Anti-Scale Magnetic Method as a Prevention Method for Calcium Carbonate Scaling (DSL.3)

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Overview

- Scaling (definition- types-cost)
- Common Solutions for scaling.
- Advantage – disadvantage of solutions
- MTM (definition – history)
- Experiment A on MTM, objectives, method and result.
- Experiment B on MTM, objective, method and result.
- Literature survey on MTM to seek for explanation for the results obtained on Experiments A and B.
- Experiment C on retarding CaCO3, method, equipments, results.
- Discussion of results, conclusion, recommendations.

Introduction

- Scaling means the **deposition of particles** on the membrane surfaces/internal surface (MSF)
- Scaling is considered as the **biggest operating problem** in desalination plants (membrane, MSF).
- Scaling is a **selective** and a **costly** problem.
  - 10% of production cost = cost of antiscalant

  - KD 0.95 million/ year / the cost of dosing 3 mg/l Kuwait desalination plant.
  - depositing of 0.036 inches of scale / heat exchanger will increase the energy cost of over 30% .
- Acid addition + Antiscalnt are the common solutions for scaling.

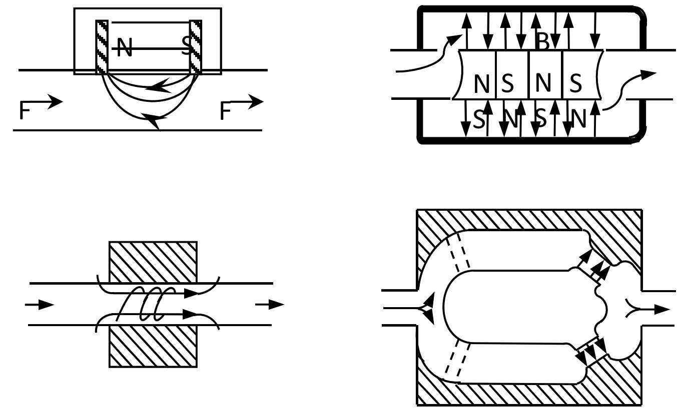
Introduction

- **Acid (shifting the reaction)**

$Ca^{2+} + HCO_3^- \text{ ------ } H^+ + CaCO_3$

- **Corrosion- $CaCO_3$ only- required precautions- less productivity- low viability.**
- **Antiscalant(chemicals change the crystal/ shape/ size/ morphology/ location of precipitation/ keep the crystal dispersed / suspended).**
- **high cost/ enhance biofouling/ loose effectiveness at high temperature (hydrolysis/ harm to environment)**
- **MTM was proposed by different local companies as physical method / chemical composition / reduce hardness/ disinfect water/ prevent scale)**

Magnetic Treatment Method(MTM)



- MTM has been applied as a

Scale controlling

Method for several

 decades in water systems.

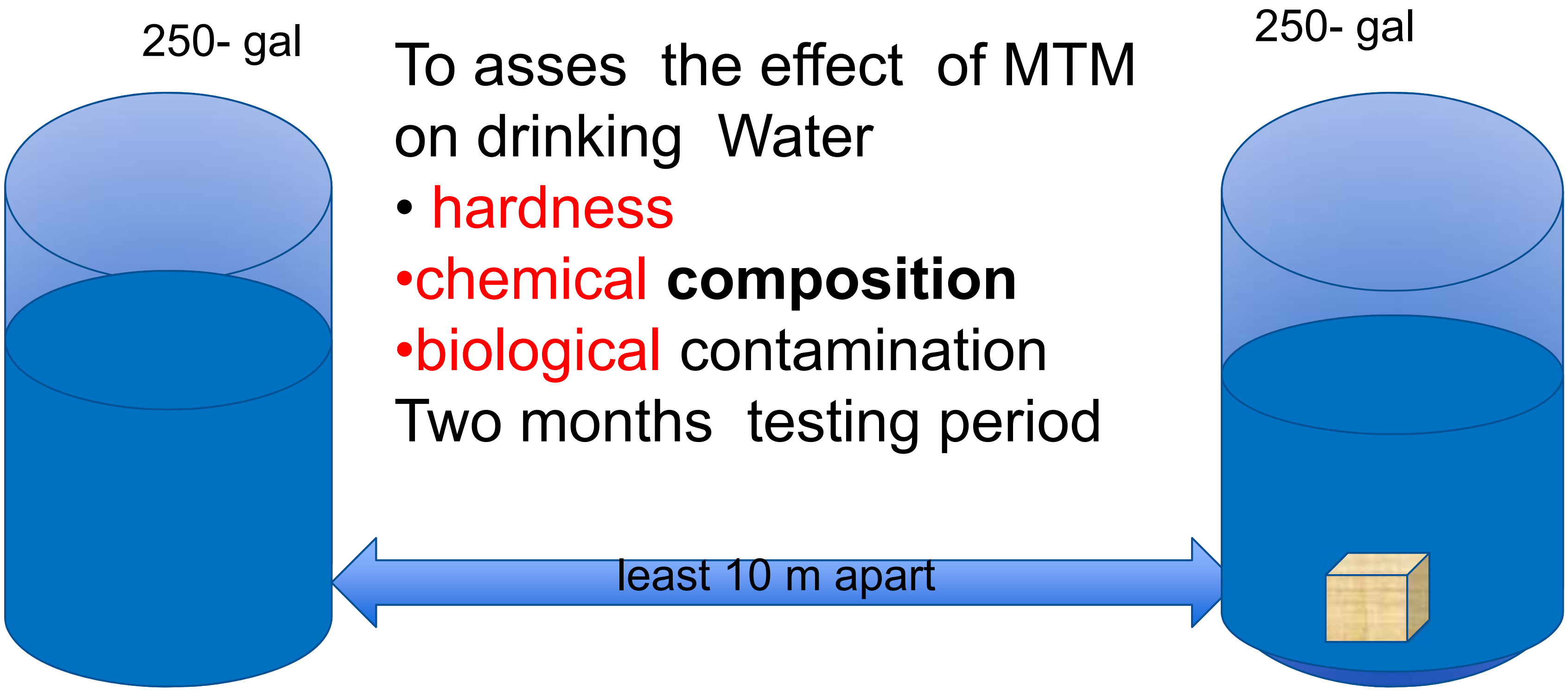
- The first commercial device to be used for

