothetical case where the entire calculated amount of washing water (2,1 l per 0.5 kg soil) was used is presented in Table 3.

The current study showed that even with a use of only 50 % of the amelorant the salt concentration in the soil decreased from 1.6 % (control) to 0.1 % in the second and third experimental setup.

Table 4

The seeds growth in the ameliorated soils

Experimental setups	The numbers of growing seeds after 7th day	The numbers of growing seeds after 12th day
HCl (30%)+ non-treated water	0	0
HCl (30%)+ treated water	1	4

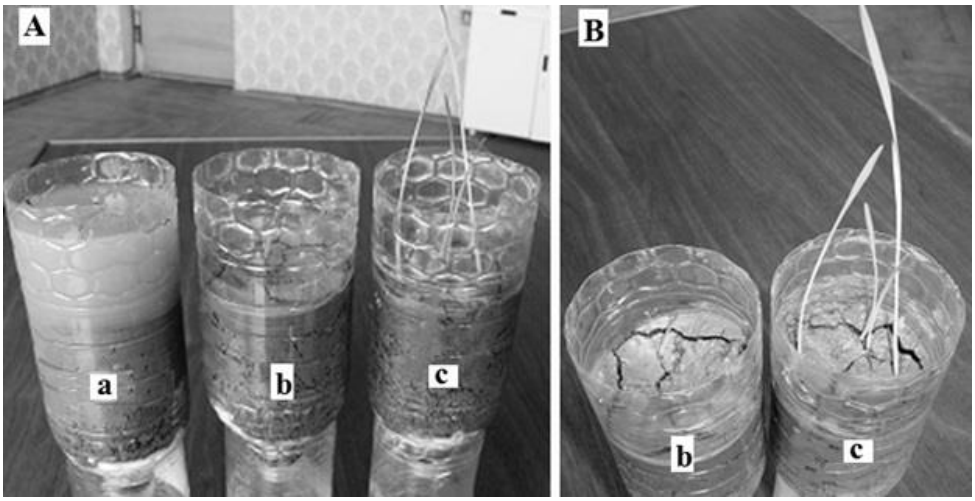

Figure 2. The growth of winter wheat in the following setups: a) control-no ameloration, b) in amelorated soil, c) after ameloratin 15 Hz (0,4 mT) EMF treated water was used. A- view from front and B- view from above

To investigate the usage of ameliorated solonetz-solonchak soil and the in the lab in each experimental setup 15winter wheat seeds were grown in polyethylene tubes. After 7 and 12 days the number of grown seeds were calculated (Table 4, Fig. 2).

After 12 days of growth significant changes($p<0.05$) in the setup where 15 Hz ELF EMF treated water was used were observed (Fig. 2).

Conclusion

Salinity is one of the major factors responsible for soil degradation. Approximately one third of the world's land surface is arid or semiarid (4.8 x 10^9 ha), half of which is estimated to be affected by salinity (Croughan and Rains, 1982). Salinity is a major abiotic stress at present (Rueda-Puente et al., 2007), and is one of the most severe environmental problems affecting crop growth (Lopez et al., 2002) and in concert with drought seems to be one of the world's most serious problems in agriculture.

The global population is about 6.3 billion, increasing day by day at an alarming rate. According to an estimate, it will be 9.0 billion by 2050 (Lal, 2007). Thus, there is a dire need to increase crop productivity either through increase in yield per unit area or by increasing area under cultivation.

EMF treated distilled water has been shown to have an activation effect on germination potential of barley seeds (Amyan and Ayrapetyan, 2004), more pronounced at 15Hz frequencies. It is also known that different plants during vegetation if irrgeted byELF EMFtreated water have elevated seedgermination, reduced root development period, increased resistance to thermal and osmotic stress (Amyan and Ayrapetyan, 2004). On the other hand it is well documented that EMF can change the physicochemical properties of water (Baghdasaryan et al., 2013).

During amelioration of solonetz-solonchak soil high amount of ameliorant (H_2S0_4-100 tonn/ha, HCl-240 tonn/ha) and 45.000-50.000 m^3/ha of irrigation water were used washing salt washout from soil (Papinyan et al., 2009). Soil becomes useable for agriculture. In the first year the yield of wheat is 40-50 c/ha, and during 3 years in that soil can be grow 100-120 c/ha of lucerne hay (Papinyan et al., 1988; 2009). Papinyan et al., (2009) shown that solonetz-solonchak soil of Ararat valley can be amelorated by «Nairit»'s surplus production of 30% hydrochloric acid solution.After amelioratation the soil was washed with non-treated irrigation water(Papinyan et al., 2009). Currently proposed amelioration method has several advantages to the conventional methods (Papinyan et al., 2009), such as increase the efficiency of the usage the soil amelioration and at the same time the crop yield.

