IMPLEMENTATION OF IoT ON WATER QUALITY IMPROVEMENT THROUGH A SUSTAINABLE DESIGN AT TASIK UTeM

This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Manufacturing Design) (Hons.)

by

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FACULTY OF MANUFACTURING ENGINEERING
2017

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: **IMPLEMENTATION OF IoT ON WATER QUALITY IMPROVEMENT THROUGH A SUSTAINABLE DESIGN AT TASIK UTeM**

Sesi Pengajian: **2017 Semester 2**

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I hereby, declared this report entitled "
Implementation of IoT On Water Quality Improvement Through a Sustainable Design At Tasik UTeM" is the result of my own research except as cited in references.

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Date : 20th JUNE 2017

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Manufacturing Design) (Hons). The members of the supervisory committee are as follow:

…….....

(Dr Suriati binti Akmal)

…….....

(Dr Saifudin Hafiz bin Yahaya)

ABSTRAK

Projek ini berkaitan dengan merekabentuk sebuah alat peningkatan kualiti air dengan menggunakan reka bentuk yang mampan yang akan diletakkan di Tasik Universiti Teknikal Malaysia Melaka (UTeM), Kampus Induk. Alat ini mampu meningkatkan tahap oksigen terlarut air tasik dengan menggunakan sumber semula jadi. Selain itu, alat ini juga mampu mengurangkan masa penyelidik untuk mengambil data air di tasik untuk menjalankan kajian dengan menggunakan IoT. Kajian ini telah dijalankan di Tasik B, UTeM di mana kaedah segmentasi telah diguna pakai untuk memulihara kualiti air di tasik ini. Kaedah ini digunakan disebabkan ciri fizikal di setiap segmen yang tidak sama dengan kawasan permukaan Tasik B yang seluas 48,076 m^2. Tasik B ini telah dibahagikan kepada 9 segmen dengan 10 data telah diambil daripada setiap segmen tersebut. Terdapat data yang diambil kira selepas penggunaan alat peningkatan kualiti air dan perbandingan dilakukan dengan data sebelumnya. Rekabentuk alat ini telah melibatkan beberapa konsep dengan menggunakan matriks pugh. Konsep yang terpilih di reka dengan menggunakan perisian Solidwork untuk memperolehi model pepejal. Bagi perlaksanaan IoT pula, ia bermula dengan lukisan gambarajah skematik sebelum pengaturcaraan program dilaksanakan. Hasil perlaksanaan IoT Bersama dengan penggunaan alat peningkatan kualiti air ini adalah penjimatan masa yang dapat dikurangkan daripada 120 minit kepada 10 minit sahaja. Selain itu, dengan penggunaan teknologi IoT, data dapat diakses secara dalam talian melalui komputer ataupun telefon pintar. Hasil keseluruhan penyelidikan ini mampu meningkatkan tahap oksigen terlarut air di Tasik B,UTeM sebanyak 23% selepas mengaplikasikan alat peningkatan kualiti air. Penggunaan IoT pula memberikan dimensi baru kepada pemuliharaan kualiti air dan seterusnya ia apat dikembangkan kepada aplikasi-aplikasi yang lain pula.

ABSTRACT

This research is related to a design of water quality improvement device using sustainable design that will be placed in the Lake of Universiti Teknikal Malaysia Melaka (UTeM) Main Campus The device is able to increase the level of dissolved oxygen in lake water by using natural resources. In addition, it reduces the time taken for researcher to retrieve data in the lake for experiment by implementing IoT. The research was conducted at Tasik B, UTeM where segmentation method is used to carry the water sample analysis process. The method is used because the physical properties of the lake water may differ due to the large surface area of Tasik B with the area of 48,076 m^2. The lake has been segmented into nine segments with 10 data taken from each segment. The data are considered after the implementation of water quality improvement device and comparisons has been made with previous data. The design of the device has involved several concepts using the Pugh matrix. The selected design in then designed in CAD software, Solidwork to obtain solid modelling. For the implementation of IoT, schematic diagram is drawn before the code being develop. The result of implementation of IoT shows the time taken for water quality research for 120 minutes to 10 minutes. Besides that, with the implementation of IoT technology, data can be accessed online via computer or smartphone. The overall findings of the project indicate that the DO level of Tasik B, UTeM is improved by 23% after applying water quality improving device that contain natural source. The use of IoT giving a new dimension to the conservation of water quality. Furthermore, the device can be further expanded to other application in the future.

DEDICATION

I dedicate this hard work of mine to my beloved parents who had always supported me,

Tneh Poay Or

Teo Lay Hean

To my supervisor,

Dr. Saifudin Hafiz bin Yahaya

To my beloved families and friend. Their continuous encouragement, motivation, inspiration, and support had led me towards completion of this project.

