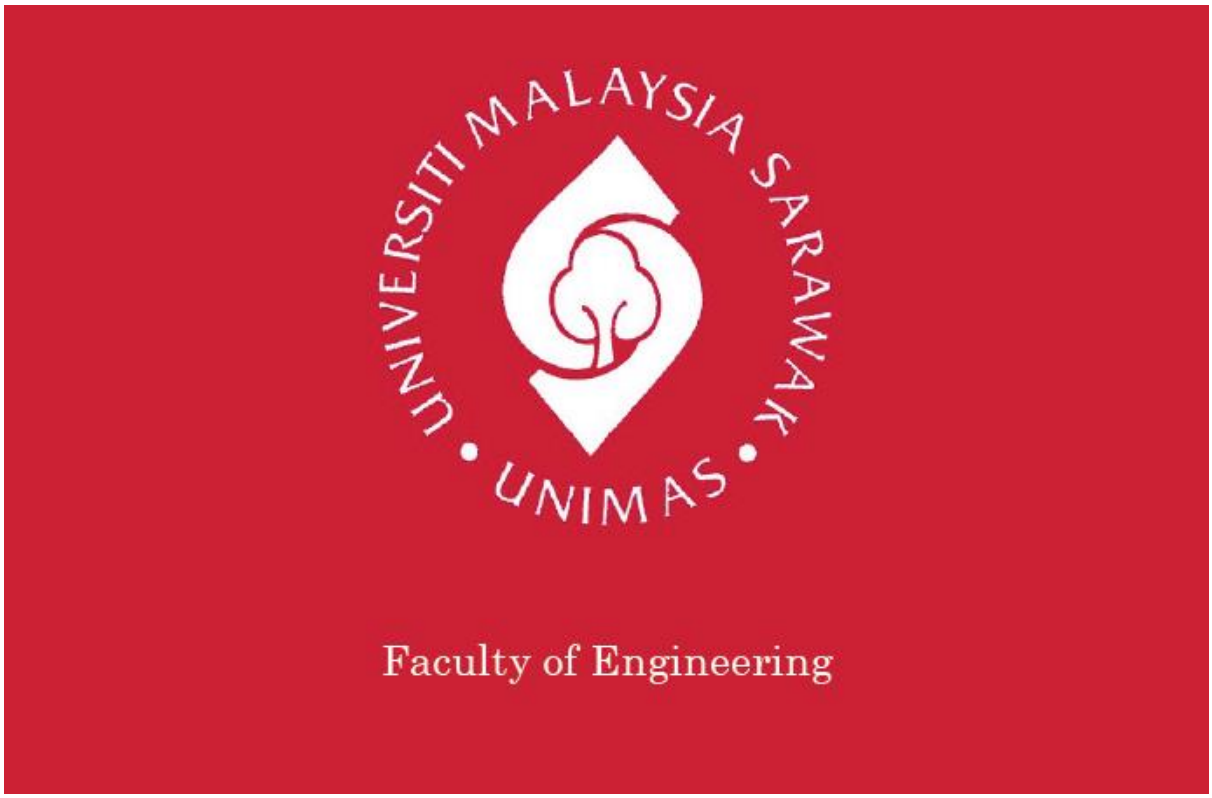

DEVELOPMENT OF SOLAR POWER SYSTEM FOR SARAWAK PEAT WATER CONTINUOUS ELECTROCOAGULATION TREATMENT PROCESS

ADARSH PHILIP

Bachelor of Engineering (Hons)

Electrical and Electronic Engineering

2019

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please Tick (√)

Final Year Project Report	√
Masters	
PhD	

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_____

DR. NAZERI ABDUL RAHMAN
(Supervisor)

12 June 2019
Date

DEVELOPMENT OF SOLAR POWER SYSTEM FOR SARAWAK PEAT WATER CONTINUOUS ELECTROCOAGULATION PROCESS

ADARSH PHILIP

A dissertation submitted in partial fulfilment
of the requirement for the degree of
Bachelor of Engineering (Hons)
Electrical and Electronic Engineering

Faculty of Engineering,
University Malaysia Sarawak

2019

Pala amai dahawa enai kui aleng ek nyalam lan aleng paen pehitok maei dahok tengayet dahin petangen akui tek alem urip kui