 MTM was patented in Belgium in 1945 and used in a hot water system.

- The use of MTM has been wide spread since 1975 in water treatment in USA.

- **In Kuwait local companies requested to test the effect of MTM on the chemical composition, hardness, water tasty, disinfect method (Exp A & B)**

Experiment A：



To asses the effect of MTM on drinking Water

- hardness
- chemical **composition**
- biological contamination

Two months testing period

Two water samples were collected weekly from the two tanks.
The two samples were biologically, chemically and physically analyzed.

Experiment B (service to a local company)

- The test used a flowing seawater and tap water under open loop and closed loop circulation. The objective was to investigate the effect of MTM on the chemical composition **of <u>different types of flowing water</u>**. (seawater)

- The MTM used was ECO-peam from ECO-technology company as a source for MF

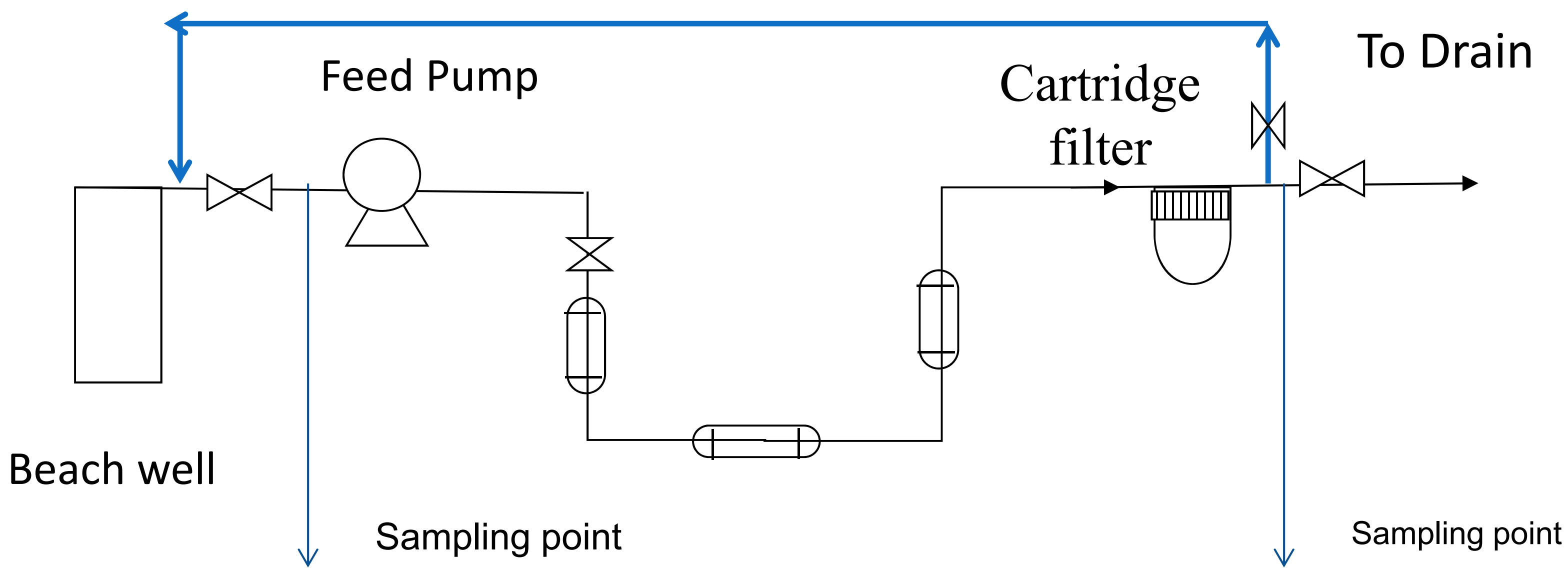


Figure 2. show the schematic diagram of the test unit (B)

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- **The results of the experiments A &B showed similar results where no significant changes (water quality and chemistry)**
- **So , a literature survey conducted to seek for an explanation for the negative results obtained.**
- **LS showed that 31/40 experiments prove the effectiveness of MTM.**
- MTM ⟺ the formation of $CaCO_3$ particles in the bulk of scaling solution, instead of precipitating on the internal surface, ⟺ particles are carried away by the **water flow**.
- The homogenous nucleation **increased** in the presence of MTM, resulting in the formation of crystals that are greater in numbers with smaller sizes.

- **pH, conductivity, salt passages, chemical compositions** are not suitable tools for evaluating efficiency MTM.
- Similar evaluating tools were used by many other researchers also yielded a **negative result.**
- A new research was proposed to test the MTM in retarding scaling of CaCO3 through increasing the retention time (suitable tool as recomm. LS)
- Retention time = maximum time where MTM can keep the particles of CaCO3 suspended instead of precipitation
- $Ca^{2+} + 2\ HCO_3^{-1}$ ---------- $CaCO_3 + H_2O + CO_2$

