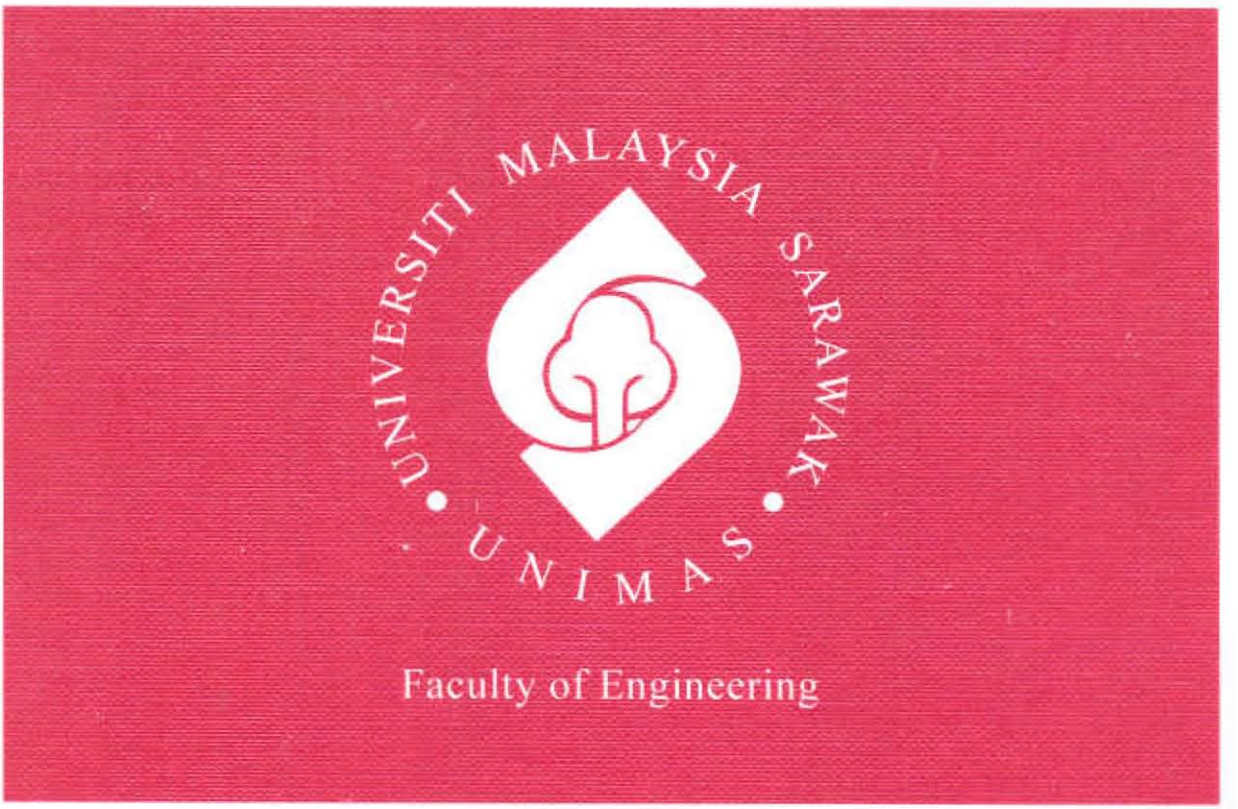

Environmental Management For Energy Industry: Application of ISO 14001 EMS and QUAL2K Modeling System

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Environmental Management For Energy Industry: Application of ISO 14001 EMS and QUAL2K Modeling System

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DECLARATION

I, Georgie Wong Abdullah (15010111) from Faculty of Engineering UNIMAS hereby declare that the work Environmental Management For Energy Industry: Application of ISO 14001 EMS and QUAL2K Modeling System, is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Georgie Wong Abdullah (15010111)

Date:

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ABSTRACT

Environment management has been widely applied by policy makers and relevant authorities particularly in industry sector. The objectives of this research are to investigate and determine the environmental and operational performances of a coal-fired power plant in Sarawak, and to determine and recommend the impacts of landfill effluent discharge on water quality of Batang Kemena and the siting (selection of location) of Maskat Landfill's effluent discharge point, respectively. The parameters are air quality, generating efficiency, power availability and reliability for the first case study. The environmental parameters are the air quality parameters which include total suspended particulate, particulate matters up to 10 μm in size and sulfur oxides. Thermal Efficiency and Equivalent Availability Factor were selected as parameters for generating efficiency and availability. For reliability, the parameters are Equivalent Unplanned Outage Factor and Equivalent Planned Outage Factor. Overall findings show that better performance was recorded on environmental aspect, suggesting more focuses were put on regulatory concerns to ensure high environmental compliances. This case study also demonstrates some relevant evidences toward treating operational improvement as equally significant and beneficial efforts for economic gain and environmental enhancement. The second case study includes physico-chemical as well as heavy metals parameters such as DO, BOD_5, uBOD (represented as fast-BOD in QUAL2K), NH_3-N, NO_3-N, total suspended solids (TSS), lead (Pb), arsenic (As), cadmium (Cd), mercury (Hg) and nickel (Ni). The spatial modeling results illustrated the landfill leachate discharge would not significantly deteriorate the water quality of both Sg. Besai and Btg. Kemena during normal operations either under normal or low flow conditions (Scenarios 1 and 2). However, leakages or untreated and sudden release of

