

**UNIVERSITI TEKNOLOGI MARA**

**STORMWATER PURIFICATION VIA  
PROGRESSIVE FREEZE  
CONCENTRATION: EFFECT OF  
INITIAL CONCENTRATION AND  
STIRRING SPEED**

**AIMAN BIN SHAHARULLAH**

Thesis submitted in fulfillment of the requirements needed for the degree of  
**Bachelor of Engineering (Hons) Chemical**

**Faculty of Chemical Engineering**

January 2019

## **ABSTRACT**

Water is one of basic needs and is essential for every living organism on Earth to survive. With increasing population, water has become scarce resource since the water demand is more than water supply. There are several methods to treat water such as evaporation, membrane processes and ultraviolet disinfection. However, these methods have limitations. Thus, researches have to find alternative ways, and this leads to the development of progressive freeze concentration (PFC) process. In this study, stormwater is chosen as alternative resource of water. By treating stormwater, not only water can be purified, but also water pollution can be prevented. This research aims to study the effect of initial concentration and stirring speed in stormwater purification via PFC towards effective partition constant (K) value, solute recovery (Y) and concentration efficiency. The range of initial concentration and stirring speed were determined at 2, 4, 6, 8 and 10 ppm and 150, 200, 250, 300 and 350 rpm. Simulated stormwater was created by using zinc chloride instead of actual stormwater to ease the process. Each effect was run at constant coolant temperature and time, -8 °C and 15 minutes. The results show at lowest initial concentration, the lowest K value was obtained with 0.25 and the highest Y value of 0.686. It was found that at stirring speed of 350 rpm produced lowest K value, 0.2305 and utmost value of Y, 0.85. Best efficiency of PFC system was achieved at 2 ppm initial concentration which is 75% and 350 rpm stirring speed which is 76.95%.

## **ACKNOWLEDGEMENT**

First of all, I wish to thank Allah S.W.T for giving me the opportunity to embark on my Degree and for completing this challenging journey successfully. My gratitude and thanks go to my supervisor Dr. Farah Hanim Ab Hamid for the endless support, patience and ideas in assisting me with this project. I also would like to express my thanks to lab assistants from Faculty of Chemical Engineering of UiTM Shah Alam. Special thanks to Nurul Nazifa Bt Iskandar and my colleagues for helping me with this project. Finally, this thesis is dedicated to my very dear father and mother for the vision and determination to give me education. Alhamdulillah.

# TABLE OF CONTENTS

	Page
<b>PLAGIARISM DECLARATION.....</b>	<b>ii</b>
<b>AUTHOR’S DECLARATION.....</b>	<b>iii</b>
<b>SUPERVISOR’S CERTIFICATION.....</b>	<b>iii</b>
<b>ABSTRACT .....</b>	<b>v</b>
<b>ACKNOWLEDGEMENT .....</b>	<b>vi</b>
<b>LIST OF FIGURES .....</b>	<b>x</b>
<b>LIST OF TABLES .....</b>	<b>xi</b>
<b>CHAPTER ONE: INTRODUCTION .....</b>	<b>1</b>
<b>1.1 Research Background.....</b>	<b>1</b>
<b>1.2 Problem Statement.....</b>	<b>2</b>
<b>1.3 Objectives.....</b>	<b>3</b>
<b>1.4 Scope of Research.....</b>	<b>3</b>
<b>CHAPTER TWO: LITERATURE REVIEW .....</b>	<b>5</b>
<b>2.1 SOURCE OF WATER TREATMENT PLANT .....</b>	<b>5</b>
<b>2.1.1 Surface Water.....</b>	<b>5</b>
<b>2.1.2 Groundwater .....</b>	<b>6</b>
<b>2.2 STORMWATER.....</b>	<b>7</b>
<b>2.2.1 Components in Stormwater .....</b>	<b>8</b>
<b>2.3 WATER TREATMENT PROCESS .....</b>	<b>9</b>
<b>2.3.1 Evaporation .....</b>	<b>9</b>
<b>2.3.2 Membrane Processes.....</b>	<b>11</b>
<b>2.3.3 Ultraviolet Disinfection.....</b>	<b>13</b>
<b>2.4 ZINC CHLORIDE .....</b>	<b>14</b>
<b>2.5 FREEZE CONCENTRATION.....</b>	<b>15</b>
<b>2.5.1 Suspension Freeze Concentration.....</b>	<b>16</b>
<b>2.5.2 Block Freeze Concentration .....</b>	<b>17</b>
<b>2.5.3 Progressive Freeze Concentration .....</b>	<b>18</b>
<b>2.6 APPLICATION OF FREEZE CONCENTRATION PROCESS IN INDUSTRIES .....</b>	<b>19</b>
<b>2.6.1 Food Industry .....</b>	<b>19</b>

# **CHAPTER ONE**

## **INTRODUCTION**

### **1.1 Research Background**

Water is one of basic needs and is essential for every living organism on Earth to survive. For example, plants need water to carry out photosynthesis process, animals and humans to carry out cell activity. For good health, we need a safe, reliable, affordable and easily accessible water supply. However, Hunter et al., (2010) stated that about a billion people in developing countries have not had a safe and sustainable water supply for several decades. Although our world consists of 71 % of water, not all of them are good for consumption. In fact, a study conducted by Leusbrock (2011) stated that fresh water is only 2.53 % of the total amount of water. Among 2.53 % of the fresh water, 68.7 % is located in the glaciers of Antarctica, Greenland and Arctica, 30.7 % are groundwater and the remaining two percent are surface water, ground ice in permafrost zones and air humidity. This statistic has led to the growth of water treatment plant all around the world so that water scarcity can be prevented and provide clean water supply for everyone.

Malaysia is blessed with abundance rainfall per year, 97 % are surface water and 3 % are groundwater. In 2015, Malaysia Kini newspaper stated that even though this country is rich with water resources, Malaysia's water consumption is unsustainable and in 2014, the average water consumption per day of Malaysians was 212 litres which is 2 litres more than previous year 2013. This indicates that the consumption is still far beyond the recommended water usage by the World Health Organization (WHO). The WHO recommended 165 litres per day for Malaysians (Abdullah, 2015). To prevent occurrence of water shortage in Malaysia, researchers need to find a new way to recover the water consumption.

There are many types of water treatment plant with different processes. Usually these water treatment plants use raw water from rivers, lakes, oceans and groundwater and physically and chemically purify the water. Common processes that have been used in industry right now are reverse osmosis, evaporation and membrane process.