Journal of Environmental Treatment Techniques
Volume 13, Issue 2, DOI 10.18502/jett.v13i2.18626
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Research Article

The Impact of Magnetic Field on Groundwater Treatment Using Steam Injection in Certain Shallow Wells Located in The Ogbomoso South Local Government Area, Oyo State, Nigeria

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Received: 1 May 2025
Accepted: 20 May 2025
Published: 25 June 2025

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Abstract

As a precious resource, groundwater needs to be shielded from pollution. It is crucial to preserve not just the amount but also the quality of the groundwater supply. Because of toxicity, health risks, and industrialization, pollution-related groundwater contamination is becoming a bigger problem. In the ogbomoso local government area of oyo state, Nigeria, a few shallow wells will be used for this study's investigation of the impact of magnetic fields on steam injection groundwater treatment. The groundwater samples tainted with oil were taken from various wells situated at various points in Ogbomoso, Oyo State. The flow source installed was a steam injection. The global health organization's (who) results and the treated water results were contrasted. The following characteristics were measured before and after treatment: ph, dissolved oxygen (do), ec, turbidity, nitrate, potassium, iron, zinc, hardness, biological oxygen demand (bod), and chemical oxygen demand (cod). There was a range of 7.53 to 7.98, 8 to 12 mg/l, 100 to 665 μs/cm, and 0. 014 to 0.106 ntu for the pH, oxygen content, ec value, and turbidity. Nitrate, potassium, iron, zinc, and other elements varied in values from 0.03 to 2.57, 1 to 28.54, 1 to 17.06, and 0.01 to 0.03 mg/l, respectively. The ranges for cod, bod, and hardness were 3 to 8.5 mg/l, 1.5 to 4.5 mg/l, and 34 to 116 ppm, respectively. The quality of treated groundwater sample is enhanced by steam injection method. The quality of treated water is significantly enhanced when steam injection is used in conjunction with magnetic fields.

Keywords: groundwater, steam injection, magnetic effects, pollutants, water quality, human health

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1. Introduction

Groundwater is the water that seeps into the earth's pore spaces under its surface. Roughly 97% of rural residents drink groundwater, of which 30–40% is fit for agricultural use. Groundwater provides about 40% of the drinking water [1]. For many different uses, such as irrigation, industrial water supply, biological use (mineral water), and the supply of drinking water for humans and cattle, groundwater is vital to the national well-being of many countries. We acquire vital raw materials such as process water containing iodine and bromine and central heating water, which is utilized to generate thermal power [2]. A variety of contaminants that may leak from landfills, be released into the environment when industrial waste is disposed of, or spill accidentally that release hazardous substances into the environment. The sources of oily water include soot from lakes and cooling water, fuel and lubricating oil leaks, drainage from settling tanks and sludge tanks, wastewater from various cleaning processes, and soil particles. An oil spill is any release of crude oil or refined products (kerosene, diesel, gasoline, jet fuel, hydraulic oils, lubricating oils, and Stoddard solvent) that has the potential to contaminate surfaces of the land, air, or water. More and more state-of-the-art subsurface remediation technologies—like in situ procedures that include heating the subsurface to facilitate the recovery of organic contaminants—are being evaluated for use at specific sites when the drawbacks of the commonly employed methodologies become evident. Significant negative effects on health result from exposure to toxicant pollution, including cancer, diminished life expectancy, organ failure, neurological diseases, physical and mental illnesses, immune system weakness, and occasionally even death [3-6].

Studies on groundwater pollution from Atenda Abattoir Wastes, Ogbomoso, Nigeria; A couple of the groundwater-related research carried out in the Ogbomoso community are Groundwater Potential Assessment in Industrial Estate Ogbomoso, Southwestern Nigeria, and Assessment of the Groundwater Quality in Ogbomoso Township of Oyo State, Nigeria [7-9]. Even after more than 20 years of intensive study and development, cleaning up contaminated groundwater is still a difficult task. As the limitations of previously employed technologies become apparent, innovative subterranean remediation technologies—like in-situ procedures based on subsurface heating to boost recovery rates of organic contaminants—are being used at particular sites. It receives great evaluations. In certain situations, thermal technology can enable quick remediation and provides a means around these technologies' drawbacks. Heat-assisted remediation methods have the capacity to eliminate pollutants from locations that are highly contaminated [10, 11].

Hot air, hot water, or steam injection are some of the techniques. Nevertheless, steam injection is being researched as a possible thermal technology to clean up tainted groundwater [13]. One technique that shows promise for cleaning up subsurface hydrocarbon pollution is steam injection. Originally created by the petroleum industry to boost oil recovery, steam injection—also referred to as thermally enhanced extraction or steam injection—has more recently been used for aquifer and soil remediation [14]. This was explained as a contrast between a numerical simulation and a one-dimensional steam injection experiment into a column filled with sand [15]. A computer simulation of a steam injection experiment into a column polluted with residual saturated xylene is demonstrated in a different work based on these data [16]. Numerical modeling of groundwater purification in Dublin, Ireland, was also done by other writers [17] Three-dimensional pollution characterization was done using this model.