leachate (Scenario 3 and Scenario 4) would certainly result in serious contamination of these rivers as the concentrations of water quality parameters would degrade to Class III-V. This case study suggests Sg. Sesalak as the immediate stream to receive the leachate before it is subsequently channeled to Btg. Kemena. It makes recommendations in the effort to have a more implementable measures for managing Btg. Kemena river system. This work also defines a coordinating structure in aligning key roles and responsibilities of relevant stakeholders involving in environmental management of energy industrial in Sarawak.

Keywords: Environment management, energy industrial, ISO 14001, environmental performance, operational performance, water quality modeling

Pengurusan Alam Sekitar Untuk Industri Tenaga: Penggunaan ISO 14001 EMS dan Sistem Pemodelan QUAL2K

ABSTRAK

Penggunaan alam sekitar telah diaplikasikan secara meluas oleh penggubal polisi serta pihak berkuasa yang berkenaan khasnya dalam sektor industri. Objektif kajian ini adalah untuk menentukan prestasi alam sekitar dan operasi sebuah loji kuasa arang batu di Sarawak, dan untuk menentukan impaks pelepasan larut resapan daripada tapak perawatan sisa Maskat. Kajian kes yang pertama melibatkan parameter-parameter untuk kualiti udara, kecekapan penjanaan, ketersediaan kuasa dan keandalan. Parameter alam sekitar adalah termasuk jumlah zarah terampai, zarah terampai sehingga 10 μm dan sulfur oksida. Kecekapan Haba dan Equivalent Availability Factor dipilih sebagai parameter untuk kecekapan penjanaan, ketersediaan kuasa. Untuk keandalan, parameter yng digunakan adalah Equivalent Unplanned Outage Factor dan Equivalent Planned Outage Factor. Keputusan keseluruhan menunjukkan prestasi alam sekitar yang lebih baik, dan ini mencerminkan lebih fokus diberikan untuk memastikan pematuhan tinggi dalam peraturan alam sekitar. Kajian ini juga memaparkan bukti yang relevan bagi menunjukkan pentingnya peningkatkan operasi sebagai usaha kepentingan bersama ekonomi dan alam sekitar. Kajian kes yang kedua merangkumi fiziko-kimia serta logam berat seperti DO, BOD_5, uBOD (diwakilkan sebagai fast-BOD dalam QUAL2K), NH_3-N, NO_3-N, total suspended solids (TSS), lead (Pb), arsenic (As), cadmium (Cd), mercury (Hg) dan nickel (Ni). Keputusan pemodelan menunjukkan larutan resapan tidak menjejaskan kualiti air Sg. Besai dan Btg. Kemena di bawah operasi normal dan di bawah kadar

pengaliran larutan resapan yang rendah (Scenario 1 dan 2). Namun, tumpahan atau pelepasan larutan resapan secara tiba-tiba (Scenario 3 dan Scenario 4) akan membawa kepada pencemaran serius kepada sungai-sungai tersebut sehingga penurunan kualiti air ke tahap Class III-V. Kerja ini mencadangkan agar Sg. Sesalak dijadikan sebagai penerima larutan resapan sebelum ia dialirkan ke Btg. Kemena. Kerja ini memberi beberapa cadangan sebagai usaha untuk mewujudkan tindakan-tindakan yang lebih dapat dilaksanakan untuk pengurusan sistem sungai Btg. Kemena. Kerja ini juga menerangkan struktur koordinasi dalam penyelarasan peranan serta tanggungjawab pihak berkepentingan yang terlibat dalam pengurusan alam sekitar dalam sektor tenaga di Sarawak.

