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DETERMINE THE CHANGES IN SOME CHEMICAL PROPERTIES OF GROWING SOIL DUE TO MAGNETIC WATER

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ABSTRACT

The amid of this study was to evaluate the effect of magnetization on the physico-chemical properties of soil. Soil samples were collected from White Nile State. 20 cm deep the samples were drawn and placed in paper envelopes. The magnetization of the water was done using a magnetic funnel with a diameter of 10 cm Water (normal and magnetized) was analyzed to study physico-chemical changes the soil was analyzed before irrigation with water and after irrigation with normal and magnetized water. The results showed significant differences in the soil germination, where there was a difference between untreated cultivated soil with any type of water and treatment with ordinary water, A statistically significant decrease was found in treated soils with magnetized water and irrigated soils in both electrical conductivity and sodium and nitrogen content Non-germinated soil showed a statistically significant decrease in both pH and sodium content while high in both electrical conductivity, calcium content, potassium, nitrogen and chlorine. The study concluded that the process of magnetization of water improves its physochemical properties as well as improves soil properties in the solubility of minerals and make them easy to absorb the plant.

KEYWORDS: *Magnetic fiels*, *Magnetic water; Non-magnetic water; Growing soil, Non-growing soil.*

INTRODUCTION

Electromagnetic fields (EMFs) have shown great potentials in medical, industrial and environmental applications (Yadollahpour., *et al*., 2014). Because of the electrical origin of the live and existence of all cells and living creatures, EMFs can interact with all living cells so that can modulate their functions. These modulations in appropriate conditions can have useful outcomes such as treatment or inducing the desire characteristics in different compounds. Water is a crucial source for life on the earth. Any living creature needs water to hydrate every cell. Long term and frequent droughts and competing water demands in most parts of the world have caused severe pressure on water resources. Therefore emerging of new strategies to reduce consumption of water is of significant importance. One of the new strategies is magnetic water technology. Various studies have revealed that magnetic treatment of irrigation water can improve the productivity of water (Gholizadeh, and Arabshahi, 2008). MWT has shown promising potential in saving water resources that will be of significant importance in near future. MWT has shown various potentials in environmental and agricultural applications (Yadollahpour, *etal*, 2014). Some of these applications are therapeutic effects of MW, preventing scale deposition, improving irrigation water quality and crop yield, scale elimination, soil improvement, corrosion control and wastewater treatment (Flórez, *et al*., 2007).

Effect on soil quality

Soil pH

Soil pH is one of the most important and common measurements performed in standard soil analyses. Most soil chemical and biological reactions are controlled by the pH of the soil solution in equilibrium with soil particle surfaces (Carter,1993).

The pH of soil or more precisely the pH of the soil solution is very important because soil solution carries in it nutrients such as nitrogen, potassium, and phosphorus that plants need in specific amounts to grow, thrive, and fight off diseases. If the pH of the soil solution is increased above 5.5, nitrogen (in the form of nitrate) is made available to plants. Phosphorus, on the other hand, is available to plants when soil pH is between 6.0 and 7.0 (Nyle., and Ray., 2004).

If the soil solution is too acidic, plants cannot utilize N, P, K and other nutrients. The development of strongly acidic soils (pH less than 4.5) can result in poor plant growth as a result of one or more of the following factors: aluminum toxicity, manganese toxicity, calcium deficiency, magnesium deficiency, and low levels of essential plant nutrients such as phosphorus and molybdenum (ASSSI,2010).

Soils become acidic when basic elements, such as calcium, magnesium, sodium, and potassium held by soil colloids are replaced by hydrogen ions. Rainfall contributes to soil acidity because water combines with carbon dioxide to form a weak acid, H_2CO_3. When the weak acid ionizes, it releases hydrogen (H^+) and bicarbonate ion (HCO^{-3}). The released hydrogen ions replace the calcium ions held by soil colloids, causing the soil to become acidic. The displaced Ca^{2+} ions combine with the bicarbonate ions to form calcium bicarbonate, which, being soluble, is leached from the soil. The net effect is increase in soil acidity (Mohamed,2013).

Nitrogen fertilizers and many plants also contribute to the soil acidity. Because nitrogen sources (fertilizers, manures, legumes) contain or form ammonium ion that increase soil acidity unless the plant directly absorbs the ammonium ions. Greater the nitrogen fertilization rates with these sources, greater may be the soil acidification. Ammonium is converted to nitrate in the soil (nitrification) and H^+ ions are released. For each 1.0 kg of nitrogen as ammonium or forming ammonium in urea, ammonium nitrate, and anhydrous ammonia, it takes approximately 1.8 kg of pure calcium carbonate to neutralize the residual acidity. The nitrate that is provided or that forms can combine with basic cations like calcium, magnesium, and potassium and leach from the topsoil into the subsoil. As these bases are removed and replaced by H^+ ions, soils become more acidic (Mohamed,2013).