Organic contaminants were deposited at the interface between the coarse and fine sand layers beneath the water table in a mesoscale, two-dimensional sandbox experiment [18]. Pollutants were gathered at the output following an initial heating phase when steam was injected above the water table [19]. In several US locations, steam injection was utilized [20]. It has been used in saturated and unsaturated zones, and in porous media like sand, it works better than in less permeable soils [21]. By pumping steam at a high pressure and temperature into the subsurface, organic contaminants can be recovered. This rapidly and efficiently purges tainted groundwater.

It has been demonstrated that reservoir fluids react to magnetic fields [22] and different crude oils' magnetic susceptibilities have been studied [23]. The effects of magnetic fields in porous media have been studied quantitatively in certain works [24]. Other research examining the impact of magnetism on groundwater and pollutant movement have undertaken comparable investigations. Additionally, we used steam injection to numerically study the impact of magnetic fields on groundwater [25–27]. It has been demonstrated that applying magnetic fields can enhance the removal of pollutants from groundwater and restrict other cleanup procedures [28]. To achieve this goal, the removal of contaminants from groundwater by magnetic steam injection has been suggested as a potentially more efficient technique in several of Ogbomoso's shallow wells in southwest Nigeria. The study of purification is ongoing.

2. Materials and Methods

2.1. Study area

The study was carried out in Ogbomoso, which is located in southwest Nigeria, West Africa, between latitudes 8 and 9. (WGS84) is her coordinate system in degrees, minutes, and seconds. 8 08' 00" latitude, 4 16' 00' longitude [26]. Through Nigeria's Guinea Savannah, her latitude is 133 and her longitude is 4.267. It is stumbling through what looks like the savanna of Sudan. The town is divided between the North and South Local Government Areas. The 2006 census data shows that there are 51,249 males and 49,566 females living in her 18 square kilometers of land area, for a total population of 100,815 people. Situated in the northeastern part of Oyo State, it has borders with Ogbomoso North LGA to the north, Ogo-Oluwa LGA to the south, Surulere LGA to the east, and Orire LGA to the west. The Sansan/Arowo

Mall in Ogbomoso is home to the main office. The savannah zone and agricultural population in the Ogbomoso city area are well-known. In the local context, most of southwest Nigeria experiences tropical rainfall in the Ogbomoso region, which experiences two different seasons. In general, the rainy season runs from March to October, and the dry season runs from November to November (Every year, October turns into February). The research region receives 1,247 mm of rainfall annually, however this amount fluctuates from 1,016 to 1,524 mm and is primarily concentrated during the rainy season. Ogbomoso's geology consists of calcareous, granular, granite, and igneous rocks.

2.2. The sampling

In Ogbomoso town, samples will be gathered at random from the following locations: Papa Adeyemo, Aguodo, Idade, New Sawmill, Ogbegun, Sabo, and Owode. The map in Figure **1** indicates the locations of the chosen shallow wells. The well water samples that were collected were taken straight to the lab for chemical and physical examination. Water samples from the well were gathered using a 20-liter barrel. Following a thorough cleaning with distilled water, the barrels were appropriately labeled. The container was cleaned once more at the sampling location before the sample was taken.

2.3. Laboratory analysis of samples

2.3.1. Physical tests

Tests conducted physically reveal qualities that are perceptible to the senses. Color, turbidity, total solids, dissolved solids, suspended solids, and odor are a few of them. The different physical examinations are as follows:

Turbidity: a measurement of dissolved organic and inorganic compounds, microorganisms, and suspended minerals. [29] Using a turbidity meter, this was found in the water sample.Nephelometric Turbidity Units (NTU) were measured using a graduated standard of 1 to 10.

Total Dissolved Solids (TDS): TDS meters and probes (Hach's Intellica probes) were used to measure the total dissolved solids in the water samples. [30] This probe was also used to assess dissolved oxygen (DO), conductivity (EC), sodium, and ammonia.

2.3.2. Chemical tests

Chemical analyses quantify the concentrations of organic and mineral elements influencing the quality of water. These include things like pH, hardness, the presence of particular chemical parameter groups, biocides, extremely poisonous substances, and B.O.D., which is highly prized.