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ABSTRAK

Sarawak ialah negeri terbesar di Malaysia yang terdiri daripada penduduk yang bertumpu di kawasan bandar tetapi bertaburan di kawasan luar bandar . Air bersih penting tetapi di beberapa kawasan bekalan sumber air bersih tidak mencukupi di kawasan pedalaman. Bekalan air luar bandar alternatif (Sawas) Sarawak adalah program alternatif dari kerajaan negeri dengan tujuan menyediakan air yang selamat dan bersih ke kawasan luar bandar. Kajian ini terbahagi kepada tiga peringkat. Pada peringkat pertama, kajian ini akan mengkaji kebolehan menggunakan kuasa solar untuk proses elektrokoagulasi untuk rawatan air. Ini termasuk penyiasatan mengenai proses asas elektrokoagulasi serta pelbagai sumber tenaga yang mungkin untuk proses tersebut. Tahap kedua kajian ini akan merancang sistem tenaga suria untuk menyokong proses rawatan air gambut untuk sistem elektrokoagulasi yang sudah dikenalpasti. Ini merangkumi reka bentuk dan fabrikasi sistem kuasa suria berskala kecil untuk sistem yang disebutkan sedemikian. Untuk peringkat ketiga kajian ini, beberapa simulasi dan kajian eksperimen dijalankan pada sistem yang direka untuk menentukan parameter yang optimum untuk sistem. Akhir sekali, projek ini dijangka dapat membangunkan sistem tenaga solar yang sesuai dan boleh ditambah dengan sistem elektrokoagulasi air gambut yang dikenal pasti untuk sistem rawatan air mandiri.

Kata Kunci: Elektrokoagulasi, Sistem Kuasa Solar, Air Gambut, Sistem Rawatan Air

ABSTRACT

Sarawak is the biggest state in Malaysia of which comprising population concentrated in urban area but very scattered in rural area. Clean water is essential but in some area the water supply is inadequate in rural area. Sarawak alternative rural water supply (Sawas) is an alternative programme from the state government to purpose of provide safe and clean water to rural areas. The main aim of this study is to design a solar power system to support Sarawak peat water continuous electrocoagulation treatment process. The study is divided into three stages. In the first stage, the study investigates the viability of utilizing solar power to power the electrocoagulation process for water treatment. This includes investigation on the electrocoagulation fundamental process as well as various possible sources of energy for the process. The second stage of the study is to design a solar power system to support the treatment process of peat water for an identified electrocoagulation system. This includes designing and fabrication of a small-scale solar power system for such mentioned system. For the third stage of this study, some simulation and experimental studies are conducted on the designed system in order to determine the optimum parameters for systems. Lastly, this project is expected to develop a suitable solar power system with can be coupled with an identified peat water electrocoagulation system for a standalone water treatment system.

Keywords: Electrocoagulation, Solar Power System, Peat Water, Water Treatment

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ABBREVIATIONS

AC	Alternating Current
BP-S	Bipolar-Series
CEO	Chief Executive Officer
COD	Chemical Oxygen Demand
DC	Direct Current
EC	Electrical Energy Consumption
EEC	Electrical Energy Consumption
EDI	Electrochemical Degradation Index
EMC	Electrode Material Consumption
HRES	Hybrid Renewable Energy Consumption
iHOGA	Improved Hybrid Optimization by Genetic Algorithm
ICE	Instantaneous Current Efficiency
MBIPV	Market Development Malaysia Building Integrated Photovoltaic
MP-P	Monopolar-Parallel
MPPT	Maximum Power Point Tracking
MP-S	Monopolar-Series
NC	Normally Closed
OGPV	Off-Grid Photovoltaic
PTM	Malaysia Energy Centre
PV	Photovoltaic
PWM	Pulse Width Modulation
RE	Renewable Energy
SARES	Sarawak Alternative Rural Electrification
SAWAS	Sarawak Alternative Rural Water Supply
SEB	Sarawak Energy Berhad
SEC	Specific Energy Consumption
SEEC	Specific Electrical Energy Consumption
TDH	Total Dynamic Head
TOC	Total of Organic Carbon
TS	Total Solid

