

# Study of Electromagnetic Waves on Industrial Waste Water

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Received November 21, 2013; Revised December 02, 2013; Accepted December 12, 2013

**Abstract** Wastewater treatment is essential to protecting the environment and human welfare. Water is a resource that is fundamental to human life, which makes taking action to protect the resource on the forefront of research. Treated wastewater effluent is a possible source that can pollute receiving water bodies and cause contamination. It is often discharged into larger bodies of water that are used in people's everyday lives. A new and novel approach technology is introduced to treat the waste water. Electromagnetic waste water is old but approached in new way to reduce the pollutant level. By applying this method chemical oxygen demand 1500mg, hardness 80mg/l, suspended solid 65mg/l was reduced respectively. The purpose of the research described herein is to test the feasibility of alternative wastewater by electromagnetic methods. Treatment facilities are implementing alternative technologies, though the cost and efficiency associated with these practices leave much room in the wastewater field for innovation.

**Keywords:** COD, current, conductivity, hardness, intensity, suspended solid

**Cite This Article:** M. Srinivasa Rao, and Omprakash Sahu, "Study of Electromagnetic Waves on Industrial Waste Water." *Physics and Materials Chemistry* 1, no. 2 (2013): 34-40. doi: 10.12691/pmc-1-2-5.

## 1. Introduction

Non-chemical water treatment devices were first proposed as a means of scale control in 1865 [1,2]. In 1873, A.T. Hay received the first US patent for a water treatment device that employed a magnetic field [3]. Today, many of these devices are commercially available. Some employ one magnet, some two or more. In some, the magnet is located inside the pipe through which the treated water flows; in others the magnet is placed outside of the pipe. Although the variety of devices on the market may seem nearly infinite, most can be classified into four basic types [4]. Whatever the design, even a cursory review of the literature surrounding these devices reveals numerous contradictions in claimed effects, low reproducibility of results, and explanations based on strange and mysterious effects of the field on the structure of water and/or interactions of the field with dissolved minerals that are generally diamagnetic [5,6].

Magnetized water is obtained by passing of water through the permanent magnets or through the electro magnets installed in/on a feed pipeline [7]. The permanent ceramic magnets or electro magnets are installed around the incoming water pipe. According to the Ampere's law, when the electricity passes into a wire, a magnetized field will be created around it. Up to now, different devices have been produced to magnetize water. In spite of variety of structures and shapes for these devices, their performing mechanism is almost the same. When a fluid

passes through the magnetized field, its structure and some physical characteristic such as density, salt solution capacity, and deposition ratio of solid particles will be changed [7]. In a water sample containing CaCO<sub>3</sub>, as the calcium and carbonate ions enter into the area that are influenced by the magnets, they are pushed in opposite directions, due to their opposite charges. As all of the calcium ions are pushed in one direction and all of the carbonate anions are pushed in the opposite direction, they tend to collide. When these collisions occur, the ions stick together forming a solid form of CaCO<sub>3</sub> called aragonite [8]. Because these microscopic crystals are forced to form while moving in the water, they do not have an opportunity to attach themselves to the pipeline. In other words, the acting of inspiration force on the fluid and because of the polarity of water, anions and cations vibrate and get close together and finally stick. Therefore, the electrical charge of suspended particles decreases and stay in the form of snowball phenomenon and suspend in water [9]. The changes caused by the magnetic influence depend on many factors, such as strength of the magnetic field, direction of applied magnetized field, duration of magnetic exposure, flow rate of the solution, additives present in the system, and the pH [8]. The magnetized water has been studied by many researches [8-13]. An experimental study showed that a relatively weak magnetic influence (field) increased the viscosity of water, which was interpreted by the stronger hydrogen bonds under the magnetic field [14]. Two theories have been developed to address magnetic field effects on calcium carbonate precipitation: (1) a direct effect on dissolved

ions and (2) a magnetic effect on particulates. The first theory postulates a direct effect on dissolved ions. Examples of ionic response to a magnetic field have been reported by Higashitani et al. [8] who investigated the characteristics of calcium carbonate crystals formed after mixing magnetically treated, quiescent-filtered solutions of calcium chloride and sodium carbonate. The second mechanism postulates a magnetic effect on particulates present in water rather than on dissolved ions and, further, that changes in the surface charge of particles influence

the rate of nucleation and precipitation of calcium carbonate [15]. Higashitani and Oshitani [16] investigated the effect of magnetic fields on the stability of nonmagnetic colloid particles, and suggested that colloidal stability is influenced by magnetic fields through alteration of the structure of water molecules and ions either adsorbed on the particle surface, or in the medium. When electricity applied to any solenoids due to that magnetic intensity generated is shown in Figure 1.