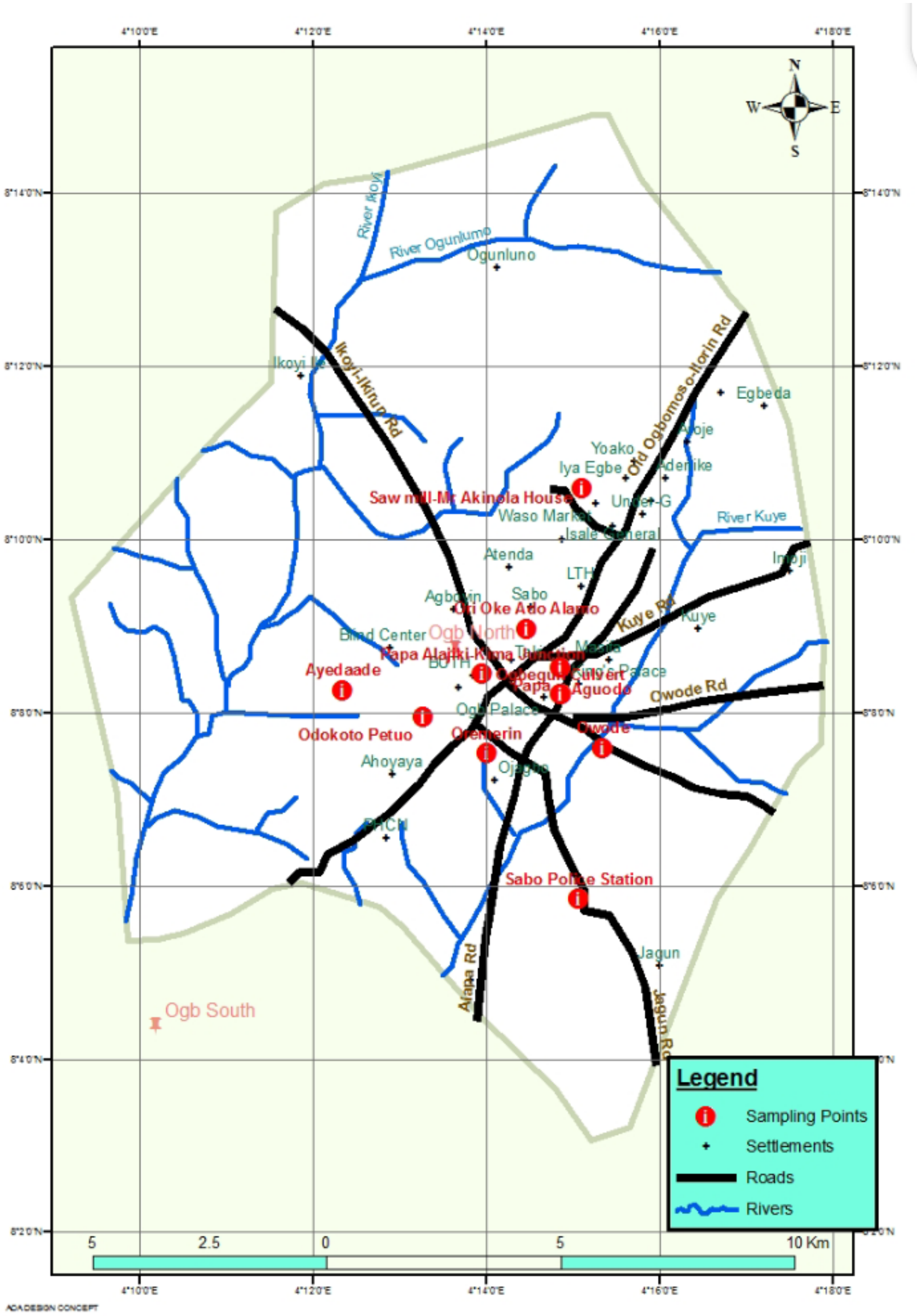

Figure 1: Map of Selected Wells in Ogbomoso.

Hardness: A small clear plastic container, a buffer solution, and a plastic titer syringe container made up the equipment. The tiny plastic syringe's cap was taken off, and sample water was used to rinse it. The sample was filled to the 0. 5 ml mark, and then the cap was replaced. Five drops of the hardness buffer solution were added after thorough mixing. One drop of the calmagite indicator was then applied. The syringe was drawn out until the 10 ml mark was reached after the tip was inserted into the ETDA solution. The EDTA titration solution is added drop by drop, mixing in between until the color changes. The milliliters of titrant solution were measured using the syringe scale and multiplied by 300.

Nitrate: Two glasses were filled with five milliliters each of the 15 milliliters of water that was prepared.

A single glass piece was placed into the chessboard disc's left side opening. This was mentioned as a gap. The reagent bag was appropriately mixed in with the other samples after being added. After being designated as a reaction sample, the solution was set aside over a light source that illuminated the sample that needed to be compared, about 30 to 40 cm away from the test disk's right opening. I rotated the disc while gazing at the sample through the color test window until the colors matched.

The test window value is expressed as milligrams of nitrogen (N-NO_3) or nitrate.

Alkalinity: A titration solution, a calibrated syringe, a clear plastic container, and a bromophenol blue indicator are among the tools used. After washing the plastic container with sample, remove the lid and add sample until it reaches the 0. 5 ml mark. Following the addition of a few drops of bromophenol blue indicator, the titration syringe was loaded with 10 milliliters of H13811. 0 solution. Drop by drop, add the titrant solution and stir until each drop causes a color shift to be seen. To get mg/L (ppm), the milliliters of titrant solution drank were measured using the syringe scale and multiplied by 300.