Kata kunci: *Pengurusan alam sekitar, industri tenaga, ISO 14001, prestasi alam sekitar, prestasi operasi, pemodelan kualiti air*

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LIST OF ABBREVIATIONS

ARM	Agricultural Runoff Model
As	Arsenic
AVG	Allgemeinverf¨ugbaresGew¨asserg¨ute
BASINS	Better Assessment Science Integrating Point and Nonpoint Sources
BOD_5	Biological oxygen demand
CBOD	Carbonaceous biochemical oxygen demand
Cd	Cadmium
COD	Chemical oxygen demand
CORMIX	Cornell Mixing-Zone
CSTR	Continuously-stirred-tank-reactor
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DYRESM-WQ	Dynamic reservoir water quality model
EAF	Equivalent Availability Factor
ECOM-si	Estuarine, coastal and ocean model
EDH	Equivalent Derated Hours
EFDC	Environmental Fluid Dynamics Code
EMS	Environmental Management System
EPOF	Equivalent Planned Outage Factor
EUOF	Equivalent Unplanned Outage Factor
HEC-RAS	Hydrological Engineering Centre – River Analysis System

Hg	Mercury
HSPF	Hydrological Simulation Program–FORTRAN
IEEE	Institute of Electrical and Electronics Engineers
IFC	International Finance Corporation
ISO	International Organization for Standardization
ISO	International Organization for Standardization
ISO	International Organization for Standardization
IWMS	Integrated Wastes Management System
MLD	Million liter per day
NDEMS	National Database on Environmental Management Systems
NH_3-N	Ammoniacal nitrogen
Ni	Nickel
NO_3-N	Nitrate nitrogen
NPS	Non Point Source model
NWQS	National Water Quality Standards
Pb	Lead
POM	Princeton ocean model
QUASAR	Quality Simulation Along River Systems
SAMM	Skim Akreditasi Makmal Malaysia
SCORE	Sarawak Corridor of Renewable Energy
SE	Standard error
SIP	Samalaju Industrial Park
SMEs	Small and Medium-size Enterprises
SWAT	Soil and Water Assessment Tool

SWMM	Stormwater Management Model
TMDLs	Total maximum daily loads
TN	Total nitrogen
TOC	Total organic carbon
ToR	Terms of Reference
TP	Total phosphorus
TSP	Total Suspended Particulate
TSS	Total suspended solids
UBOD	Ultimate biochemical oxygen demand
USEPA	United States Environmental Protection Agency
VBA	Visual Basic for Applications
WASP	Water Quality Analysis Simulation Program
WQI	Water quality index
WSSD	World Summit on Sustainable Development
XOCs	Xenobiotic organic compounds

CHAPTER 1

INTRODUCTION

1.1 Introduction

Since the 1972 Stockholm Conference on the Environment and the 1992 Earth Summit, the environment continues to remain high on the international agenda. After the World Summit on Sustainable Development (WSSD) in 2002, positive progress has been made which has resulted in the establishment of a variety of environmental management mechanisms formulated to address specific environmental issues (Ejdyset *et al.*, 2016).

In Malaysia, the government has always been desirous and aware of the need to achieve sustainability in development since the implementation of the Malaysia Plans in the 1960s. To achieve sustainable development, environmental protection and development must go hand-in-hand. Thus, Parliament enacted the law, namely the Environmental Quality Act (EQA) in 1974, to provide the regulatory framework for environmental management.

At present, most states in Malaysia have started to diversify and transform its economy from agricultural and manufacturing based economies into industrialization. In the context of Sarawak, since independence about half century ago, Sarawak has progressed from a primarily rural agriculture based economy to a modern, progressive industrialised country. Industrialisation has intensified over the last decade and this rapid

developments and structural changes of the State's economy have brought in their wake many environmental problems which must be addressed satisfactorily.

1.2 Problem Statement and Research Hypothesis

Currently, Sarawak is implementing a long-term economic perspective plan which covers a period of 15 years from 2016 until 2030. In this plan, energy industry has been identified as the most focused industry to power Sarawak towards industrialized economic structure, where the energy intensive heavy industry is located. Significant changes in the Sarawak's environment resulting from accelerated development require changes in environmental management framework to protect and enhance the environmental quality.

There are 2 main issues experiencing in environmental management with regard to energy industry in Sarawak. The first issue is to have a more self-regulating environmental management system (EMS). Given the complexity and diverse scope of environmental issues in energy industry, the hard enforcement approach of government regulations has been experienced as having some limitations which include inflexible against realities on the ground; reactive rather than proactive initiatives; heavy-handed; cost-ineffective etc. In this regard, the government is promoting a more self-regulating approach in environmental management system (EMS) in order to expedite paradigm shift with respect to environmental management and sustainability.