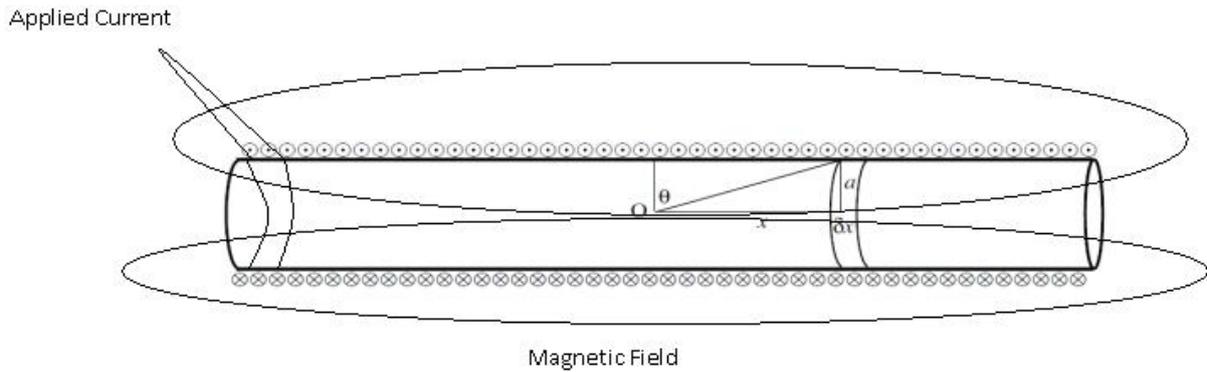


Figure 1. Magnetic field developed inside pipe

The important components for effective magnetic treatment are flow rate through the apparatus and certain chemical parameters of water, namely, carbonate water hardness of more than 50 mg/L and concentration of hydrogenous ions in water at  $\text{pH} > 7.2$  [17]. Mostafazadeh-Fard et al. [18] investigated effects of magnetized water and irrigation water salinity on soil moisture distribution in trickle irrigation. They showed that the mean soil moisture contents at different soil depths below the emitter for the magnetized irrigation water treatment were more than the non-magnetized irrigation water treatment and the differences were significant at 5% level. Finally it was know that magnetized method has good approached to treat the waste water. In this regard the effort has been made to treat the industrial waste water by applying electromagnetic field.

the effluent was shown in Table no.1 and it was store in 20°C.

Table 1. Parameters of industrial Waste water

S.No	Parameters	Industrial Water
1	Color	Dark yellow
2	pH	8
3	BOD	970mg/l
4	COD	4500mg/l
5	Oil and Grease	12
6	Temperature	33°C
7	Electrical Conductivity	600 $\mu\text{Scm}^{-1}$
8	Suspended Solid	150 mg/l
9	Calcium	361 mg/l
10	Magnesium	268 mg/l
11	Sulphate	419 mg/l
12	Iron	12.8 mg/l
13	Lead	0.065 mg/l
14	Zinc	0.26 mg/l
15	Copper	0.135 mg/l
16	Hardness	300 mg/l

## 2. Material and Methods

### 2.1. Electromagnetic Treatment

The water sample was collected from Boramdev Sugar Factory Ltd. Kawardha (C.G.) India. The charterstices of

