PHYTOREMEDIATION OF HEAVY METALS AND DESALINATION OF BRACKISH WATER WITH *IPOMOEA AQUATICA* USING AQUAPONICS SYSTEM

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Bachelor of Applied Science (Hons) Industrial Biotechnology

UNIVERSITI MALAYSIA PAHANG

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Honours.) in Industrial Biotechnology.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_____

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ABSTRACT

This study presents the phytoremediation and desalination of heavy metals in brackish water with *Ipomoea aquatica* in an aquaponics systems. The study of phytoremediation by *Ipomoea aquatica* in saline condition had not been study extensively. *Ipomoea aquatica* was separated into roots and shoots and the scales of tilapia fish was harvested at Day-0 and Day-30 from two aquaponics tanks. The purpose for this research was to investigate the phytoremediation and desalination capability of *Ipomoea aquatic*. Synthetic saline water and field water collected from Kuantan Estuary were sent for ICP-MS analysis at Day-0 and Day-30 to determine the concentration of 22 types of metal elements contained. The field water sampled from Kuantan Estuary showed a decrease in Na, Mg, K and Ca from Day-0 to Day-30. This indicated that *Ipomoea aquatica* was able to uptake major constituents that contributes to the salinity and has potential in desalination. Na was decreased to 4692.0 ppm from 14070.0 ppm, showing a percentage of 66.65%. Mg had reduced as much of 77.47%, from 1630.0 ppm to 367.2 ppm. K had a reduction rate of 64%, depleting from 446.0 ppm to 159.0 ppm while Ca had a reduction rate of 68.54% when the initial concentration of 486.7 ppm had plunged to 153.1 ppm at Day-30. Cr decreased 33.33%, from 84.0 ppb to 56.0 ppb. There was a total of 12 samples and the samples were subjected to wet digestion. The samples were then analyzed for its Mg content. The samples generally showed an increase in Mg concentration from Day-0 to Day-30. The parameters of water from both tanks including pH, DO, EC, TDS, salinity and temperature were taken as background data throughout the commence of experiment. Conductivity, total dissolved solids and salinity reduced from Day-0 till Day-35 in both tanks as the metal ions were being absorbed by plant biomass and fish scales. In conclusion, the built aquaponics systems were able to phytoremediate heavy metal-contaminated field water by translocating the pollutants within the tissues of *Ipomoea aquatica* and the scales of tilapia.

ABSTRAK

Kajian ini membentangkan *phytoremediation* dan penyahgaraman logam berat dalam air payau dengan *Ipomoea aquatica* menggunakan sistem aquaponics. Kajian *phytoremediation* menggunakan *Ipomoea aquatica* dalam keadaan limpahan belum dikaji secara mendalam. Tujuan kajian ini adalah untuk menyiasat keupayaan *phytoremediation* dan penyahgaraman tumbuhan tesebut. Air limpahan sintetik dan sampel air dari muara Kuantan telah dihantar untuk analisis ICP-MS pada hari-0 dan hari-30 untuk menentukan konsentrasi 22 jenis unsur-unsur logam yang terkandung. Sampel air dari muara Kuantan menunjukkan penurunan dalam Na, K, Mg dan Ca daripada hari-0 hingga 30 hari. Ini menunjukkan bahawa *Ipomoea aquatica* adalah mampu untuk mwnyerap juzuk utama yang menyumbang kepada kemasinan dan mempunyai potensi penyahgaraman. Na telah menurun daripada 4692.0 ppm dari 14070.0 ppm, menunjukkan peratusan sebanyak 66.65%. Mg telah berkurangan sebanyak mungkin ini merupakan 77.47%, daripada 1630.0 ppm kepada 367.2 ppm. K memiliki kadar pengurangan sebanyak 64%, berkurangan dari 446.0 ppm kepada ppm 159.0 manakala Ca memiliki kadar pengurangan sebanyak 68.54% apabila konsentrasi awal 486.7 ppm telah menjunam ke 153.1 ppm pada hari-30. CR menurun 33.33%, daripada 84.0 ppb untuk 56.0 ppb. *Ipomoea aquatica* telah dipisahkan kepada akar dan pucuk dan sisik ikan tilapia adalah dikumpulkan pada hari-0 dan hari-30 dari dua tangka aquaponics. Terdapat sejumlah 12 sampel dan sampel tersebut diprocess melalui cara *wet digestion*. Sampel kemudiannya dianalisis untuk kandungannya Mg. Sampel secara amnya menunjukkan peningkatan pada konsentrasi Mg dari hari-0 hingga 30 hari. Ia didapati bahawa antara sisik ikan, akar dan pucuk, sisik ikan menunjukkan bacaan konsentrasi tertinggi Mg dalam kedua-dua sistem pada hari-0 dan hari-30. Pucuk mengandungi konsentrasi yang lebih tinggi Mg manakala akar mempaparkan bacaan terendah. Parameter air dari kedua-dua sistem termasuk pH, kelarutan oksigen, kekonduksian elektrik, jumlah pepejal terlarut, kadar kemasinan dan suhu diambil sebagai data latar belakang sepanjang eksperimen. Kekonduksian, jumlah terlarut pepejal dan kemasinan berkurangan dari hari-0 hingga hari-35 dalam kedua-dua sistem kerana logam telah diserap oleh *Ipomoea aquatica* dan sisik ikan tilapia.