Iron and Manganese: The equipment consisted of a plastic container and a color comparator cube.

After taking off the plastic container's lid, a sample of water was used to rinse it. After that, it was filled to the 10 ml line. Iron Reagent HI 3834-0 1 packet was added. After replacing the cover, the mixture was stirred until the solids were completely dissolved. After taking off the cover, the mixture was put to a color comparator cube. The color that corresponded to the iron solution in the cube was measured in milligrams per liter, or ppm. To combine, add 4 drops of the buffer reagent and vortex. After adding one package of oxalate reagent (HI 38079A-0), the mixture was agitated for 30 seconds using a plastic spoon. The reaction was left to stand for around five minutes in order to finish. I mixed everything together after adding a drop of Calmagite indicator. Completely insert the syringe's plunger into the HI 380798-0 EDTA solution container, then pull it out until the syringe's 0. 0 mL mark is reached by the bottom edge of the seal. The syringe's milliliters of titrant solution were read. The magnesium mg/l (ppm) calculation

Dissolved Oxygen Determination: The dissolved oxygen content, which is influenced by the physical, chemical, and biological activities inside the body of water, is a trustworthy indication of water quality. Variations in the dissolved oxygen concentration may indicate future changes in the conditions of the water body. Among the instruments used are a flask, burette, graduated cylinder, pipettes, and a 250–300 ml BOD bottle. Among the reagents are manganese sulfate (MnSO4), alkali iodide-azide reagent, and distilled water in a rinse bottle. The American Public Health Association (APHA) was followed in this process, and Equation 1 was used to determine DO (mg/L) ((0.2 x 1000) x (0. 025) ml thiosulfate)/201 (1) 6. Biochemical Oxygen Demand Determination (BOD): BOD measures the amount of oxygen in water, polluted water, and wastewater during the aerobic oxidation of degradable organic matter and specific inorganic compounds at regulated temperatures and incubation times. It is an empirical laboratory test that is standardized and used to measure demand. The amount of oxygen required for the oxidation process described above is calculated using Equation 2 in the [31] APHA (2005) standard procedure.

The formula for BSB O_2 (mg/L) is as follows: After five days of incubation, B2 is the blank (inoculated dilution water) DO (mg/L), and F is the ratio of seeds in the diluted sample to seeds in the seed control (vol. Seed/capacity in diluted samples (DO of seeds in seed control). The seed control's DO is expressed as B_2∧' (mg/L) after five days of incubation, whereas it is indicated as B_1∧' (mg/L) prior to incubation.

Measuring Chemical Oxygen Demand (COD): This is the amount of oxygen consumed by organic molecules in an acidic boiling potassium dichromate solution. This indicates, in terms of oxygen equivalents, the amount of organic matter in a water sample that can oxidize under test conditions. An Erlenmeyer flask with conventional conical glass connections, a Friedrich reflux condenser, an electric hotplate, volumetric pipettes with capacities of 10, 25, and 50 ml, a burette, and 50 ml with a precision of 0.01 ml were among the tools utilized. 1000 volumetric flasks are included.

Sulfamic acid, standard ferrous ammonium sulfate, silver sulfate, reagent powder, mercury sulfate, ferroin indicator solution, standardized sulfuric acid solution (d = 1.84), standard potassium dichromate solution, diluted standard potassium dichromate solution, and anti-bumping agent were the reagents used.

Using Equation 3, the analysis was carried out in accordance with APHA [17]. ((a-b)X c) = COD (mg/l) For the blank value, v is the sample volume (ml), c is the molar concentration of ferrous ammonium sulfate (mol L-1), and b is the amount of ammonium ferrous sulfate utilized in the sample (ml).

Hardness Determination: To measure water hardness, a conventional indicator of the water's capacity to precipitate soap, you'll need a 100 ml Erlenmeyer flask, buffers, inhibitors, Eriochrome Black T indicator, sodium hydroxide (NaOH), standard ethylenediaminetetraacetic acid (EDTA) solution, and standard calcium solution. To guarantee that the EDTA concentration is 1 ml = 1 mg as $CaCO_3$, dilute to 1000 ml to obtain 1 ml = 1 mg CaCO3. Standardize the EDTA solution with a standard calcium solution. Equation 4 was used to determine total hardness, which is expressed as $Ca(CO)_3$ (mg/L) = C. The residue in the water sample is a rough representation of all the suspended and dissolved particles in the sample. Turbid solids (TSS) are defined as the dry weight of the particles removed by filtering a standard water sample volume through a standard filter.

Determination of Total Alkalinity: The amount of water that neutralizes acids is known as its alkalinity. Total alkalinity (or CaCO3), is the quantity of strong acid needed to neutralize alkalinity (in milligrams per liter). A pipette, 30 ml burette, and Erlenmeyer flask are among the tools used.