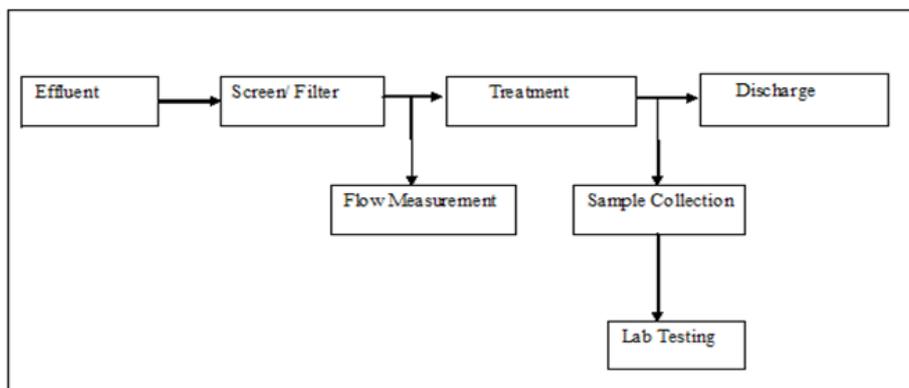


Figure 2. Arrangement of Experiment

The arrangement of the experiment is shown in Figure 2. The waste water supply and the flow can be control by digital flow meter device. Electromagnetic fields generated by a solenoid coil (diameter 50 mm, 80 mm high, copper wire, 700 turns/m, self inductance  $L = 3 \text{ mH}$ , ohmic resistance  $3 \Omega$ ). The signal produced by a function generator (Agilent 33120A), consisted of successive sinusoidal signals in the current range from 100 to 500 mA. The calculated magnetic field density at the center of

the coil was according to Faraday law. After treatment sample was collected, tested and discharge.

The treatment system shown in Figure 3, it is connected with flow measure digital device a solenoid with copper coil and joint with electric supply. When current is supply to the coil the magnetic field was induced on the pipe. Once magnetic field generated the positive charge of pollutant is attracted toward the surface of pipe and stick. The intensity of magnetic field was calculated by Biot-Savart Law.

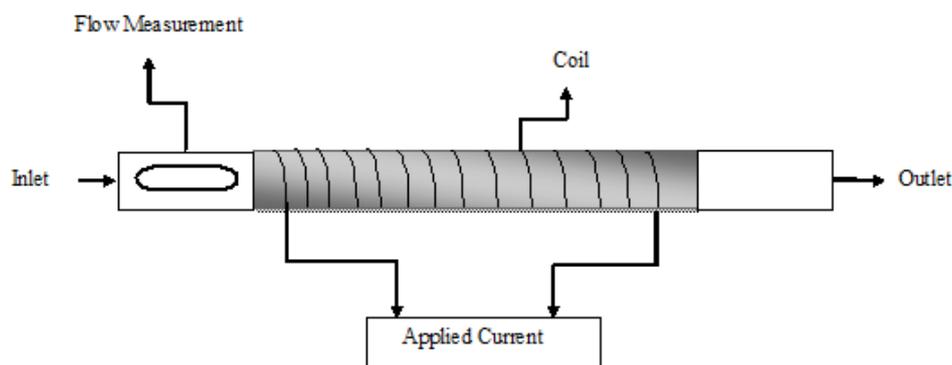


Figure 3. Electromagnetic system to treat the waste water

## 2.2. Physicochemical Water Analysis

The different measurements, using a multiparametric system (multimeter Consort C835, Fisher Scientific) were always done, in the glove box, in the same order: conductivity/temperature, oxygen concentration, pH, and oxidation-reduction potential (ORP). Data values from the multimeter were recorded on a computer. For conductivity measurements, the apparatus was equipped with a specific electrode of cell constant  $K=0.1 \text{ cm}^{-1}$  for low ionic concentration solutions with automatic temperature correction (Pt1000) and calibrated with two ionic strength solutions ( $84$  and  $1413 \mu\text{S}\cdot\text{cm}^{-1}$  at  $25^\circ\text{C}$ , Hanna Instruments). pH measurements were done using a combined electrode (LL-Aquatrode, Metrohm) adapted for pure water. The electrode was calibrated using a test kit buffer (Scott-Geräte). For ORP measurements, we used a combined electrode with platinum ring (N90417, Fisher