To decrease soil acidity (raise the pH), the soil is usually amended with alkaline materials that provide conjugate bases of weak acids (carbonate and hydroxide). These conjugate bases are anions that are capable reacting with H+ ions to form weak acids (such as water).

These bases are supplied in their calcium and magnesium forms ($CaCO_3$, etc.) and are referred to as agricultural limes. Some liming materials contain CaO and MgO, which forms hydroxide ions in water. Liming materials are used to supply plant nutrients in relatively small amounts for plant nutrition (Brady., and Weil.,2008).

The pH value alone does not determine how much lime is required but is used in conjunction with exchangeable acidity (EA) in determining lime rates. The pH determination is useful for indicating when too much lime has been applied and for evaluating micronutrient availability, particularly manganese (Mohamed,2013).

Soil Electrical Conductivity (EC)

Ions in aqueous solution conduct electricity, therefore the total amount of soluble soil ions can be determined by measuring the soil EC of a soil water extract. Soil EC is the measure of how much electrical current soil can conduct. The unit of EC is deciSiemens per meter (dS/m). Generally EC measurements are used for the determination of soil salinity. Soils can be classified by the EC measurements related with amount of soluble salts and sodium adsorption ratio (SAR).

Soil EC is a measurement that correlates with soil properties that affect crop productivity, including soil texture, cation exchange capacity (CEC), drainage conditions, organic matter level, salinity, and subsoil characteristics. EC measurement shows (Mohamed,2013).

The conduction of electricity in soils takes place through the moisture-filled pores that occur between soil particles. Therefore, the EC of soil is influenced by the interactions between the following soil properties (Mohamed,2013).

Cation exchange capacity (CEC)

Mineral soils containing high levels of organic matter (humus) and/or 2:1 clay minerals such as montmorillonite, illite or vermiculite have a much higher ability to retain positively charged ions (such as Ca^{+2}, Mg^{+2}, K^+, Na^+, $NH4^+$, or H^+) than soils lacking these constituents. The presence of these ions in the moisture-filled soil pores will enhance soil EC in the same way that salinity does.

Soil phosphorus

Phosphorus is an essential element for plant growth and is often applied to agricultural land to increase crop production. Animal waste generally has a high concentration of phosphorus. Livestock feedlots and cattle grazing on grassland can introduce substantial amounts of phosphorus rich manure to the environment (USDA, 2010).

Phosphorus is lost from agricultural land to surface water bodies in sediment-bound and dissolved forms. Sediment-bound P includes P associated with minerals and organic matter. Dissolved P constitutes 10 to 40 % of the P transported from most cultivated soils to water bodies through runoff and seepage (Sharply, et al,1995).

Surface runoff from grassland, forest, and uncultivated soils carries little sediment and carries dominantly dissolved forms of P. Unlike sediment-bound P, dissolved P is readily bioavailable and thus is the main cause of eutrophication. A concentration of P above 0.02

mg/L in lake water generally accelerates eutrophication. This concentration is much less than the P concentration in soil solution of cultivated soils and leads us to an important question regarding the relationship between P in soil and surface runoff. Selection of an appropriate soil test is essential for understanding this relationship and for identifying nonpoint sources of P contamination from agricultural land (Sharply, et al,1995).

Soil potassium

The potassium in soil is found in three forms, unavailable, slowly available and exchangeable. Unavailable potassium is contained within the crystalline structure of micas, feldspars and clay minerals. Plants can not use this form of potassium. Over long periods, these minerals break down, release their potassium as the available K^+ ion . (Mohamed,2013).

Soil nitrogen

Nitrogen is also an essential plant nutrient. Nitrogen is found primarily in organic forms in soil, move in soil and plants mostly in the anionic form. At the same time is responsible for serious environmental problems. Excesses of some nitrogen compounds in soils can adversely affect human and animal health. High nitrate concentration in soil can lead to sufficiently high nitrates in drinking water as to endanger to the health of human infants and some animals (Brady., and Weil., 2004).

Nitrogen is present in soils in organic and inorganic forms. There is a wide variation in the types of organic compounds that contain nitrogen. Organic compounds can be small and easily degraded by microorganisms like amino acids, or large complex molecules that are quite resistant to microbial decay. The most resistant of these soil organic materials are typically referred to as humus. Inorganic forms of nitrogen are nitrate, nitrite, ammonium, and ammonia. Nitrate and ammonium are readily taken up by plants and beneficial for plant growth. Nitrite and ammonia are toxic to plants (Camberati , 2001).