The ISO 14001 is a systematic approach, taken proactively to effectively integrate environmental considerations into an organization's daily operation and management

culture, enhance a company's performance and ensure that an organization is effectively managing its environmental risks (Alberti et al., 2000; Nicholas and Smith, 2005). Realizing that there will be wide range of benefits offered by the ISO 14001 EMS, the Sarawak government is proposing ISO 14001 as the regulating mechanism to ensure environmental sustainability of the industry.

Many researches have conducted studies and written literatures on ISO 14001 EMS implementation and improved environmental performance, compliance of legislations, increase of corporate image and etc; however, there are very limited studies to justify the effectiveness of ISO 14001 EMS in energy related industry, particularly in Sarawak.

To get a better understanding on the overall performances as highlighted from the above paragraph, a research on the effectiveness of ISO 14001 in energy related industry that are currently adopting ISO 14001 EMS is deemed necessary and appropriate.

The hypotheses of this research: there are positive implications attributed to the implementation of ISO 14001 EMS; and there are compliances to the environmental regulations as well as satisfactory operational performances.

The second issue of environmental management faced by the energy industry in Sarawak is to have a water quality modeling system for better management of industrial effluent discharge. Water quality models try to simulate changes in the concentration of pollutants as they move through the environment in water bodies Thus, there are needs to apply water quality modeling in order to determine sources of pollution, to allocate pollutant loads, and to predict the effectiveness of actions taken to meet water quality standards. The model is crucial to predict water quality impacts in a relatively simple

manner compared with the complexities of actual water systems. This will also help to address limitations and uncertainties inherent in measuring the attainment of water quality and facilitate in water quality management.

Through extensive literature works, it was found that application of water quality modeling has substantial ability and performance for modeling river water quality, however, currently there is no such research on the application of this model for industrial effluent discharge in Sarawak. It could be due to the lacking of an institution or expertise for water modeling system.

Considering the need for more systematic manner in water catchment management, a study on the water quality modeling system is required as it can serve as one of the ideal approaches for effective management of industrial effluent discharge in Sarawak.

The hypotheses of this research: development of water quality modeling for modeling effluent discharge of industrial wastes, by applying the existing modeling tool; and prediction of the potential polluted segment of a river system by the effluent discharge through simulation of the interactions between multiple chemical and biological parameters and river water system.

1.3 Objectives and Specific Aims

The primary objectives of this research are 1) to investigate and determine the environmental and operational performances of a coal-fired power plant in Sarawak currently implementing ISO 14001 EMS; and 2) to determine and recommend the impacts of landfill effluent discharge on water quality of Batang Kemena and the siting (selection of location) of Maskat Landfill's effluent discharge point, respectively.

The specific aims of this research are as follows:

I) Environmental and operational performances

a) To evaluate the operational and environmental performances of a coal power plant in Sarawak;
b) To monitor the power plant's past few years' trends of performances by comparing the data with the available standards;
c) To recommend some relevant approaches and strategies which could improve the implementation of ISO 14001 EMS for continual improvement in the plant.

II) Impacts of Effluent Discharge on Labang Water Treatment Plant

a) To set up a water quality modeling QUAL2K applicable for modeling industrial effluent discharge;
b) To model the water quality of the potential polluted segments by applying different modeling scenarios; and
c) To make recommendations on the siting (selection of location) of discharge point of the industrial effluent in order to minimise adverse impacts to the nearby community.

1.4 Scope of the Research

The scope of the first research is to conduct EMS literatures review as to assess effectiveness of ISO 14001 as an EMS in the Sejingkat Coal Power Plant. Air quality is chosen as environmental indicator for evaluation of environmental performance. The air quality data ranging from January 2013 to June 2015 will be utilized in this research. For operational performance, data from 2010 to 2013 of the relevant performance parameters in accordance with performance standards developed by the Institute of Electrical and Electronics Engineers (IEEE) are used.

All data will then be statistical analysed and compared with the Recommended Malaysian Air Quality Guidelines and the Environmental Quality (Clean Air) Regulations, 2014 to determine the compliance status. Some air quality treatment technologies will be suggested to further improve the treatment effieciency with the attempt to improving the air quality.

For the second research, research work is to apply QUAL2K water quality modeling system for building a model for modeling industrial effluent discharge and its implication to the water quality of Batang Kemena and its main tributaries. There will be two separate water quality models developed for Sg. Besai discharge and Btg. Kemena discharge. In addition, the potential polluted segment (from effluent discharge of Maskat waste treatment facility) of Batang Kemena to Labang raw water intake point will also be covered in the modeling work. There are four (4) modeling scenarios designed based on various effluent discharge rate and river water flow conditions. This is to provide a representation of various river conditions against pollution input of effluent discharge.