Scientific) and for oxygen measurements; we used a combined electrode oxygen/temperature (N98338, Fisher Scientific). The ORP probe was calibrated using a redox solution of  $470 \text{ mV}$  (Pt-Ag/AgCl at  $25^\circ\text{C}$ , Scott-Gerate) and the oxygen probe calibrated with 100% of oxygen content in air. The COD of the samples was determined by the standard dichromate reflux method. Hardness was determined by titration methods. Suspended solid in sample is carried out by filtering the wastewater through a  $0.45 \mu\text{m}$  membrane filter (or a fiber pad filter) and then measuring the dry weight (obtained by drying the filter and its content at  $103\text{-}105^\circ\text{C}$ ) of the material so collected. Ambient magnetic fields (geomagnetic and environmental) analysis The dc and ac electric as well as magnetic fields were measured inside of the insulated cages with a low field axial probe Mag B, positioned at  $60^\circ$ , connected to a Mag-01H (Bartington Instruments Ltd) for the dc measurements.

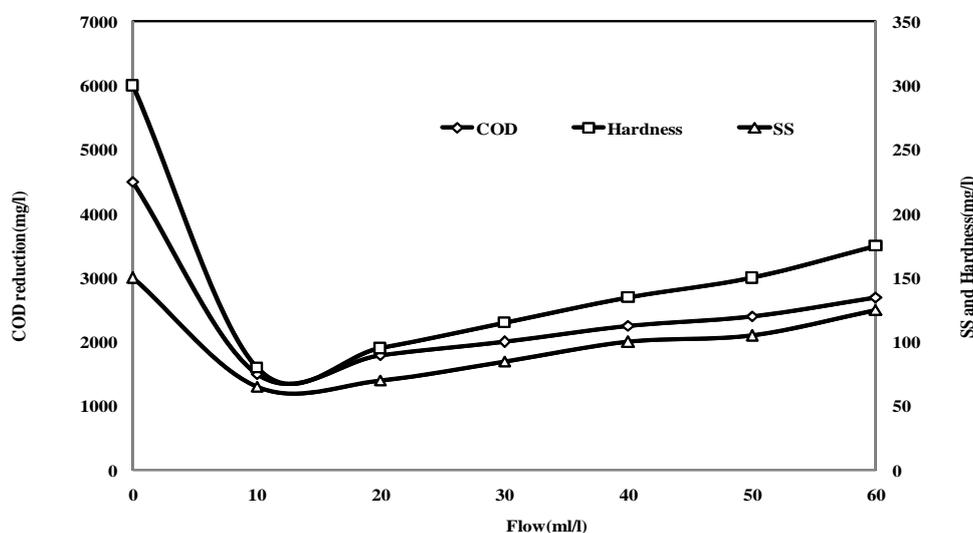


Figure 4. Effect of different flow rate on industrial waste water at fixed time ( $T = 15$ second, Current ( $A$ ) =  $500 \text{ mA}$ , Magnetism field ( $G$ ) =  $879 \text{ T}$ ,  $\text{COD}_0 = 4500 \text{ mg/l}$ , Hardness =  $300 \text{ mg/l}$  and Suspended Solid ( $\text{SS}$ ) =  $150 \text{ mg/l}$