Living plants cannot use organic forms of N. This is why microbes living in the soil are so valuable, because they can convert organic N into inorganic forms of N that plants can then use. Temperature, moisture, fertilization and cropping, factors influence its dynamic relationship with the organic fractions, and also within the inorganic forms. Nitrogen is an integral component of many essential plant compounds. It is basic molecule of amino acids of proteins and enzymes which control virtually all biological processes. Other essential nitrogenous plant components include the nucleic acids, in which heredity control is vested and chlorophyll, which is at the heart of photosynthesis. A good supply of nitrogen stimulates root growth and development (Brady., and Weil., 2004).

Soil sulfur

Sulfur is a major macronutrient for plants. For many years, the significance of sulfur was neglected, because there were no serious problems in S nutrition of crops, due to the liberal use of ammonium sulfate, super-phosphate (%18 (P_2O_5), and potassium sulfate fertilizers. However, today the importance of S is recognized for improving yields of plants, containing significant amounts of essential amino acids, proteins and vitamins (Conklin, 2005). In addition to its vital roles in plant and animal nutrition, sulfur is also responsible for several types of air, water, and soil pollution and is therefore of increasing environmental interest. The environmental problems associated with sulfur include acid precipitation, certain types of forest decline, acid mine drainage, acid sulfate soils, and even some toxic effects in drinking water used by humans and livestock (Brady., and Weil., 2008).

It is present in soils in organic and inorganic forms. 90% of the S in plants is present in the form of amino acids. In active volcanic regions, volcanic gas and eruptions are adding substantial amounts of inorganic sulfur in elemental form to the soils (Conklin, 2005).

Effects on soil chemical contents

The findings of previous studies have reported changes in polarity, surface tension, pH, refractive index, and solubility of salts of water due to magnetic field exposure (Smikhina, 1981; Chang ,2008). Magnetized water imposes direct and indirect influence on the soil. The direct influence is effect on the composition or the mineral structure (Bresler, 1975). The usage of magnetic water can change soil pH, EC, available P and extractable K. Different magnetized water sources have significantly increased available soil N, P and K (Maheshwari, and Grewal,2009; Mohamed,2013). Increasing in soil available P and extractable K under magnetically treated water has played some role improving yield and water productivity of plants (Maheshwari, and Grewal,2009). In addition, Magnetic treatment of water has shown affect on desorption of P and K from soil adsorbed P on colloidal particles complex and thus improved plant growth and productivity through increasing its availability to plants (Mohamed,2013).

In the other words, magnetically treated irrigation water has reportedly reduced soil pH and increased soil EC and available P (Ibrahim,2013). The Variations in pH and EC in magnetically treated water may be relate to changes in hydrogen bonding and increased mobility of ions. Exposure of water to magnetic fields caused to changes in hydrogen bonding and increased mobility of Na^+ and Cl^- ions (Tai, et al., 2008). Irrigation the soil with magnetized water were significantly increased available soil P content even in the lower layers of soil (Mohamed,2013).

The nutrient extraction from soil had higher iron content, when the soil was irrigated with magnetized water. Hilal et al. (2002) investigated effect of irrigation with magnetically treated water and their results showed increase in Zinc (5 times), P (3 time) and Fe (9 times) in the root and harvest. They also reported the maximum increase in Mn content. Results have indicated differences in the concentrations of Na, K, P, N, and Ca^+ in soils irrigated with magnetically treated water to compare with normal water (Noran, et al., 1996). Magnetic treatment of water because of acceleration of the crystallizations and sedimentation slows down the movement of minerals (Maheshwari and, Grewal ,2009). Results of several studies also showed an increase in P content of citrus and nutrient uptake by magnetically treated irrigation water (Duarte, et al,1997; Hilal et al., 2002).

MATERIALS AND METHODS

Experimental design

This study involved selected soil samples from area at White Nile State- sudan, and divided in three groups one is uses as control and the other two growing and irrigated by water (row and magnetic) for three weeks. After that soil and water (row and magnetic) samples were analysis for physico-chemical properties.

Collecting soil samples

Six soil samples were collected separately using a spade from different fields. The shovel was dipped up to 20-cm depth. A pit was opened with a shovel. Soil samples were obtained about the 2-cm of thickness, 3–4-cm width and 20-cm length of the part of soil. Approximately, 1 kg of soil sample was collected and placed in a plastic bag and then mixed, they turned by around a few times, in order to make the soil homogeneous.