ACKNOWLEDGEMENT

Thanks to Dr Saifudin Hafiz bin Yahya for giving me guidance and motivation through the project. Thanks for his sharing of his precious knowledge and his experience to help me succeed in my life and completing the project.

Besides that, I also like to thanks to Innovate Malaysia Design Competition 2017 for lending me the Intel Edison Arduino Breakout board to complete my research. Besides that, I would also like to thanks, En Mohd Fairuz bin Dimin for lend me the Dissolved Oxygen Meter for me to complete my experiment

Last but not least, I would like to give special thanks to my friends who gave me motivation and cooperation in completing my FYP report. They had given their critical suggestion and comment throughout my research.

Finally, I would like to thanks to everybody who was important to this FYP report, as well as expressing my apology that I could not mention personally each one of you.

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LIST OF ABBREVIATIONS

BOD	-	Biochemical Oxygen Demand
COD	-	Chemical Oxygen Demand
DO	-	Dissolved Oxygen
EPA	-	Environment Protection Agency
GND	-	Ground pin
IoT	-	Internet of Things
INWQS	-	Interim National Water Quality Standard
pH	-	pouvoir Hydrogène
SS	-	Suspended Solid.
VCC	-	Voltage pin
WSN	-	Wireless Sensor Network
WQI	-	Differential scanning calorimetric

CHAPTER 1
INTRODUCTION

1.0 Introduction

This chapter provides the general overview and the idea of the research studies, which including the five main sections, started with background study, and followed by the problem statement. Besides, the objectives of the study are also stated in this chapter. Furthermore, the significance of this study will be briefly discussed through this chapter. Finally, the chapter ends with the explanation of report organization.

1.1 Background of The Study

Water is an important resource in daily life. Besides of river and stream, the lake is also one of the resources of water. The lake is an area surrounded by land apart from the river. It is not a part of the ocean so it is distinct from lagoons and is larger than a pond Lakes can be contrasted with rivers or streams, which are usually flowing. However, most lakes are fed and drained by rivers and streams. The water in lakes comes from rain, stream, and groundwater. Usually, most lakes contain fresh water.

The lake can be naturally formed and construct by a human being. Now in the modern day, lakes built by human for industrial and agricultural. Besides, it is also applied for power generation through hydroelectric power generation and domestic water supply. Besides that, lake also can be a place for recreation activities such as swimming, fishing, canoeing and

kayak, but certain lake produced an unpleasant smell from time to time because of the living organism. Due to unpleasant smell, people are not comfortable to conduct activities near the lake. The increasing of impurities in the lake is the main factor that causes the unpleasant smell produced by the lake. The decreasing of dissolved oxygen will cause the increasing impurities. Lake aeration system is used to increase dissolved oxygen.

There are two lakes located in Universiti Teknikal Malaysia Melaka (UTeM) which are Tasik A and Tasik B The area of the lake is 26148.1 m^2 and 48076.8m^2 respectively. The Figure below shows the map of Tasik UTeM A and B.

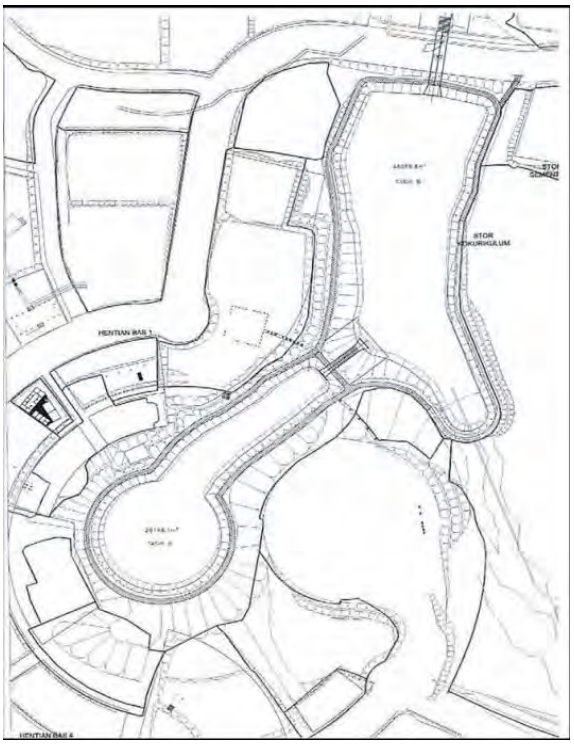

Figure 1.1: Map of Tasik UTeM (Yunus, 2015)

In the past few years, Tasik UTeM has been suspected polluted by the leptospirosis virus that may cause death. Since the lake has suspected contaminated, the recreational activities at the lake are prohibited.