### 3. Results and Discussion

#### 3.1. Effect of Flow Rate

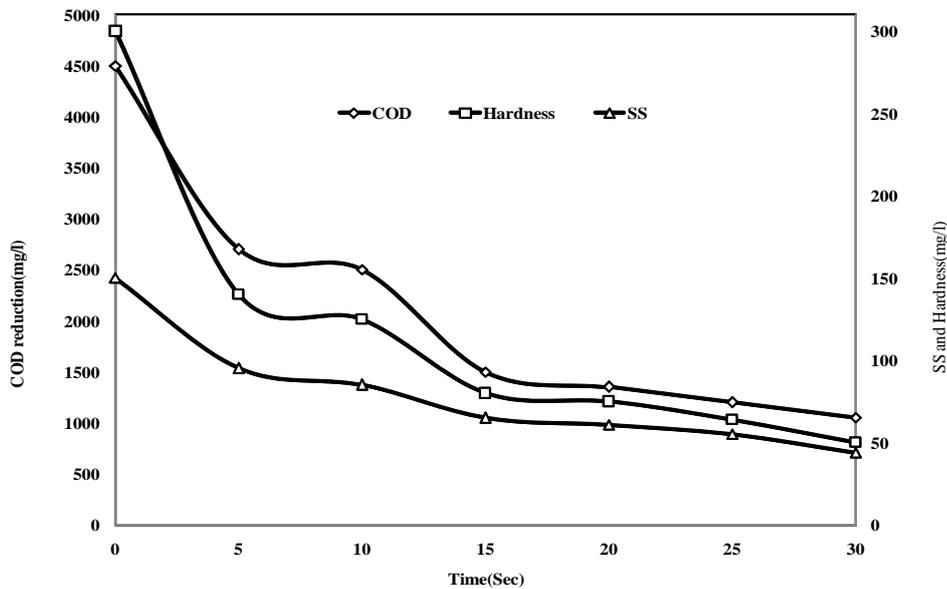
Effect of flow rate on the COD, hardness and suspended solid removal is experimentally shown in Fig. 4, where magnetizing works were conducted by varying the flow rate from 0.67 ml/s to 4ml/s. It is shown that the COD, Hardness and suspended solids (SS) removal is increased as the flow rate is decreased. It seen that when flow rate varies from 10, 20, 30, 40,50, and 60ml/15 second, the COD reduction 1500, 1800, 2000, 2250, 2400 and 2700mg/l hardness 80, 95, 115, 135, 150 and 175mg/l and SS 65, 70, 85, 100, 105 and 125mg/l was found. It might be due to increased flow rate means increased in drag force. Therefore particles contained in pollutant are not properly magnetized under this high flow velocity. For

a lower flow rate reduction of COD, hardness, SS is found to be higher. The reason is that in slower flow rate pollutant particles received more magnetic fields thus more suspended particles are attracted and cloaked together. Consequently this behavior would contribute to extra reduction of suspended solids. So it concluded that less flow rate more pollutant remove.

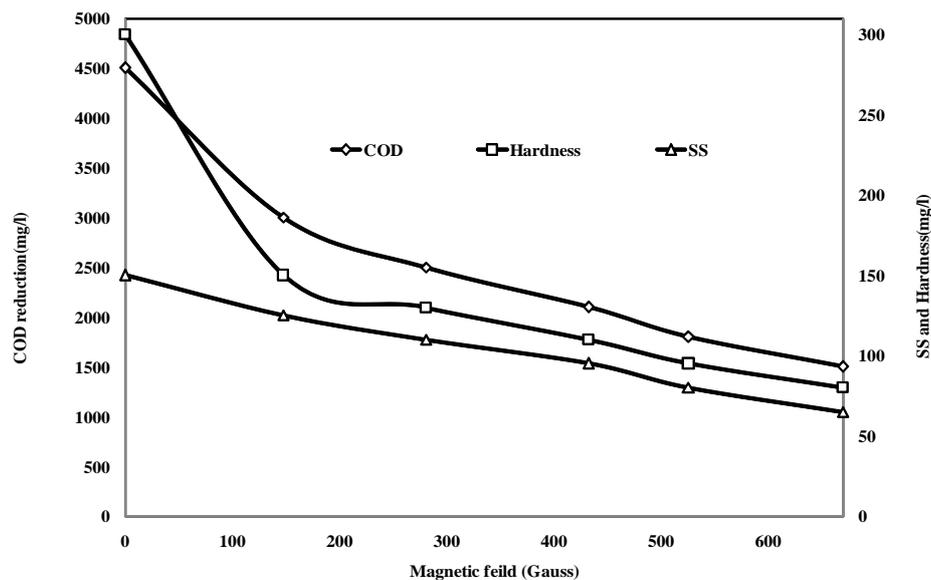
#### 3.2. Effect of time

In this experiment several flow rates were used to achieve several exposure time applied to the system. The exposure time obtained from the flow rate is described by the bellowed equation:

$$\text{Applied charge (Q)} = \text{Volume (V)} / \text{Time (t)}$$



**Figure 5.** Effect of different time at fixed flow rate of industrial waste water at Magnetism field (G) = 879T, COD<sub>0</sub>= 4500mg/l, Hardness =300mg/l and Suspended Solid (SS) =150mg/l



**Figure 6.** Effect of different magnetic field on industrial waste water at time (T) =60second, COD<sub>0</sub>= 4500mg/l, Hardness =300mg/l and Suspended Solid (SS) =150mg/l

In equation (1) Q is the flow rate, V is the volume of the tube and t is the exposure time. The magnetic strength used was 700 μT. It was observed that changes in

exposure time would significantly affect the COD, hardness and SS concentration. Effluent that has longer exposure time gives better reduction compared to shorter.