Thus, the proposed goals to increase the useage of solonetz-solonchak soil, reduce the cost of ameliorantion processes and amount of water for irregation, to induce the germination of seeds and increase the yield of cultivated crops, have been approved with our methods.

It can been concluted that using ELF-EMF treated water it is possible to decrease of used amount of amelorant and washing water, to increase the germinetion of the seeds, to induce the futher growth, to encrease the yield production of agricaltural cultivatred plants and to gain ecologicaly clean products.

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15 ՀՑ ՀԱՃԱԽԱԿԱՆՈՒԹՅԱՄԲ ՄՇԱԿՎԱԾ ՋՈՒՐԸ ԲԱՐՁՐԱՑՆՈՒՄ Է ԱՂԱԿԱԼԱԾ ՀՈՂԻ և ԲԵՐՔԱՏՎՈՒԹՅԱՆ ՕԳՏԱԳՈՐԾՄԱՆ ԱՐԴՅՈՒՆԱՎԵՏՈՒԹՅՈՒՆԸ

Գ.Ա. Սաֆարովա
Շուշիի տեխնոլոգիական համալսարան

Երկրագնդի վրա կան շատ տարածքներ, որոնք գտնվում են աղակալած հողերի տակ և արդյունավետ, մատչելի և էկոլոգիապես պիտանի հողաբարելավման համար ուշադրության կարիք ունեն: Գրեթե մեկ հարյուրյամյակի արձանագրությունները բացահայտում են ջրի, բերքի, քիմիական բարելավման, էլեկտրական հոսանքի և վարելահողի օգտագործումը որպես հողաբարելավման գործիքներ այսպիսի հողերի համար: Վերջին երկու տասնամյակում երկրագնդի որոշ մասերում բարելավման արժեքի մեջ աստիճանական աճի շնորհիվ, այս հողաբարելավման ռազմավարությունը դարձել է ինտենսիվ արժեք, մասնավորապես՝ կենցաղային ֆերմերների համար՝ զարգացող երկրներում: Ընթացիկ աշխատանքի նպատակն է մեծացնել աղակալած հողերի և բերքի արտադրողականության օգտագործման արդյունավետությունը: Այս նպատակով կիրառվեց քիմիական ուղղման (հողաբարելավման) մեթոդը. օգտագործվեց հիդրոքլորիդ թթու՝ որպես հողաբարելավման նյութ, ինչից հետո հողը ջրվեց 15հցչափազանց ցածր հաճախականություն ունեցող էլեկտրամագնիսական (0.4մլ) ջրով:Հողաբարելավման գործընթացը ճնշվում է, և բերքը մագնիսացված ջրով ոռոգման դեպքում դառնում է ավելի արդյունավետ, քան ոչ մագնիսացված ջրով ջրելիս՝ առաջարկելով ներկայացված մեթոդի ավելի մեծ արդյունավետություն աղակալած հողերում բերքատվությունը բարձրացնելու համար:

Բանալի բառեր. բարելավում, խիստ ցածր հաճախականությամբ էլեկտրամագնիսական դաշտ,մագնետիկ ջուր,նատրիումական հող, աղակալած հողեր:

15 ГЦ УЛЬТРАНИЗКОЙ ЧАСТОТЫ ЭЛЕКТРОМАГНИТНЫХ ПОЛЕЙ С ОЧИЩЕННОЙ ВОДОЙ ПОВЫШАЮЩЕЙ ЭФФЕКТИВНОСТЬ ИСПОЛЬЗОВАНИЯ СОЛОНЦЕ-СОЛОНЧАКОВЫХ ПОЧВЫ И УРОЖАЙНОСТИ КУЛЬТУР

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Есть большие районы мира, которые существуют в рамках натриевых почв и требуют внимания для эффективного, недорогого и экологически возможной мелиорации. Записи почти столетие старые

раскрывают использование воды, урожая, химической поправки, электрического тока, а также обработки почвы в качестве мелиоративных инструментов для таких почв. Вследствие постепенного роста стоимости поправки в некоторых частях мира в течение последних двух десятилетий, эта стратегия мелиорация стала затратным, особенно для фермеров в развивающихся странах. Целью настоящей работы является повышение эффективности использования в натриевый почвы и урожайности сельскохозяйственных культур. Для этого предлагается был использован химический метод мелиорация: соляная кислота использовалась в качестве мелиорантов, после чего почву промывали 15 Гц крайне низкой частоты электромагнитного поля (0,4 мТл) обработанной воды. Мелиорация прессы и урожайность были более эффективными в случае орошения с намагниченной водой, чем с необработанного водой, что указывает на более высокую эффективность предлагаемого метода для повышения урожайности в солонцов-солончаковых земель.

Ключевые слова: мелиорация, крайне низкой частоты электромагнитное поле, магничная вода, натриевые почвы, земли солонцы-солончаки.