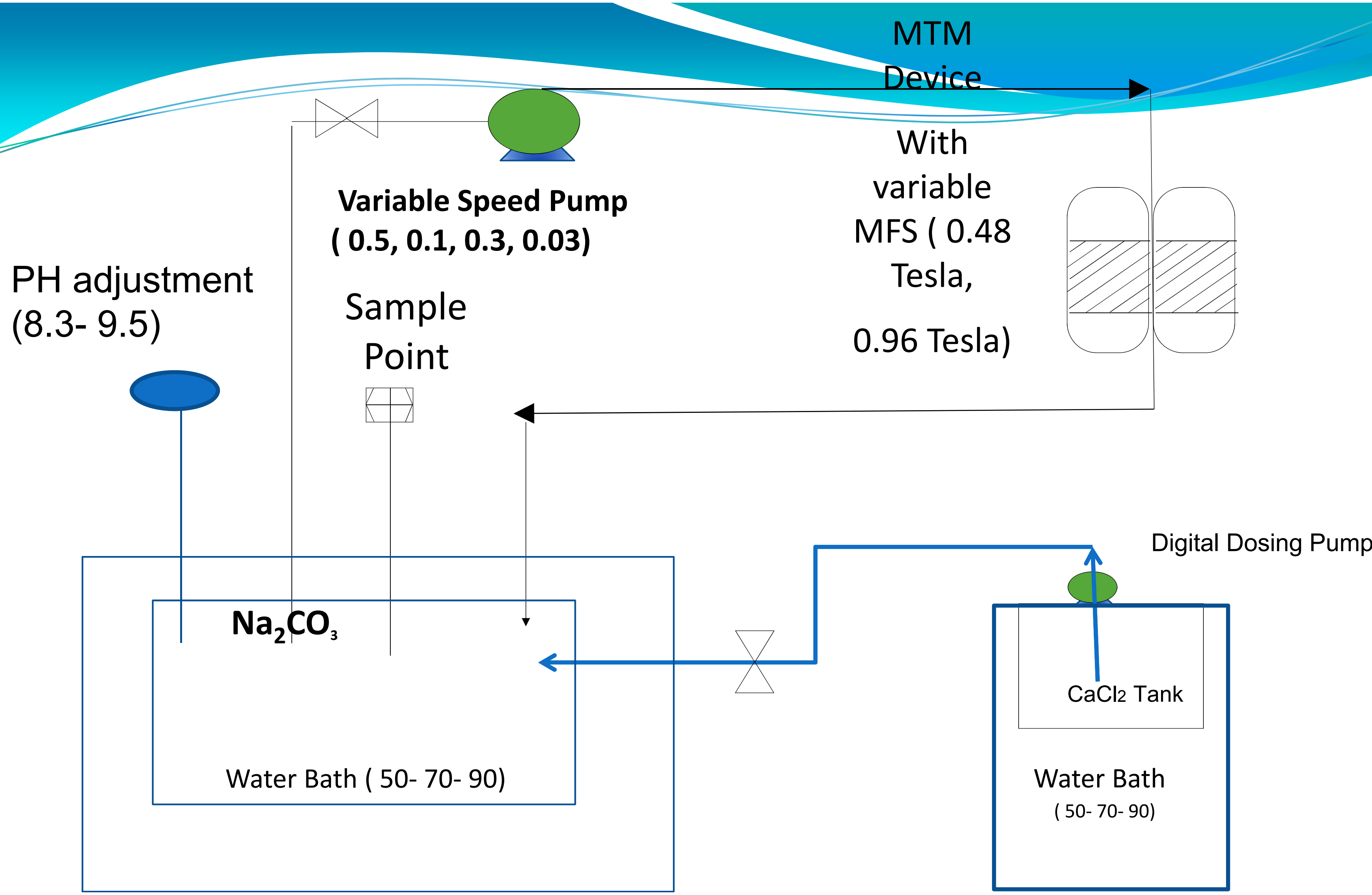

Fig. 3 schematic diagram of the test unit (C).

Methodology

- Two tanks / water bath /digital dosing pump/ variable speed pump/ sensors/valves.
- $CaCO_3$ scaling solution ($CaCO_3$) was prepared by mixing 0.5 M of $CaCl_2$ and 0.5 M of Na_2CO_3.
- Control (PH- Temp- flow V- MFS)
- Base solution was circulated through MTM to be **magnetically treated** without mixing with $CaCl_2$ solution.
- Mixing time = zero time for scale formation/ sampling / HCO_3^-, analyzed /to test the effectiveness of MTM.