Longer exposure time means the charged pollutant particles received more ionic charge. This results in greater attractive forces among the suspended particles (positive and negative charged particles) and as this happened more particles are trapped and settle down. It was observed that when exposure time was 5, 10, 15, 20, 25 and 30 second and flow rate is fixed for 10ml. It was found that COD reduction 2700, 2500, 1500, 1350, 1200, 1050mg/l, hardness 140, 125, 80, 75, 64, and 50mg/l and SS 95, 85, 65, 61, 55 and 44mg/l respectively. This proves that exposure time is also one of the main parameter which should be taken into consideration. It was observed that the third and fourth seconds would be the optimum exposure times to be used in this magnetic treatment. Although the eighth second gives the highest reading in the percentage of suspended solid removal but it is not practical to be applied since the used flow rate is too slow.

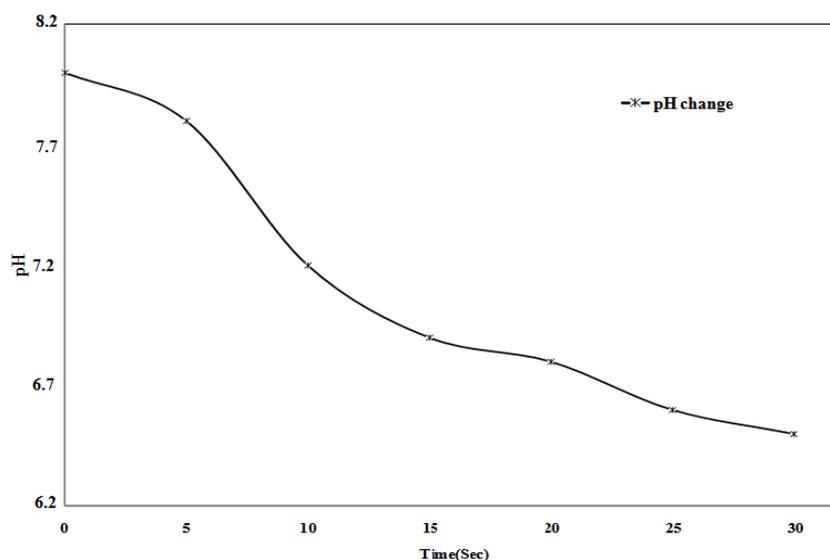
### 3.3. Effect of Magnetic Intensity

The effect of magnetic intensity on the COD, hardness and SS removal is experimentally studied by varying the magnetic field strength between 175 T to 879 T at 0.167ml/s. It is shown that the COD, hardness and suspended solids removal increases as the magnetic

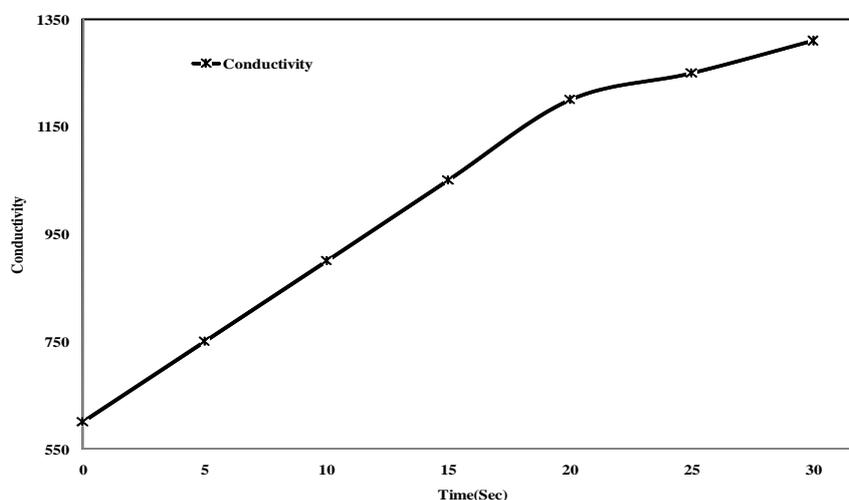
strength is increased. From Figure 5 it was observed that with the increase in magnetic intensity 175, 351, 527, 703 and 879T, the hardness 3000, 2500, 2100, 1800, 1500 mg/l, hardness 150, 130, 110, 95, 80mg/l and SS 125, 110, 95, 80, 65mg/l respectively. It is due to the charged ion will attract the oppositely charged water molecule. With the increase in magnetic intensity more no of negative ions generated and more no of positive ion are sticks on the inner wall of the pipe/surface.