1.2 Problem Statement

Tasik UTeM has been classified as polluted due to the faecal coliform contamination of also known as Leptospirosis. Due to this issue, Tasik UTeM has been closed and prevent student for conducting the recreational activities on the lake. In addition, peoples are uncomfortable to get near to the lake because the unpleasant smell produced by the lake that caused by organism that live in the lake such as fish and planter. The dissolved oxygen in lake is low and enhances the impurities in the lake. Dissolved oxygen is one of the content in the water that against impurities produced by living organism in the lake Furthermore, it is found that the conventional method of taking a water sample for testing and data logging is time consumed and less efficiency.

In order to reduce the faecal coliform contamination in Tasik UTeM, it is suggested to install an aeration system to increase the dissolved oxygen (DO) and reduce the biochemical oxygen demand (BOD) of the lake water. This is because through stirring the water at different speeds with impellers or forcing air streams of different velocities tangentially over the surface caused relatively gradual changes in the rates of oxygen in solution (Downing, 1955). The reduction of the coliform contamination and the biochemical will increase the water quality index (WQI).

The implementation of the internet of thing (IoT) is suggested for improving the efficiency of the water sample taking and the data logging of the lake water quality by using the application of real-time monitoring features. The implementation of IoT in this project is to reduce the procedure and the time taken of the process of sampling of the lake water DO, BOD, and pH value, by using sensor, network and cloud for sensing, analytics purposes at any time, anything and anywhere (Gubbi, 2013).

1.3 Objectives

The objectives of this research study are listed as follows:

i. To design a water quality improvement device with a sustainable design.

ii. To develop Internet of Things (IoT) device that contain live monitoring function especially for Tasik UTeM.

iii. To fabricate a water improvement device that contain automated filtration system.

1.4 Significance of Study

This section will describe the product design that successfully implement the IoT device to the water quality improvement devices that using sustainable device in its application. By using IoT device, the changes of the water quality can be monitored at any time anywhere. The device not only applicable to the lake ecosystem, it is also able to apply at industry and aquarium. Hence, the next paragraph will discuss the application using the IoT device to the water quality improvement device.

In the application of the device to the lake ecosystem enable user and researcher to monitored the condition of the lake water by using real time monitoring. Which mean user can get the most recent data of the lake water. So, they able to take appropriate action when notice the sudden change of the DO, BOD and pH level. From this study, the process of the sample taking from the lake can be reduced and save the cost and the time for collecting the data of the lake ecosystem for analysis.

In industry use, the device able to apply at the water treatment plant. By using the IoT implemented water quality improvement devices, the water quality that going through the purification system can be inspected automatically without using the operator for sample taking process. The data of the water will be saved at the server or database, for the further analysis of the result or the efficiency of the water quality improvement devices. It can reduce the time and cost for industries to checking and inspect the water quality frequently because the device is able to send the signal or information to the administrator of the respective company when having the sudden change of the data or the quality of the water is getting below the threshold limit.

Water quality is very important for the aquarium environment especially the pH of the water. The sudden change of the pH level in the water environment can harmful even fatal to a fish

(Shirlie,2016). Thus, monitoring of the water quality of the aquarium are very important. Through this research, owners can detect the quality of the water without manual inspection on the water. It can be done automatically by using the sensor and owner only need to check it from the real-time monitoring display. The device also can provide the sufficient level of DO to the aquarium automatically. While the pH and the DO level can be set or define by the owner to get the perfect environment for their fish.

1.5 Organization of Report

Chapter 1 discusses the background study and the problem that faced by the project. Besides, the objectives of the project are being stated and discussed in this chapter to help reader have a clear idea about what is going to be done in this research. The problem of the research is then narrow down by the scope of project for us to complete the research right in time. Finally, the chapter ends with the significance of the research and the report organization.

Chapter 2 reviews the related studies including the introduction for water quality, the parameter that can be found in the water body including the datasheet and the standard published in the Environment Quality Act. Besides, the ways of improving the water quality of the lake and the effect of the aeration process that used to increase the dissolved oxygen level in the lake water are also being discuss in detail in this chapter. Furthermore, this chapter also include the explanation of the history of internet of things (IoT), the component included in IoT such as hardware, middleware, and the presentation of the data by using IoT. Finally, the present product of the water quality monitoring device and the water quality improvement device specification is being studied and finding for improvement.

Chapter 3 presents the methods of carry out in the research. This chapter provides a detail information of the research from the method of research, to the method of analysis and finally the method of implementing IoT to the water quality improvement device. Beside that the conceptual diagram and the technical specification of IoT implementation.