Effect of MTM on the Retention Time of $CaCO_3$

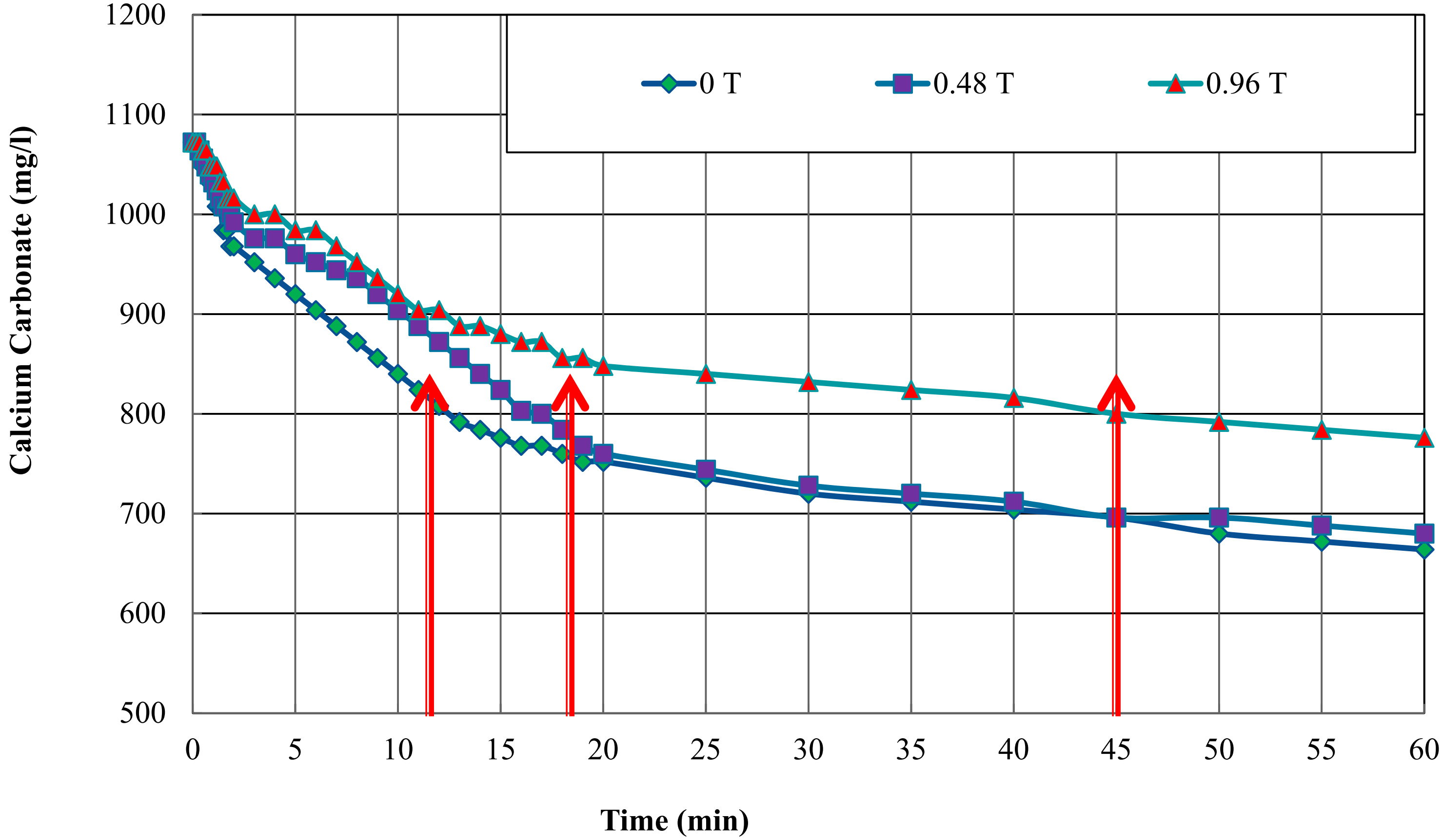

Fig. 4. Calcium carbonate concentration at 0.5 m/s velocity, pH 8.3 and 50°C at different MFS