### 3.4. Effect on pH change

To study the effect of electric and magnetic on the pH the experiment was carried out at 879T magnetic intensity 0.167ml/s flow rate. It was observed that with increase in exposure time the pH was decrease means flow rate 10ml/5sec, 10ml/10sec, 10ml/15sec, 10ml/20sec, 10ml/25sec, 10ml/30sec the pH 8, 7.8, 7.2, 6.9, 6.8, 6.6 respectively. Without alkalinity boosters, the pH of the solution goes slightly up, stays almost constant for a while, and then decreases. The inherent buffer works very efficiently that hinders the raise of pH during electromagnetic treatment. pH in the range of 6.5- 7.5 is vital for significant production of ions when sacrificial iron pipe are used.



**Figure 7.** Effect on pH different flow rate on industrial waste water, Magnetism field (G) = 879 T, COD= 4500mg/l, Hardness =300mg/l and Suspended Solid (SS) =150mg/l



**Figure 8.** Effect conductivity different flow rate on industrial waste water, Magnetism field (G) = 879T, COD= 4500mg/l, Hardness =300mg/l and Suspended Solid (SS) =150mg/l

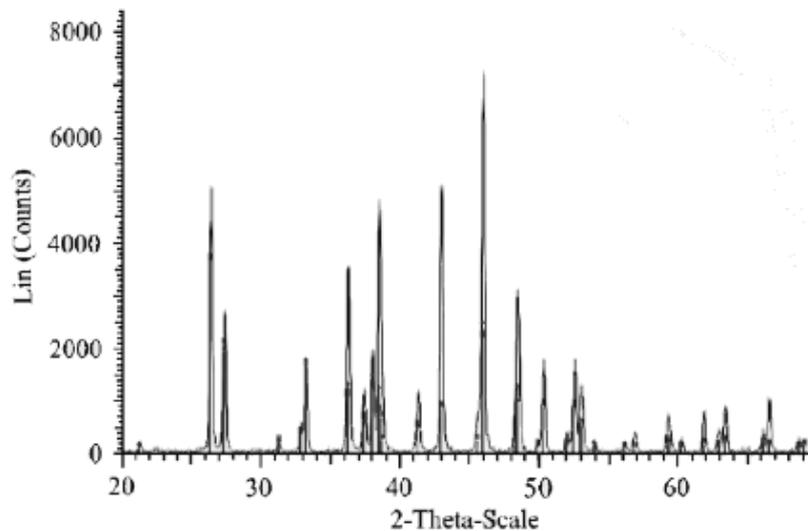
### 3.5. Effect on Conductivity

To study the effect of electric and magnetic on the conductivity the experiment was carried out at 879T magnetic intensity 0.167ml/s flow rate. It was observed that with the increase in exposure time the conductivity of waste water increases. From Figure 7 it was observed that when the flow rate was 10ml/5sec, 0ml, 10ml/10sec, 10ml/15sec, 10ml/20sec, 10ml/25sec, 10ml/30sec, the conductivity was 600, 750, 900, 1050, 1200, 1250, and 1310  $\mu\text{s}/\text{cm}$  respectively.

### 3.6. X-ray Diffraction Study

To determine the X-ray diffraction of samples' the data were collected with AXS-Baker/Siemens/D5005 X-ray powder diffractometer (using Cu K radiation). Phases

were determined by Search/Match program. Spectrographs are practically identical for the samples and one of them is presented in Figure 9. In world literature, there is a general opinion that calcite is responsible for hardness of water because it forms rhombohedral crystals, which are highly adhesive, while the presence of needlelike crystals of aragonite is the main factor for the formation of softer, porous, more soluble deposits. This explanation is reasonable for many laboratory results of magnetically raised ratio aragonite/calcite, but in our case deposits in the blank line were already aragonite, which was surprisingly hard and tenacious. Obviously, in practical water-processing cases, some thermal and hydrodynamic factors affect the radial development of aragonite needles.