As well as sodium carbonate, H_2SO_4, phenolphthalein, methyl orange indicator, and mixed indicators, the reagents for analysis are standard deionized water solutions with conductance less than 0. 2 mSm^{-1} and pH greater than 6. 0. Equation 5 is used to determine the total alkalinity, per APHA [32]. T is equal to (100000) mg/L. Studies on the application of steam injection methods for groundwater treatment. At this point, the investigation is experimental. The New Fluid Mechanics Laboratory, Department of Mechanical Engineering, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria was the site of the experiment.

2.4. Utilizing steam injection technology in an experimental setting

A steam boiler produced steam (Figure **2**) was a part of our pilot. Through the inlet, the created saturated steam entered the test chamber at a controlled flow rate via a tap. Experiments with steam injection were carried out in a three-dimensional sandbox. The sandbox's inside measurements are 110 x 74 x 8.5 cm (Figure **3**). A layer of coarse sand was deposited into the sandpit up to a predetermined height. A pipe was filled with sand to guarantee a consistent fall height. It was determined how porous the coarse layer was. A dense layer of stones coated the beach. This is to make sure that the liquid and the sand pack do not flow through a preferred path. The sandbox was allowed to equilibrate for one day before to beginning each experiment, and then steam injection was started.

Constructed from galvanized steel, the sandbox had a front glass window that permitted photography, visual examination, and sand pack access. In order to reduce heat loss and contamination loss, the sandbox is insulated. Through an intake, steam was introduced into the sandbox. Temperature and steam pressure were recorded immediately prior to the input. Pressure transducers and temperature sensors were installed in the sandbox. Pollutant effluent gas exits the sandbox via the extraction port and travels beneath the exhaust via a condenser.

The condensed liquid was collected in a phase separator, as shown in Plate 3. The temperature of the heated groundwater sample was monitored at different times. The steam injection experiment created a steam zone above the groundwater table. Heat from a contaminated area carries the evaporated liquid to the heat front, where it condenses and gathers. The contaminants were held and then collected as a separate phase liquid from above the water table using a phase separator. After the impurities in the phase separator stopped condensing, the entire sand pack was heated to steam temperature until no pollutants were recovered.

2.5. Methods for groundwater remediation experiments with steam injection and magnetic effect

Then, before each experiment ran as usual, the temperature of the tainted water was monitored as it heated up at different times. When the contaminant reached its boiling point and started to evaporate, the extraction port was opened to collect effluent gases through the condenser and into the phase separator.e. The condensate was then allowed to settle in the phase separator for a few minutes in order to provide an easy and efficient method of separating water from the recovered contaminant.was then measured with a graduated cylinder (the main result of the experiment) to determine the overall amount of pollution recovered.The contaminated water was heated. While the contaminated water was heating, its temperature was periodically monitored. When a pollutant reaches its boiling point, evaporation begins.

The exhaust gas was then collected by a condenser inside the phase separator once the extraction hole was opened.

Figure 2: Steam Boiler.

3. Results and Discussions

3.1. Results of the laboratory analysis on water samples from selected wells

Table **1-4** displays the pH, TDS, Ec, and TSS values prior to and during steam injection and magnetic field steam injection treatments. Following the injection of steam, the pH of groundwater samples from the Sawmill and Ogbegun localities increased by a small amount, ranging from 1 to 4.2%.Aedade's pH dropped to 7.44 from 7.98. Following steam injection using Tesla 1 and Tesla 3 magnetic fields, the pH values of groundwater samples from the sawmill region reduced somewhat, ranging from 0.53 to 0.7%. Following steam injection using Tesla 1 and Tesla 3 magnetic fields, the pH values of groundwater samples in the Ogbegun area further dropped, ranging from 1.6% to 3.8%. The chemical makeup and pollutants in the groundwater samples could be the cause of this disparity. Both the pH levels prior to and following treatment are within the World Health Organization recommends that pH values be between 6.5 and 8 before and after treatment [33]. Inorganic salts and trace amounts of organic materials that evaporate during steam injection (boiling) make up TDS. TDS values below 300 mg/liter are deemed excellent by the World Health Organization, between 300 and 600 mg/liter are deemed good, and between 600 and 75.3% are deemed significant. TDS in Ayeedade and sawmill water samples was dramatically reduced by 74.3 and 63.8%, respectively, following treatment with magnetic field steam injection in Tesla 1 and Tesla 3.

Figure 3: Steam Boiler, SandBox, and Condenser Set-Up.

Readings of TDS greater than 1200 mg/liter are not allowed. Following water treatment, the EC values decreased from 42% to 74% for each sample that was examined. The EC decreased from 9.7% to 75.5% after water at Sawmill and Ogbegun was treated with Tesla 1 and 3 magnetic fields. Electrical conductivity (EC) is a measure of the quantity of ionic processes in a solution that allow for the passage of electricity. This has a direct bearing on the water's ion concentration. Injecting steam into the water deionizes it and lowers its conductivity level. The treated water's Ec value is less than the WHO recommended limit of 1400μS/cm.

Table 1: pH Before and After Treatment.