Effect of flow velocity on MTM performance

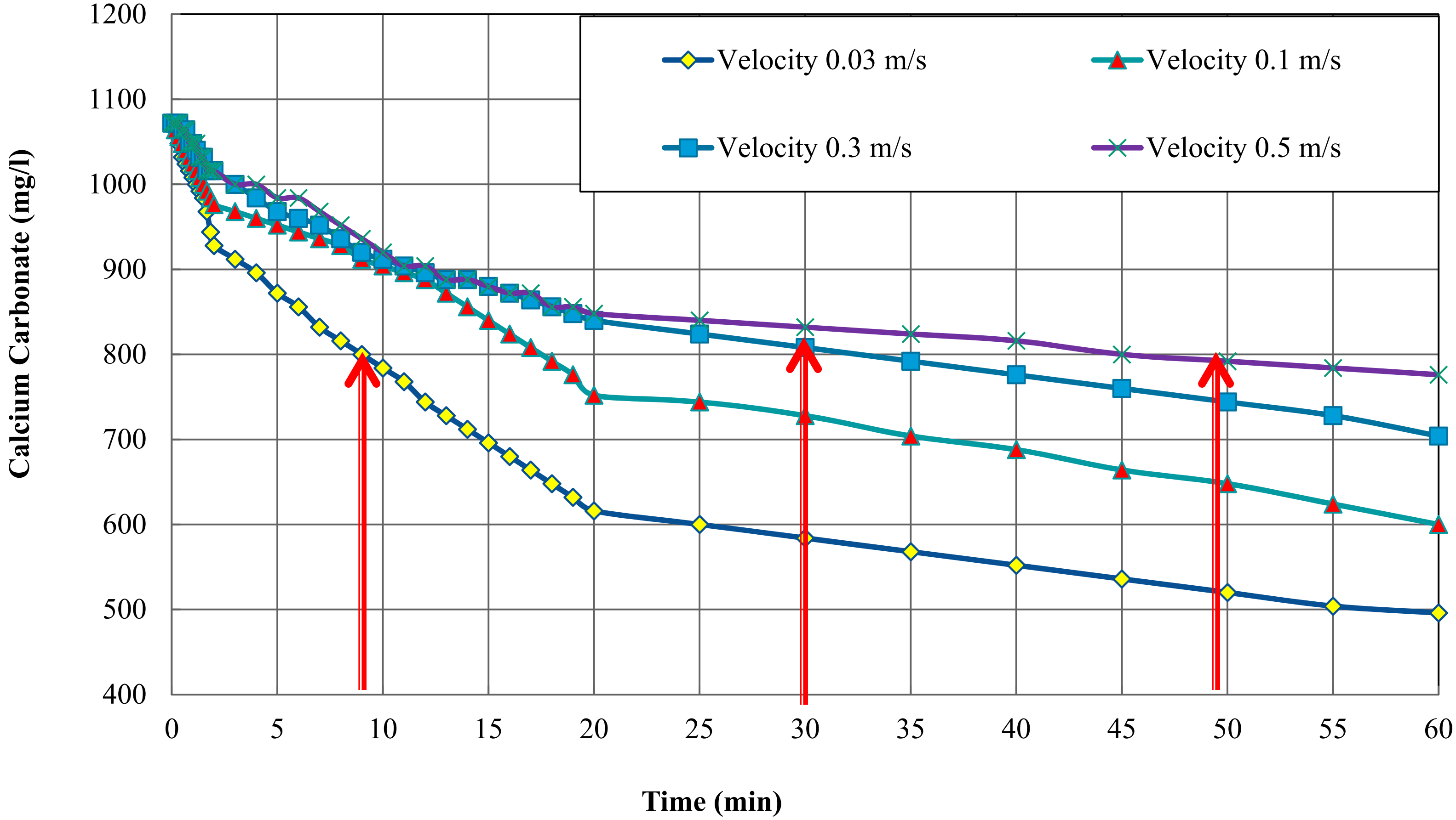

Fig. 5. Calcium carbonate concentration at pH 8.3, 50°C, and 0.96 T magnetic fields at different velocities.