Soil analyses

The soil (growing and non-growing for plants) samples used in the experiment were analysed for its physico-chemical properties before treating and after treating by row water and magnetic water.

Soil sample preparation

Samples were prepared using the following method: 72 hours air-dried soil samples (at room temperature) were passed through a 2.0 mm sieve. Extraneous materials and soil particles remaining in the sieve were also broken down with a pestle and mortar, until all aggregates were disrupted and only small stones (2.0 mm) were left behind on the sieve surface. Then analysed for pH, electrical conductivity (EC) available sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), nitrogen (N) , sulphate (SO^{-2}_4), chloride (Cl) and alkalinity (carbonate and bicarbonate).

Analysis of soil chemical properties

Determination of soil pH

Soil pH was determined using the method of Klute (1965), as reported by Ibitoye (2006). Approximately 10 g of air-dried soil samples were weighed into a 100 ml beaker and 20 ml of distilled water was added (ratio 1:2 soil to water) and the suspension was stirred thoroughly with a glass rod to form an homogenous slurry and left at room temperature for 20 minutes. Soil pH was determined using a pre-calibrated Jenway 3520 electrode pH meter. Then the glass electrode of the pH meter was well inserted into the partly settled suspension in the beaker and after equilibrium, the pH value of each treatment soil was observed and recorded. The electrode was rinsed with distilled water and wiped dry with clean tissue paper after each reading.

Determination of total soil nitrogen

The Kjeldahl analytical method (Anderson and Ingram 1996; Omotoso and Shittu, 2007) was used to determination of total nitrogen (N) in soil.

For each soil sample, a 5 g was weighed into 500 ml digestion flask and two Kjeldahl catalyst tablets were added. Copper sulphate is the most commonly used catalyst and it was used in this experiment. Subsequently, 20 ml tetraoxosulpate (VI) acid was added and the mixture was heated on a Bunsen burner flame and changed into a grey/white colour, which indicated complete digestion of the soil. The soil was then left to cool at room temperature for 30 minutes. Organic N was converted to ammonium-N by the addition of sulphuric acid and the catalyst. The acid digest produced was distilled for 4 minutes in the presence of 40% NaOH. Ammonium ions NH_4^+ were converted to ammonia during this phase and it was then released from the solution by steam distillation and condensed as ammonium hydroxide (NH_4OH) and the distillate is then trapped. 5 ml of 2% boric acid was then added. The distillate was titrated with 0.01/0.1 M HCl until the colour changed from light green to pink, and the titrate value was noted for the determination of total N present in the soil samples.

Determination of exchangeable cations (Na, K, Ca, Mg) in soil samples

Procedures of soil digestion

For each treatment, a 2 g of air-dried soil were weighed into a 250 ml conical flask and 10 ml of aqua regia (HNO_3/HCL in ratio 1:3) was added. The mixture was gently heated on a hot plate at 200ºC and heating continued until the brown fumes turn to white in a fume cupboard. The conical flask was allowed to cool to room temperature. The mixture was rinsed with 20 ml deionised water and filtered with Whatman No.1 filter paper. Subsequently, 20 ml of the filtrate was stored in a universal sample bottle till analysis by Atomic Absorption Spectrophotometry (AAS).

Preparation of stock standards for Sodium (Na)

4.6 g of Na_2CO_3 salt was weighed into a 250 ml Pyrex beaker and dissolved in 100 ml distilled water. The solution was rinsed into a 1000 ml volumetric flask and made up to mark with distilled water. This is expressed as:

Molar mass of Na_2CO_3 = 126 .Molar mass of Na = mass of 1 mole of Na in Na_2CO_3 .Therefore: 106 /23 = 4.6 g is equal to 1 mole of Na in Na_2CO_3

Preparation of stock standards for Potassium (K)

3.5 g of K_2CO_3 salt was weighed into a 250 ml Pyrex beaker and dissolved in 100 ml of distilled water. The solution was rinsed into a 1000 ml volumetric flask and made up to mark with distilled water. This is expressed as:
Molar mass of K_2CO_3 . Molar mass of K = mass of 1 mole of K in K_2CO_3
Therefore: 138 /39 = 3.5 g is equal to 1 mole of K in K_2CO_3

Preparation of stock standards for Calcium (Ca)

The stock standard was prepared by weighing 2.5 g of $CaCO_3$ salt and dissolving in 1000 ml of 5% HNO_3. The salt was initially dissolved in a Pyrex beaker after which it was rinsed into a 1000 ml volumetric flask with 5% HNO_3 and made up to mark. This is expressed as:
Molar mass of $CaCO_3$. Molar mass of Ca = mass of 1 mole of Ca in $CaCO_3$
Therefore: 100 /40 = 2.5 g is equal to 1 mole of Ca in $CaCO_3$.