Location	Before Treatment	Steam Injection	TESLA (T) 1	TESLA (T) 3	WHO Bench Mark
Sawmill	7.53	7.85	7.47	7.49	6.5-8
Ogbegun	7.50	7.60	7.79	7.62	6.5-8
Ayedaade	7.98	7.44	0	0	6.5-8

Table 2: TDS Before and After Treatment.

Location	Before Treatment (mg/L)	Steam Injection (mg/L)	TESLA (T) 1 (mg/L)	TESLA (T) 3 (mg/L)	WHO Bench Mark
Sawmill	389	141	158	96	1000
Ogbegun	88	87	78	48	1000
Ayedaade	331	85	0	0	1000

Table 3: EC Before and After Treatment.

Location	Before Treatment (µS/cm)	Steam Injection (µS/cm)	TESLA (T) 1 (µS/cm)	TESLA (T) 3 (µS/cm)	WHO Bench Mark
Sawmill	783	282	316	192	1400
Ogbegun	175	176	158	158	1400
Ayedaade	665	176	0	0	1400

Table 4: TSS Before and After Treatment.

Location	Before Treatment	Steam Injection	TESLA (T) 1	TESLA (T) 3	WHO Benchmark (mg/L)
Sawmill	460	460	360	360	-
Ogbegun	320	320	330	640	-
Ayedaade	230	530	0	0	-

TSS is the dry weight of the suspended particles in a water sample that are soluble enough to filter out but not dissolved.particles suspended that are bigger than two micrometers. Below this threshold, they are referred to as TDS. Sand naturally filters out particles that can create Total Suspended Solids (TSS) from groundwater when pollution from human activity is absent. As a result, the groundwater samples from Aidade contained much less than 1% TSS. By applying a magnetic field to pump steam into mills Tesla 1 and Tesla 3, TSS was reduced by 21.7%. On the other hand, TSS decreased for Ogbegun steam injection from 3.1% to 100% with Tesla 1 and 3, respectively. This might be because of where it is and the contaminants that are there. Table **5** shows the sulfate content both before and after therapy. After treating groundwater with steam injection, the sulfate content rose from 23% to 51%. After treating Sawmill's groundwater with steam injection and a magnetic field at Tesla 1 and 3, respectively, the sulfate level rose from 17.2 to 28.1%.

Similar results were seen in Ogbegun, where Tesla 1 and 3 magnetic field steam injection treatments raised the treated groundwater's sulphate level from 69.3% to 213%, respectively.

Sulfates, polyatomic anions frequently found in medications and cleaning supplies, could be the cause of this. It can also be found in rocks naturally. Water with a sulfate content more than 250 mg/L may taste bitter. Plumbing, particularly copper pipes, can corrode from high sulfate levels. Sodium, potassium, and magnesium sulfates are the three most significant sulfates found in water.

Table 5: Sulphate Before and After Treatment.

Location	Before Treatment (mg/L)	Steam Injection (mg/L)	TESLA (T) 1	TESLA (T) 3	WHO Benchmark (mg/L)
Sawmill	35.65	43.87	29.53	25.65	250
Ogbegun	22.86	32.86	38.7	71.56	250
Ayedaade	39.08	59.08	0	0	250

The concentration of phosphorus before and after treatment is displayed in Table **6**. In samples from sawmills, phosphate levels rose by 92%, while in Ogbegun and Aidade, they fell by 44–48%. Phosphate levels rose by 38% in the Sawmill sample and by 28.6–42.9% in the Ogbegun sample after steam injection in Tesla 1 and 3 magnetic fields. A condition known as eutrophication can result from too much phosphorus stimulating the growth of big aquatic plants and algae and lowering dissolved oxygen levels. Elevated amounts of phosphorus have the potential to cause algal blooms, which in turn can yield toxins that pose a risk to the health of humans and animals. Tables **7** and **8** show the DO and turbidity before and after treatment. In the treated sample, the amount of dissolved oxygen dropped from 12 to 25%. With steam injection at the magnetic field at Tesla 1 and 3, respectively, for the sawmill, the amount of dissolved oxygen in the treated sample was further reduced from 45.8 to 100%. After using a magnetic field at Tesla 1 and 3, respectively, for steam injection, the amount of dissolved oxygen in the treated sample was lowered from 5 to 25%. This suggests that some cations and anions in water absorbed dissolved oxygen to produce oxide. Aquatic life experiences stress when water's dissolved oxygen concentration drops below 5.0 mg/l. You will feel more stressed out the less focused you are.

If oxygen levels remain below 1-2 mg/l for several hours, many fish may die. High dissolved oxygen levels are good for municipal water supplies since they enhance the flavor of the water. Except at Idade, where the results remain identical, turbidity decreases by 19–85% after being treated with steam injection water. The turbidity of water treated by steam injection with Tesla 1 and 3 magnetic fields decreases by 1.9–100%, with the exception of Idade, where the measurements remain unchanged. The increased particle count in the water column brought on by the steam injection deionization process affects light scattering and turbidity. Reduced turbidity significantly improves the quality of groundwater. Higher water treatment costs for food and drink preparation could come from this. Turbidity in rivers and lakes lowers the amount of light needed for photosynthesis, which affects the rate at which aquatic plants, especially algae (microaquatic plants), develop.