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LIST OF SYMBOLS

m	milli
g	gram
L	litre
µ	micro
S	siemens
N	number of samples

LIST OF ABBREVIATIONS

Be	Berylium
Na	Sodium
Mg	Magnesium
Al	Aluminum
K	Potassium
Ca	Calcium
V	Vanadium
Cr	Chromium
Mn	Manganese
Fe	Iron
Co	Cobalt
Ni	Nickel
Cu	Copper
Zn	Zinc
As	Arsenic
Se	Selynium
Mo	Molybdenum
Ag	Silver
Cd	Cadmium
Sb	Antimony
Ba	Barium
Pb	Lead
Cs	Cesium

U	Uranium
Sr	Strontium
Hg	Mercury
TPC	Total petroleum hydrocarbon
PCB	Polychlorinated biphenyls
PCP	pentachlorophenols
Fl	Floride
Cl	Chloride
NO_3	Nitrate
SO_4	Sulphate
AAS	Atomic Absorption Spectrometry
ICP-MS	Inductively coupled plasma mass spectrometry
SE	Standard error
SD	Standard deviation
ppm	parts per million
ppb	parts per billion
DO	Dissolved oxygen
EC	Electrical conductivity
TDS	Total dissolved solids

CHAPTER 1

INTRODUCTION

This research was conducted to study the use of *Ipomoea aquatica*, an aquatic plant, to remove magnesium, a type of heavy metals in brackish water via phytoremediation means using an aquaponics system. Fish scales of the tilapia in the aquaculture tank would be the secondary subject studied for its properties to accumulate the stated metal element. This chapter briefly explained the background of this research, problem statements, research objectives and the scope of study.

1.1 RESEARCH BACKGROUND

Industrialization has modernized and improved the living style of mankind by exploiting the natural resources that are available on earth's crust. However, this rapid development process resulted in massive waste production which contained organic and inorganic pollutants that were hard to remove or degrade. Soil and water, two of the fundamental resources required to sustain aquatic and terrestrial life, had been contaminated by these waste. Researchers had been conducting extensive studies to remove these toxic pollutants via one of the bioremediation means, which was phytoremediation. This recent technology was non-intrusive. The eco-friendly properties had contributed to the reason phytoremediation had been gaining public acceptance.

Phytoremediation technique using aquaponics system to remove heavy metals had not been studied extensively. It could be scaled up accordingly. The principle of phytoremediation involved the cleaning up contaminated site, could be soil or water, using plants to remove, immobilize, sequester, accumulate or biodegrade the pollutants

(Kiraly, 2003). Aquaponics system was the combination of hydroponics, the farming of plants in water without the need of soil, and aquaculture which reared aquatic animals in tanks. The combination of these two systems created a symbiotic environment to produce fish and plants in an enclosed system.

During phytoremediation application, the contaminated site was first located and identified as the area of study. Sample collection, or biomass harvesting, was done on site by analyzing the potential heavy metal bioaccumulators. These bioaccumulators possessed the traits to grow under harsh conditions, especially when the surrounding environment was polluted by toxic waste, and these plants were able to uptake certain amount of heavy metals. The harvested biomass was sent for lab analysis to determine the concentration of heavy metals accumulated within the plants.

There had been a research that studies the phytoremediation of freshwater crayfish culture wastewater using spinach in aquaponics system (Hefni Effendi, 2015). The waste water contained in the aquaculture tank contained high amount of nitrogen and phosphorus due to the excretion from crayfish. The integrated aquaponics system with phytoremediation technology was capable in removing excess nitrogen and phosphorus by utilizing it as a source of nutrient for the growth of spinach, *Ipomoea aquatic*. However, the availability of studies regarding heavy metal removal in saline condition, or brackish water using phytoremediation technology integrated with aquaponics system had yet to be studied extensively.

The effects of anthropogenic pollution had taken a toll to the aquatic ecosystem as well. Public concerns had been growing as aquatic life was one of the most important source of protein, minerals, trace elements and vitamin contents. As heavy metals were constantly released from man-made activities into the aquatic environment, our food source had been contaminated with these toxic as research had shown that heavy metals accumulate in the tissues of edible fish (Alturiqi and Albedair, 2012). The high level of toxic heavy metals found in the tissues of fish endangers human health as human is the last consumer in the food chain.

1.2 PROBLEM STATEMENT

Phytoremediation in brackish water was lacking in research. Hence for this research, *Ipomoea aquatica*, or better known as water spinach or *kangkung* by Malaysians was used to study the efficiency of heavy metals removal in brackish water collected from Kuantan Estuary. The roots and shoots of *Ipomoea aquatica* and the scales of tilapia were determined for its concentration of magnesium.

The aquaponics system with *Ipomoea aquatica* had the potential to desalinate the brackish water. The outcome of this experiment provided insights for the future as solutions to reduce salinity of contaminated water supply in terrestrial area. This desalination technology integrated with aquaponics system was cost-effective and eco-friendly.

The outcome of the research served as an evidence to prove practicality of a floatable farming system in field application for phytoremediation purpose.

1.3 RESEARCH OBJECTIVES

I. To evaluate quantitatively the phytoremediation capability of the system in reducing pollutants from the collected water sample.
II. To investigate the uptake of magnesium by *Ipomoea aquatic* and fish scales of tilapia growing in a recirculating system with brackish water.
III. To evaluate the desalination property by observing the changes of Na^{+}, Mg^{2+}, K^{+} and Ca^{2+}, which are the components that contribute to salinity.

1.4 SCOPE OF STUDY

This research project mainly studied the uptake of magnesium in contaminated brackish water by *Ipomoea aquatica*. The phytoremediation strategy was integrated with aquaponics system, which involved the combination of a hydroponic technology and a traditional aquaculture. The effluent from the fish tank containing fish excretion served as a nutrient source to sustain vegetative growth in the hydroponic grow bed located above. The brackish water sampled from Kuantan Estuary which believed to contained

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