Effect of Temperature on Performance of MTM

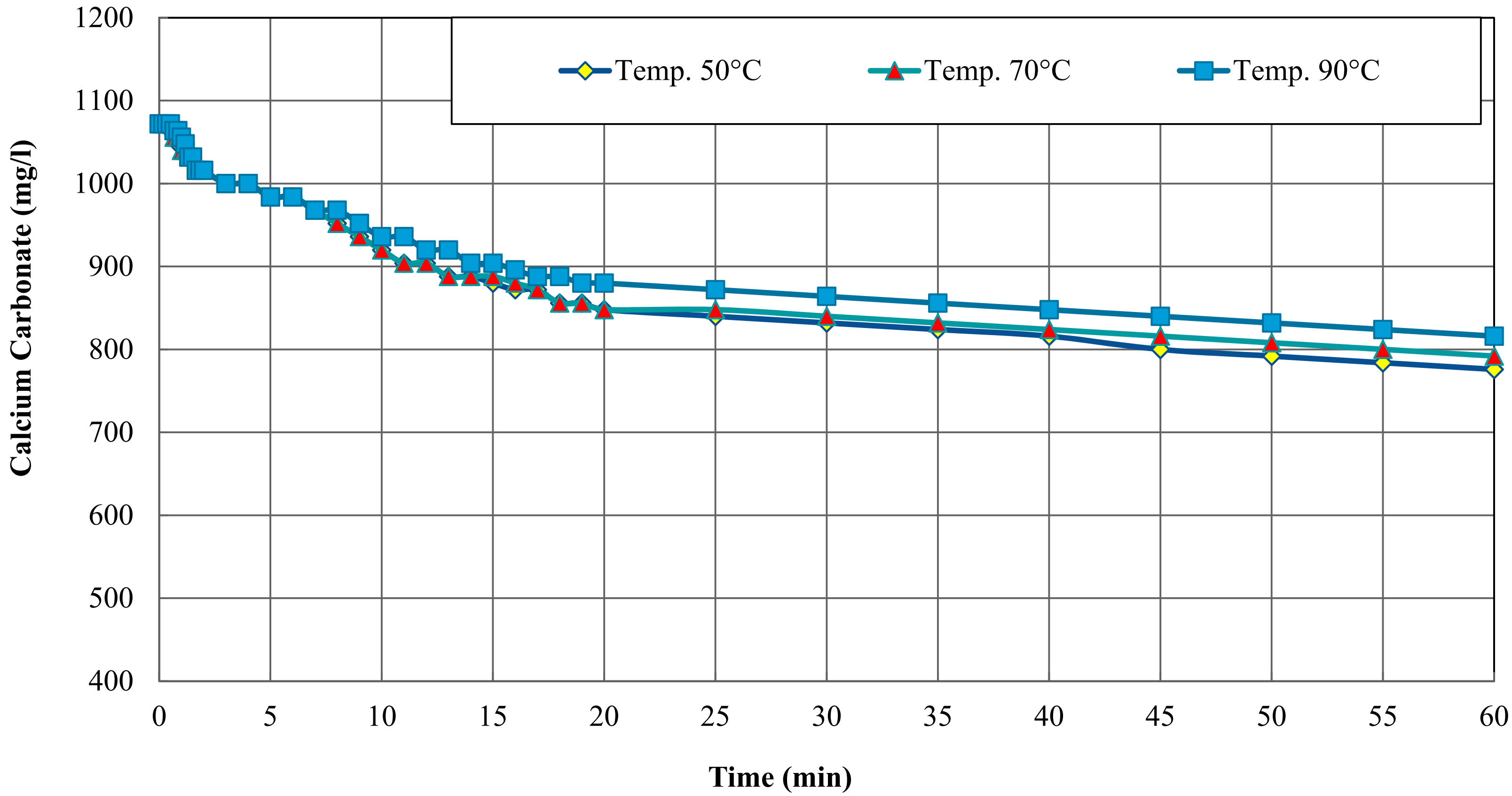

Fig. 6. Calcium carbonate concentration at 0.5 m/s velocity, pH 8.3, and 0.96 T MFS at different temperatures.