Table 6: Phosphorous Before and After Treatment.

Location	Before Treatment (mg/L)	Steam Injection (mg/L)	TESLA (T) 1	TESLA (T) 3	WHO Benchmark (mg/L)
Sawmill	1.3	2.5	1.8	1.3	0.1
Ogbegun	2.1	1.1	2.7	3	0.1
Ayedaade	4.3	2.4	0	0	0.1

Table 7: Dissolve Oxygen Before and After Treatment.

Location	Before Treatment (mg/L)	Steam Injection (mg/L)	TESLA (T) 1 (mg/L)	TESLA (T) 3 (mg/L)	WHO (mg/L)
Sawmill	12	9	6.5	0	5.0
Ogbegun	10	8	9.5	12.5	5.0
Ayedaade	13	11.5	0	0	5.0

Table 8: Turbidity Before and After Treatment.

Location	Before Treatment (NTU)	Steam Injection (NTU)	TESLA (T) 1	TESLA (T) 3	WHO (NTU)
Sawmill	0.094	0.014	0.023	0.094	5
Ogbegun	0.106	0.086	0.082	0.104	5
Ayedaade	0.093	0.093	0	0	5

Tables **9–11** display the amounts of iron, potassium, and nitrate before and after treatment. In treated water, nitrate reduction ranged from 25 to 99%. At Aidade, the highest scores were obtained. By injecting steam with a magnetic field, the treated water's nitrate reduction further varied, ranging from 97.1 to 99%. The outcomes demonstrated that, in comparison to pre-treatment, water treatment enhanced the quality of the water. Although nitrates are vital nutrients for plants, an excess of them can seriously harm the quality of water. Along with phosphorus, excessive nitrate levels can hasten the process of eutrophication, which results in a sharp rise in the development of aquatic plants and alterations to the types of plants and animals that live in rivers. In treated water, potassium and iron levels rose by 6–90%. Potassium, the sixth most common element in the earth's crust, is present in the sand used for steam injection. Tesla 1 and 3 magnetic fields were used to inject steam, increasing the quantity of iron in sawmill process water to 54.4-61.8%. The steam injection method using Tesla 1 and 3 magnetic fields resulted in a 36.8% reduction in iron content from 14.8% in Ogbegun's treated water. By adding this, the treated water's already-high value is increased. Even after treating drinking water with potassium permanganate, there is currently no proof that potassium concentrations in municipally treated drinking water could be harmful to public health. Setting health-related limits for potassium in drinking water is deemed unnecessary. Although potassium is a necessary element for human health, it is rarely found in drinking water at amounts that should worry healthy individuals. A daily need of at least 3000 mg is advised. Weathering causes iron to be liberated into water. Magnetite, hematite, goethite, and siderite are the primary iron minerals that are found naturally. A staple meal, iron is essential to many natural processes.

Table 9: Nitrate Before and After Treatment.

Location	Before Treatment (mg/day)	Steam Injection (mg/day)	TESLA (T) 1 (mg/day)	TESLA (T) 3 (mg/day)	WHO Benchmark (mg/day)
Sawmill	1	0.85	0.027	0.01	2.6
Ogbegun	0.34	0.03	0.01	0.051	2.6
Ayedaade	2.57	0.03	0	0	2.6

Table 10: Potassium Before and After Treatment.

Location	Before Treatment	Steam Injection	TESLA (T) 1	TESLA (T) 3	WHO Benchmark
Sawmill	5.2	28.54	18.67	18.8	-
Ogbegun	1	16.43	26.08	28.95	-
Ayedaade	10	18.56	0	0	-

Table 11: Iron Before and After Treatment

Location	Before Treatment	Steam Injection	TESLA (T) 1	TESLA (T) 3	WHO Benchmark
Sawmill	0.68	0.7	1.05	1.1	100
Ogbegun	2.85	0.2	1.8	2.45	100
Ayedaade	2.39	1.65	0	0	100

Table **12** shows the zinc levels before and after treatment. For Ogbegun and Ayedade, the value stays the same, but in the Sawmill treated sample, it rises by 50%. The sources of zinc in groundwater are metals from surface runoff that seep into the aquifer and contaminate the land.Due to taste concerns, the EPA has declared that the maximum amount of zinc that should be present in drinking water is 5 mg/L (5 mg/L). Zinc has been shown to efficiently lower inflammation, strengthen the immune system, lower the risk of age-related illnesses, hasten the healing of wounds, and alleviate acne symptoms.

Table 12: Zinc Before and After Treatment.