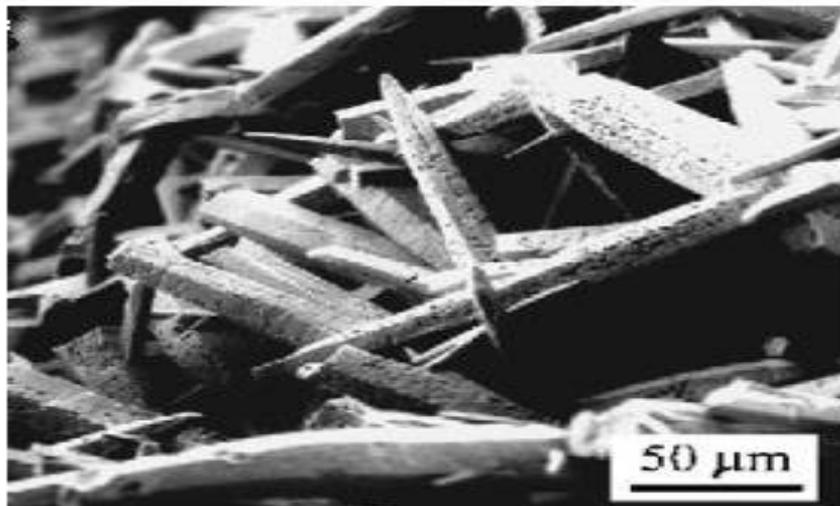


**Figure 9.** X-ray diffraction spectrograph of scale from outlet pipe in the blank line, identifying the sample as aragonite at magnetic intensity =879T flow rate = .167ml/second

### 3.7. Scanning Electron Microscope (SEM)

To study the structure of scale deposited on the surface of pipe the samples from the experiment, observed by FEI-QUANTA 200 3D Environmental Scanning Electron Microscope, which is shown in figure. Figure 10 presents the cross-section morphology of the compact, but porous

scale from the outlet pipe. Aragonite needles can be seen in small voids. The needles are in the case of magnetic treatment approximately four times thinner than in the case without the treatment. This can be a result of enhanced nucleation or retarded growth of aragonite crystals, somehow caused by magnetic treatment.



**Figure 10.** Scanning Electron Microscope of treated waste water at magnetic intensity =879T flow rate = .167ml/second

## 4. Conclusion

In our research, we have attempted to identify measurable effects of magnetic effect on industrial waste water. To investigate the effects of magnetic field, this research depends on four variables of COD, Hardness and SS (Suspended Solid) as following : DC Current (i), time (t), magnetic strength (B), and concentration (C). Based on the results from the series of tests described it was found that the COD reduction 1500mg/l, hardness 80mg/l and SS was 65mg/l, pH 6.5 and conductivity 1350 at 879T magnetic intensity. The X-ray study defined the formation of scale is aragonite nature and it was conformed through the SEM study. Finally concluded that magnetic waste water treatment effective and time saving, we have identified several effects that are likely to occur in the type of magnetic treatment studied in this research. However, we cannot yet prove that these effects are directly linked to the claims of pollution reduction, nor do we know whether other effects, yet to be uncovered, are also occurring. However, because the effects uncovered, to date, can be reasonably related to scale deposition, we believe that magnetic water treatment should not be dismissed out of hand. This does not mean that every magnetic treatment device currently on the market actually works or that those that do work are effective under every possible scaling situation. Even if magnetic treatment can be shown to reduce scaling conditions when used properly, the question remains as to whether the technology is robust enough in comparison with chemical means of pollution prevention. If magnetic treatment devices are effective, and we are finally able to understand how they operate, the best strategy could be a combination of magnetic and chemical treatment.

## Acknowledgement

Authors acknowledge to department of chemical engineering NIT Raipur for funding and facilities.

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