Chapter 4 discusses the design stage of the water quality improvement device and the schematic diagram design of the IoT implementation. The concept requirement, concept generation, concept screening, concept scoring and the selected design are included in this chapter. Besides that, the way of connection of the sensor to the IoT development board also discussed in detail in this chapter.

Chapter 5 analyses the collected data. The DO's data are collected and utilized in this chapter. Moreover, the data after implementation of the Water Quality Improvement Device are also utilized in this chapter. The validation is made between the improvement of the DO and existing DO in Tasik B, UTeM. Finally, the appearance of IoT implementation also included in this chapter.

Chapter 6 remarks the conclusion of this research. This chapter concludes either all the objectives are achieved or otherwise. All the evidences are included in this chapter to support the achieved objective. Besides that, this chapter also highlighted some recommendations for future work. Finally, the sustainability of the product also covered in this chapter.

CHAPTER 2
LITERATURE REVIEW

This chapter focused on the study of the journal, article, books, proceeding paper and other resources that related to the research. Generally, this chapter has been written into three section which include water quality, aeration system, and the related study of Internet of Things (IoT). The parameter of water quality and the factor affecting the water quality index will be discuss in detail in Section 1 while the background and the types of the aeration system will be discussed in Section 2. Finally, section three will discuss in detail about the implementation of IoT to the real-time monitoring application and the related work on the existing real-time monitoring project.

2.1 Water Quality

Water is the most important natural resource in the world because it provides the needs to the life and most of the industries. Without the presence of water, life cannot exist and most of the industry cannot work. The presence of safe and reliable source of water is thus a crucial criterion for formation of a stable community. History shows many occasions where agricultural development has been hindered by the interference with water supplies as part of the conflict between landowners and settlers that has occurred in numerous parts of the world. Other conflicts in relation to water supplies can arise because of the effects that human and industrial wastes can have on the environment. This means that the importance

of water as a natural resource, requiring careful management and conservation, must be universally recognized (Tebbutt, 1998).

Water quality is a neutral term that relates to the composition of water as affected by natural processes and human activities. The quality of water also is related to its specific use, and usually measured in terms of the concentration of its constituents. Water quality measurements include physical, chemical, and biological parameters. Therefore, water quality can be defined by a range of variables which limit water use. Although many uses have some common requirements for certain variables, each use will have its own demands and influences on water quality. Quantity and quality demands of different users will not always be compatible, and the activities of one user may restrict the activities of another, either by demanding water of a quality outside the range required by the other user or by lowering quality during use of the water (Bartram, 1996).

2.1.1 Water Quality Parameters

The water quality parameters and the water use classes is being standardize by the Department of Environment. There are total of 72 parameters in 6 water use class stated in the National Water Quality Standard which is applied to the water surface. There is a total of three main type of parameter can be categorized from the 72 parameters of the water quality which are physical parameters, chemical parameters, and biological parameters.

At year 1985, a team of multidisciplinary team of researcher from university throughout the country was formed to study and create a “benchmarks” for national water quality per the parameter basis. This research is carried due to the climate of Malaysia is different with the cool climate country hence the oxygen solubility of the water may be different. At the end of the research, the draft of Interim National Water Quality Standard (INWQS) was formed (Zaki, 2010). The water classes have been defined into 6 classes and every class of the water indicates the different use of the water (Ibrahim, 2016). Table 2.1 shows the uses of the water at its respective class.

Table 2.1: Water classes and uses (Ibrahim, 2016)

Class	Uses
CLASS I	Conservation of natural environment water supply I – practically no treatment necessary. Fishery I – very sensitive aquatic species
CLASS IIA	Water Supply II – conventional treatment required Fishery II – sensitive aquatic species
CLASS IIB	Recreational use with body contact
CLASS III	Water Supply III – extensive treatment required Fishery III- common, of economic value, and tolerant species livestock drinking
CLASS IV	Irrigation
CLASS V	None of above

Several parameters classify the class of the water. The parameters include Ammoniacal Nitrogen, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), pH, colour etc. A value of these parameters is used and Table 2.2 applies as a guideline of the water class classification. The value of the parameter will indicate the class of the water from CLASS I to CLASS V (Afroz, 2014).

Table 2.2: National Water Quality Standards for Malaysia (Ibrahim, 2016).

Parameters	**Unit**	**Classes**					
		I	**IIA**	**IIB**	**III**	**IV**	**V**
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
BOD	mg/l	1	3	3	6	12	> 12
COD	mg/l	10	25	25	50	100	> 100
DO	mg/l	7	5 - 7	5 - 7	3 - 5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Electrical Conductivity*	µS/cm	1000	1000	-	-	6000	-
Floatables	-	N	N	N	-	-	-