Preparation of stock standards for Magnesium (Mg)

The stock standard was prepared by weighing 5 g of $MgSO_4$ salt and dissolving in 50 ml of 5% HCl. The salt was initially dissolved in a beaker after which it was rinsed into a 1000 ml volumetric flask with 5% HCl and made up to mark. This is expressed as:
Molar mass of $MgSO_4$. Molar mass of Mg = mass of 1 mole of Mg in $MgSO_4$.
Therefore 120 /24 = 5 g is equal to 1 mole of Mg in $MgSO_4$.

Serial dilution of stock standards

The stock standards prepared were serially diluted to concentrations of 5, 10, 15, 20 and 25 ppm. These different standard calibration levels were used to generate a suitable curve, which was used to calibrate the instrument using the serial dilution formula:
C1V1 = C2V2
Where, C1 is the initial concentration . C2 is the final concentration .V1 is the initial volume . V2 is the final volume
After the serial dilution of stock standards the different calibrants' were fed into the AAS as standard samples. These were used by the AAS to generate a suitable calibration curve prior to sample analysis.

RESULT AND DISCUSSION

Table (4.1): The result of physicochemical parameters of growing soils.

Parameters	Growing soil		
	Untreated	Treated with raw water	Treated with magnetic water
PH	7.62 ± 0.057^{a}	7.17 ± 0.057^{b}	7.37 ± 0.115^{ab}
E.C	86.90 ± 1.154^{a}	8.17 ± 0.057^{b}	2.37 ± 0.057^{c}
Calcium	12.50 ± 0.577^{a}	10.50 ± 0.577^{b}	35.50 ± 0.577^{c}
Magnesium	2.00 ± 0.114^{a}	7.00 ± 0.173^{b}	17.00 ± 0.114^{c}
Sodium	96.83 ± 0.577^{a}	3.768 ± 0.057^{b}	1.726 ± 0.519^{c}
Potassium	6.77 ± 0.115^{a}	11.83 ± 0.057^{b}	6.77 ± 0.115^{a}

Data are presented as means ±SE
a,b,c and d value with different superscripts in the same row are significantly different at ($P \leq 0.05$)

Table (4.2): The result of anions concentration of growing soils.

Parameters	Growing soil		
	untreated	Treated with raw water	Treated with magnetic water
Nitrate (N^-)	16.80 ± 0.057^{a}	33.60 ± 0.173^{b}	11.20 ± 0.115^{c}
Sulfate	1.50 ± 0.288^{a}	2.80 ± 0.173^{b}	2.70 ± 0.0115^{b}
Chloride	0.20 ± 0.115^{a}	0.60 ± 0.115^{b}	0.20 ± 0.577^{a}
Carbonate	6.00 ± 0.288^{a}	4.00 ± 0.173^{b}	6.00 ± 0.115^{a}
Bicarbonate	5.00 ± 0.057^{a}	0.00 ± 0.00^{b}	5.00 ± 0.692^{a}

Data are presented as means ±SE
a, b, c and d value with different superscripts in the same row are significantly different at ($P \leq 0.05$)

DISCUSSION

The results showed that all types of growing soil have a significant difference on the soil pH values, between unirrigated soil and soil irrigated with raw water but no significant difference between them and soil irrigated with the magnetic water. Also, soil EC decreased with irrigated with magnetic water. This is agree to the study by (Tahir: and Karim , 2010). The analysis of calcium showed that there was significant between all types of soil thus , increased of calcium on soil irrigated with magnetic water compared to control soil, also magnesium was a significant difference ($P \leq 0.05$) between all samples with increased in soil irrigated with magnetic water , this result agree with (Noran, *et al*. 1996).

Analysis of variance irrigated soils in Table 1 shows that the effect of magnetic irrigated water on soil sodium was decreased compared to the control soil and soil irrigated by raw water with significant between them. Potassium showed no significant between control soil and soil irrigated with magnetic water table 1 this is not agree with (Cakmak et al. 2009).

In table 2 showed that there was significant in N and sulphate between control soil and soil irrigated with magnetic water this agree with the study by (Algozari 2006). There was no significant difference other anions (chloride, carbonate and bicarbonate) on control soil and soil irrigated with magnetic water this agree with (Hilal ,*et al*,2002) study.

CONCLUSION

These results confirm that magnetically-treated water is essential for improving soil properties. Additionally, the treatment of soil with magnetic water increased plant growth and development and, consequently, plant production. This finding is potentially useful in agriculture because inexpensive magnetic energy can be utilised to enhance soil characteristics and increase plant yield.

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