WHO	World Health Organisation
WT	Wind Turbine

NOMENCLATURE

A	Ampere
dm^3	Cubic Decimetre
dm^3h^{-1}	Cubic Decimetre Per Hour
F	Faraday's Constant (96485 C/mol)
g	Gram
g/cm^3	Gram per Cubic Metre
g/mol	Molecular Weight of Metal
ha	Hectare
j	Joules
kg/m^3	Kilo Gram per Cubic Metre
km	Kilometre
kWh	Kilowatt hour
kWh/m^3	Kilowatt hour per Cubic Metre
L	Litre
Mj	Mega Joule
OC	Operating Cost (RM/m^3)
P.M.	Post Meridien (after noon)
Q	Volume
S	Second
sq.m	square.metre
T	Time
τ	Residence Time
%	Percentage

CHAPTER 1
INTRODUCTION

1.1 Domestic Water

Domestic water is the supply of clean water for activities in household activities. In Malaysia, only 3% of the domestic water supply sources is derived from groundwater while 97% is from the surface water [1]. Indoor usage and outdoor usage are two of the classified main usages of domestic water. For indoor usage, water is used for drinking, showering, cooking and washing dishes as well as clothes. While for outside purposes, water is utilized for watering plants, cleaning drain and washing car. The percentage of consumption of water can be arranged into eight primary classes [2]. **Table 1.1** depicts the typical household water used in the residential area.

Table 1.1 Typical Household Water Usage [2]

Type of Water Usage	Percentage (%)
Toilets	27
Shower	17
Faucet	16
Clothes Washer	22
Other domestics	2
Dishwasher	1
Baths	2
Leaks	13
Total	**100**

All social and economic endeavors need water as an important element in maintaining life. Abdullah [1] reported in *Malaysia Kini* that the consumption of water by Malaysians per day in 2013 was 210 liters L, and in 2014, the average water consumption raised to 212 L. This shows that malaysian water consumption exceed the recommendation of water consumption by World Health Organisation (WHO) which is 165 L daily.

1.2 Peat Water

Peat is the heterogeneous mixture of partially decomposed plant remains mostly in organic soil. sand, silt, and clay under damp and anaerobic condition. 13% of the Sarawak State's total land area is covered with peat which is approximately 1.7 million hectares, ha [3]. Some community in Sarawak is using peat water as their domestic water supply. In

Sarawak, Sibu division has the largest area covered with peat water in Sarawak [4]. **Figure 1.1** shows the distribution of peatland in Sarawak while **Table 1.2** shows the area covered by peatland in the division of Sarawak.

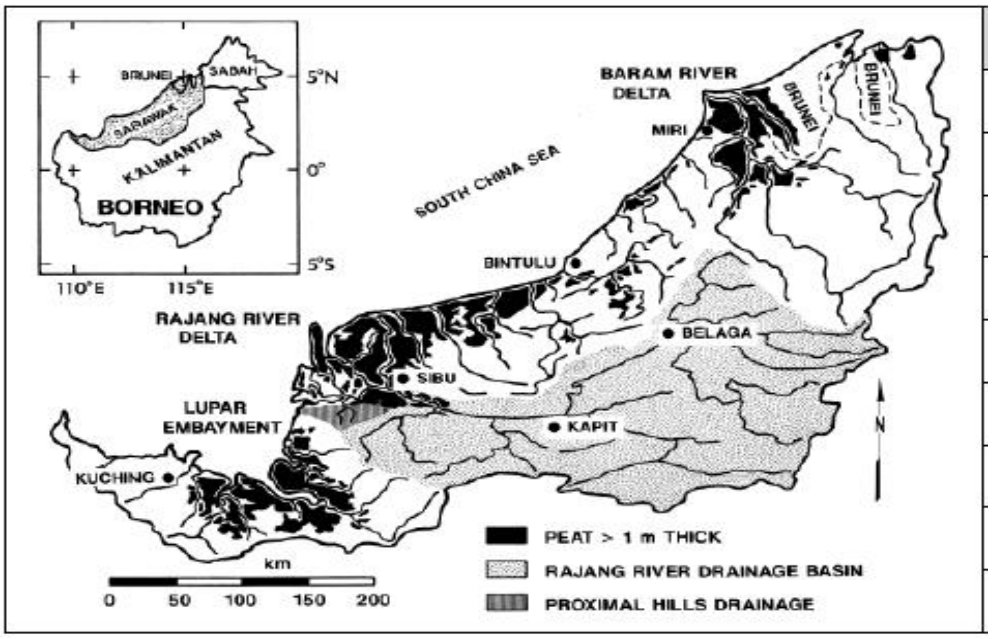

Figure 1.1 The distribution of peat in Sarawak [4]

The complex aromatic compound organic matter known as humic substances which constituent of at least 30% of total matter is a typical peat characteristic in Sarawak [5]. The peat water found in Sarawak is slightly acidic and colored because of the existent of these humic substances [6]. The peat water has a slight yellowish-brown color shading as depicted in **Figure 1.2**.