Effect of Feed PH on the Performance of MTM

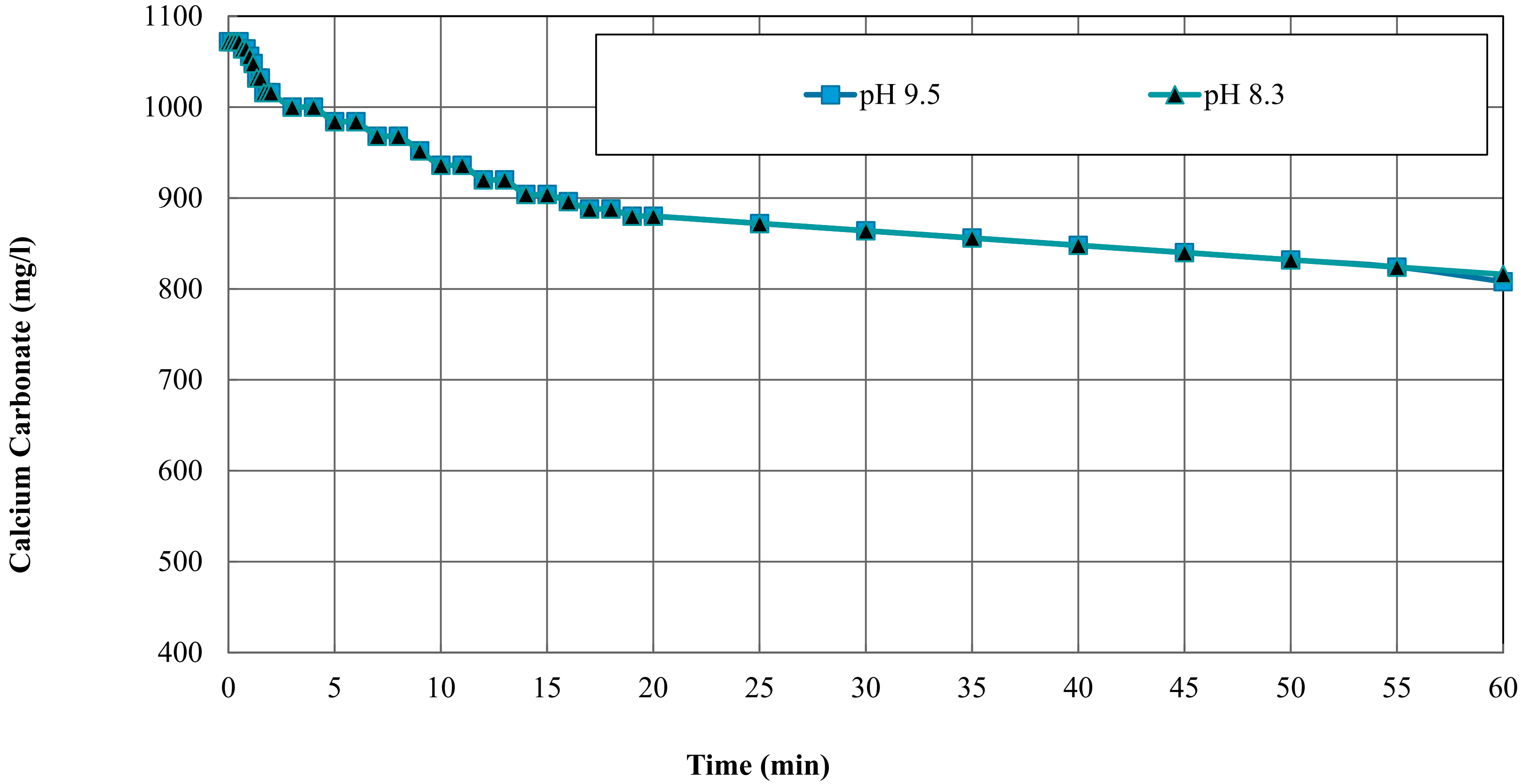

Fig. 7. Calcium carbonate concentration at 0.5 m/s velocity, 70°C, and 0.96 T MFS and different pHs.