Location	Before Treatment (mg/L or ppm)	Steam Injection	TESLA (T) 1	TESLA (T) 3	WHO Benchmark (mg/L or ppm)
Sawmill	0.02	0.01	0.02	0.02	5
Ogbegun	0.03	0.03	0.02	0.01	5
Ayedaade	0.02	0.02	0	0	5

Tables **13** and **14** display the values of hardness and alkalinity both before and after treatment. The Sawmills and Ogbegun samples' alkalinity increased from 48 to 56% after treatment. After receiving treatment, groundwater samples from Ayedaade revealed a 50% reduction in alkalinity. Following treatment with steam injection and magnetic field at Tesla 1 and Tesla 3, the alkalinity of the Sawmills and Ogbegun samples increased from 117 to 716.7%. The amount of acid that can be given to a liquid without significantly changing its pH is known as its alkalinity. After steam injection, surface waters with higher alkalinity levels will be able to withstand acid rain and other acid wastes, as well as avoid pH shifts that could endanger aquatic life.

All of the water samples had a 12–53% reduction in hardness. Following treatment with steam injection and a magnetic field at Tesla 1 and 3, Sawmill's water hardness decreased by 51.7–67.2%. For Ogbegun, there is an increase of 39.3-539.3%. In harder water, other metals often have less of an adverse effect on aquatic life. Hard water causes some metal ions to precipitate out of the solution, forming insoluble precipitates that are indigestible by the body. Large levels of hardness are not desired primarily for economic or cosmetic reasons.

Table 13: Alkalinity Values Before and after Treatment.

Location	Before Treatment	Steam Injection	TESLA (T) 1	TESLA (T) 3	WHO Benchmark (mg/l)
Sawmill	58	184	164	126	200
Ogbegun	30	84	184	245	200
Ayedaade	164	82	0	0	200

Table 14: Hardness Values Before and after Treatment.

Location	Before Treatment (ppm)	Steam Injection (ppm)	TESLA (T) 1	TESLA (T) 3	WHO Benchmark (ppm)
Sawmill	116	54	38	56	300
Ogbegun	56	34	78	358	100
Ayedaade	116	102	0	0	100

Tables **15–17** show the changes in phosphate, BOD, and COD both before and after treatment. In all samples, phosphate increased by 29–50%. Phosphate levels rise from 28.6 to 90% in Sawmill and Ogbegun when steam injection with a magnetic field is used at Tesla 1 and 3, respectively. Chemical substances containing phosphorus are called phosphates. Although too much phosphate can lead to eutrophication, a type of water pollution, it is necessary for plant and animal life. Following treatment, the Sawmill groundwater sample's biological oxygen demand (BOD) decreased by 24%. Ogbegun and Ayedade's BOD values don't change. BOD has a direct effect on the amount of dissolved oxygen (DO) in rivers and streams. This suggests that higher aquatic organisms have less oxygen available to them. The same effects that result from excessive BOD also occur from low dissolved oxygen: aquatic living things.

The COD value dropped by 6–67% when all groundwater samples were treated with steam injection. Similar to Sawmill, Ogbegun's COD value increased from 50 to 56.3% while Sawmill's COD value declined by using steam injection with a magnetic field at Tesla 1 and 3. Higher COD levels in the sample imply higher concentrations of oxidizable organic material, which will result in lower dissolved oxygen (DO) levels. Anaerobic conditions brought on by lower DO levels can be detrimental to higher aquatic life.

Table 15: phosphate before and after Treatment.

Location	Before Treatment (mg/L)	Steam Injection (mg/L)	TESLA (T) 1	TESLA (T) 3	WHO Benchmark
Sawmill	0.7	0.9	0.9	0.4	-
Ogbegun	0	0.45	0	0.9	-
Ayedaade	0.6	0.9	0.9	0	-

Table 16: BOD Before and after Treatment.

Location	Before Treatment	Steam Injection	TESLA (T) 1	TESLA (T) 3	WHO Benchmark (mg of oxygen per liter)
Sawmill	4.5	3.4	3.1	2.5	40
Ogbegun	1.5	1.5	2.8	1.1	40
Ayedaade	2.6	2.6	0	0	40

Table 17: COD Before and after Treatment.

Location	Before Treatment	Steam Injection	TESLA 1	TESLA 3	WHO Benchmark (mg/L)
Sawmill	8.5	2.8	5.5	7.5	120
Ogbegun	3.2	3.0	4.8	5	120
Ayedaade	6.0	3.0	0	0	120

4. Conclusion

In this study, the use of steam injection with magnetic effect for water purification was investigated experimentally. The outcomes of the experiment are compared between water treatment and non-treatment. This indicates that following water treatment with steam injection, the water samples showed significant improvements. The treated groundwater samples showed an increase in the following parameters after steam injection: ph, phosphate, alkalinity, zinc, iron, potassium, and sulfate. Similar drops in cod, bod, do, hardness, nitrate, turbidity, phosphorus, ec, and tds were noted in the treated samples. Additional advantages come from using steam injection and a magnetic field to purify water. This suggests that steam injection using magnetic field technology improves the quality of treated groundwater samples even more.

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