Table 1.2: Distribution of peat in Sarawak [3]

Division	Area (ha.)
Kuching	23, 059
Kota Samarahan	192, 775
Sri Aman	283, 076
Sibu	540, 800
Sarikei	169, 900
Bintulu	146, 121
Miri	276, 579
Limbang	25, 300
Total	**1, 657, 600**

1.3 Water Treatment System

Water treatment can be divided into a few classes which are chemical, biological and physical treatment. Each of these classes has its own purpose in removing various elements

for water treatment [7]. Chemical treatment is a process to treat water with the additions of chemicals. The production of chemical sludge contributes to environmental problems in which making the chemical process less preferable than the other processes [8]. A wide range of microorganism and bacteria are utilized in biological treatment in treating water making it different with chemical processes. One of the common biological treatments is activated sludge process [8].

Figure 1.2 Peat Water

The availability of dissolved oxygen in wastewater influences the type of biological processes as in the case of aerobic, anaerobic or facultative. Filtration, membrane and electrocoagulation are the common physical treatment. Electrocoagulation is a process to remove suspended solids, colloidal material, and metals as well as other dissolved solids from water and wastewaters by mean of introducing electricity process [9]. Electrocoagulation is an electrochemistry process for the removal of pollutants in water treatment. The description of different types of water treatment technologies is stated in **Table 1.3**.

Table 1.3: Types of Water Treatment Technologies [7]

Types	Description	Processes
Chemical	In order to purify the water, additional of chemicals are required to react with the targeted pollutants	Ion exchange, coagulation
Biological	By utilizing the microorganisms for contaminants degradation, the biological treatment processes mainly remove the organic contents and nutrients in wastewater.	Activated sludge, trickling filters
Physical	Additional chemicals are not used. Screening and filtering are the physical technique being relied solely on	Membrane filtration, electrocoagulation

1.4 Electrocoagulation Fundamental Process

Electrocoagulation is one of the well-known wastewater treatment technique which coagulates the sediments particles and ions by using electric current. The operating concept for electrocoagulation is based on coagulation, flotation and electrochemistry. By comparing to chemical coagulation, electrocoagulation is a more eco-friendly as this method does not require the adding of chemicals into the water. However, the capital and electricity cost of the operation is found to be impractically high for electrocoagulation system [7]

High absorption ability in electrocoagulation is an environmental-friendly process for treating wastewater with heavy metal (m) ions and toxic organics which is characterized by the in-situ generation of hydroxide flocs and coagulant [10]. The basic requirement for electrocoagulation process is dissolution of metal cations from the anode reactor with the simultaneous formation of hydroxyl ions and hydrogen gas at the cathode as shown in **Equation (1.1)** and **Equation (1.2)** [11].

Anode $: M \rightarrow M^{+} + ne^{-}$ **(1.1)**

Cathode $: 2H_2O(l) \rightarrow OH^{-} + H^{2}(g)$ **(1.2)**

1.5 Solar Power System

The location of Sarawak is on the north of the Equator which lies between 0° 50’ and 5°N latitude and longitude of 109° 36' and 115° 40' E. The state approximate total length is 800 km with an area covering 124,449.51 square kilometers along the northwest coast of Borneo [12]. Sarawak location of being near to the equator where the sun’s ray intensity is at its peak giving much more solar radiation than poles make its the strategic place for instalment of solar power system. According to Malaysia Energy Centre’s (PTM) technical adviser Tan Sri Vincent Tan, there was a lot of potential to develop solar power system in Sarawak where the sky is clearer in Southern Sarawak as it is nearer to the equator while the best time for solar harvesting is between 1 pm and 2 pm when the sun is at its peak [13, 14]. The measurement of solar power harvesting on a specified location is called solar irradiance. There are several factors to be considered on this solar irradiance as it varies throughout the year on different seasons depending on the position of the sun in the sky and the weather [15]. **Figure 1.3** shows an annual average solar radiation (Mj per sq. m) across Sarawak [16].