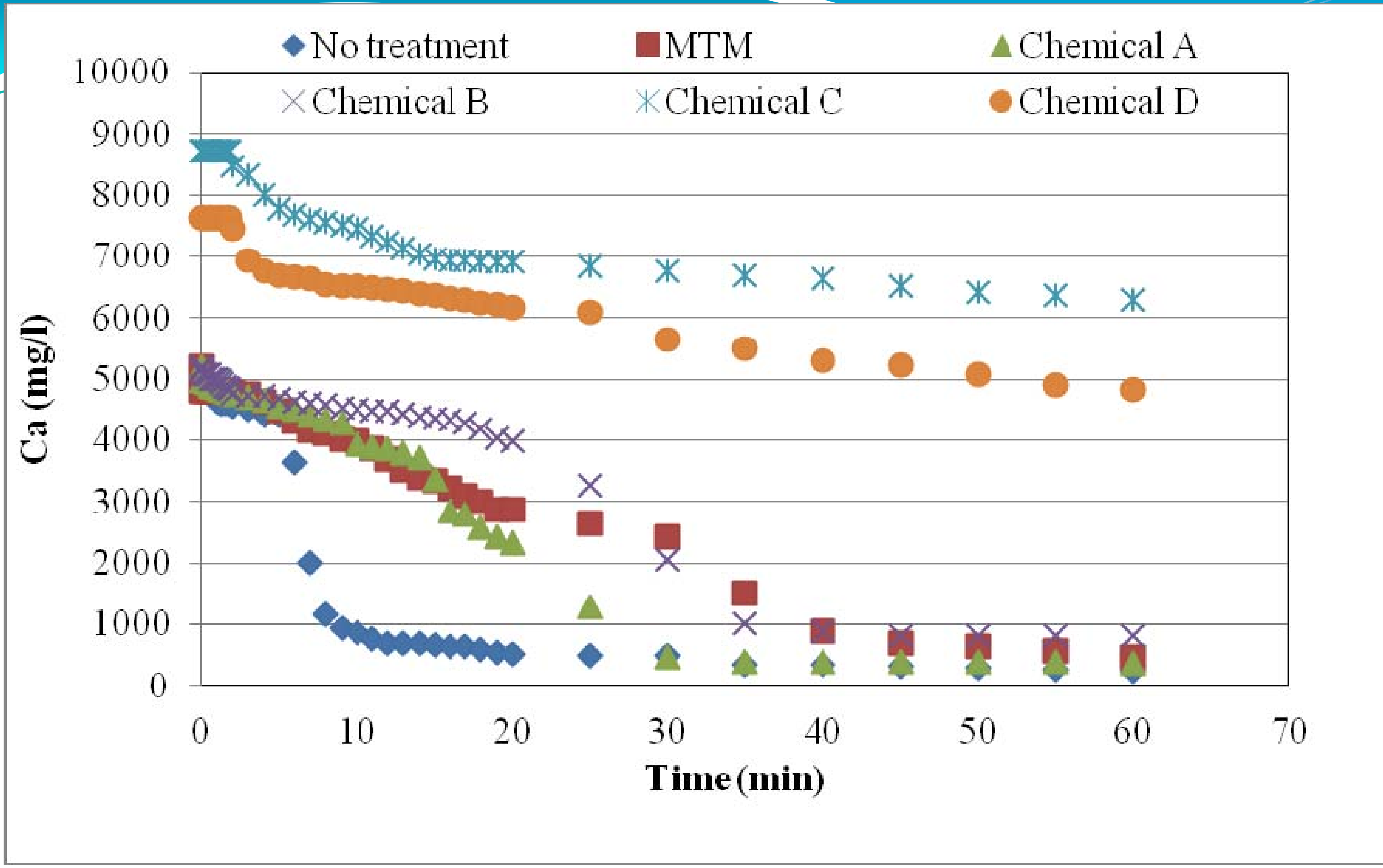

Fig. 8. The performance of 5 ppm of different antiscalants compared to the MTM in retarding $CaCO_3$ at ambient temperature.

Conclusion & Recommendations

The performance of MTM in retarding calcium carbonate depend on(**flow V, T , MFS).**

- The **effectiv. MTM** **increased** as **MFS** **increased**.
- MTM **Increased** RT of $CaCO_3$ scaling at Conc. above 800 mg/s, V 0.5 m/s, MFS 0.96T by **three-fold** (10 to 50 min).
- As the **Temp.** Increased as the **RT of $CaCO_3$** **increased** when the **temp. slightly increased** (not too much effective).
- The **PH** of Feed water has no effect on PR MTM.
- The **flow velocity** is the **key parameter** of the PR. MTM in increasing the RT of $CaCO_3$.