ASSESSMENT OF URBAN LAKE WATER QUALITY AT THREE DIFFERENT TYPES OF SOIL PROPERTIES

BY

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ABSTRACT

The assessments of water quality in Malaysia depend on several guidelines such as National Lake Water Quality Criteria and Standard, Urban Storm Water Management Manual for Malaysia and National Water Quality Index Standard. However, these guidelines are very limited in evaluating the status of water quality without considering the significant contribution that affected the quality of water, such as the type of soil. The concern of soil problems in Malaysia arising from laterite, sandy, acid sulphate and organic soil. In addition, the soil is a pollutant-transmitting agent of water run-off and enhance the toxicity level in soil and water bodies. Thus, this research aimed to confirm the interaction between the cation exchange capacity (CEC) of 3 different types of problem soil towards water quality index. The relationship between CEC and urban lake quality index was investigated and verified by spectrophotometry and ICP-MS towards soil and water physicochemical properties as well as heavy metals content. This study established that laterite, sandy and acid sulphate soil differ significantly with respect to CEC, soil texture, soil colour and distribution and concentrations of heavy metals in soil and water bodies. A total 100 samples were evaluated for quantitative and qualitative physicochemical properties in 3 different types of soil, water bodies, and heavy metals. Soil colour was found to correlate with CEC and heavy metals content in both soil and water bodies. The main heavy metals group identified in laterite soil were Fe, Al, Mn and Zn whereas in sandy and acid sulphate soil only Al and Mn were detected. The ratio of these heavy metals series varies between the type of soils. CEC value was detected higher in laterite soil (9.35 to 22.85 mg/kg) whereas in sandy and acid sulphate soil CEC were found less than 10 mg/kg. On the other hand, the main heavy metals group identified in water bodies in urban lake at laterite were Fe, Al, Mn and Zn; at sandy area were Pb, Cr, Fe, Ni, Al and Cd and water bodies at acid sulphate soil area were Mn, Al, Fe and Cr. Marked differences were observed between the heavy metals content and concentration in soil and the urban lake water bodies. Therefore, heavy metals profiles of the 3 different types of soil and water bodies showed highly significant differences between the CEC, soil colour, soil texture, and all other combinations of interactions, indicating the complex nature of factors influencing water bodies composition. Reflectance colorimeter measurement of yellow-red hue component in this study confirmed that the higher the CEC content, the greater the yellow-red intensity colour and clay content. Lastly, in order to complete this study, an effective rating system using physico-chemicals properties were established to assess urban lake quality index status based on both water bodies and specific type of soil parameters influencing heavy metals composition.

خلاصة البحث

تعتمد تقييمات جودة المياه في ماليزيا على عدة مبادئ توجيهية مثل معايير جودة مياه البحيرة الوطنية ودليل إدارة مياه العواصف الحضرية لماليزيا وأيضًا المعيار الوطني لجودة المياه. ومع ذلك، فإن هذه الإرشادات محدودة للغاية في تقييم حالة جودة المياه دون النظر إلى المساهمة المهمة التي أثرت على نوعية المياه مثل نوع التربة. والاهتمام بمشاكل التربة الناشئة، في ماليزيا، عن الكبريتات الرملية والحمضية والتربة العضوية. وبالإضافة إلى ذلك، فإن التربة هي عامل ملوث ينقل جريان المياه ويعزز مستوى السمية في المسطحات المائية والتربة. وهكذا، يهدف هذا البحث إلى تأكيد التفاعل بين قدرة تبادل الكاتيون (CEC) لثلاثة أنواع مختلفة من المشاكل التي تسببها التربة نحو جودة المياه. وتم التحقيق في العلاقة بين CEC ومؤشر جودة البحيرة الحضرية والتحقق من القياس الطيفي و ICP-MS تجاه الخصائص الفيزيائية والكيميائية للتربة والمياه وكذلك محتوى المعادن الثقيلة. وأثبت هذا البحث أن تربة الكبريتات الرملية والحمضية تختلف اختلافًا كبيرًا فيما يتعلق بـ CEC، وملمس التربة ولون التربة وتوزيعها وتركيزات المعادن الثقيلة في المسطحات المائية والتربة. وتم تقييم ما مجموعه 100 عينة للخصائص الفيزيائية والكيميائية الكمية والنوعية في ثلاثة أنواع مختلفة من التربة والمسطحات المائية والمعادن الثقيلة. وتم إثبات أن لون التربة يرتبط مع CEC ومحتوى المعادن الثقيلة في كل من التربة والمسطحات المائية. وكانت المجموعة الرئيسية للمعادن الثقيلة التي تم تحديدها في التربة غير المستصلحة هي Fe ، Al ، Mn ، Zn، بينما في تربة الكبريتات الرملية والحمضية فقط وجد كل من ال Al ، Mn. وتختلف نسبة سلسلة المعادن الثقيلة هذه حسب نوع التربة. وتم اكتشاف أن قيمة CEC أعلى في التربة غير المستصلحة والتي تتراوح بين 9.35 إلى 22.85 ملجم/كجم، بينما تكون في التربة الرملية والكبريتية الحمضية، أقل من 10 ملجم/كجم. ومن ناحية أخرى، كانت المجموعة الرئيسية للمعادن الثقيلة التي تم تحديدها في المسطحات المائية في البحيرة الحضرية في وقت لاحق هي Fe ، Al ، Mn ، Zn ؛ وفي المناطق الرملية كانت Pb و Cr و Fe و Ni ،Al ، Cd ووجد في المسطحات المائية في منطقة تربة الكبريتات الحمضية عناصر Mn ، Al ، Fe ، Cr. وقد لوحظت فروق واضحة بين محتوى المعادن الثقيلة وتركيزها في التربة والمسطحات المائية في البحيرة الحضرية. ولذلك، أظهر ملامح المعادن الثقيلة للأنواع الثلاثة المختلفة من التربة والمسطحات المائية اختلافات كبيرة في كل من محتوي CEC ولون وملمس التربة وجميع مجموعات التفاعلات الأخرى، مما يشير إلى الطبيعة المعقدة للعوامل التي تؤثر على تكوين الأجسام المائية. وأكّد مقياس الانعكاس لمكون الصبغة الأصفر والأحمر في هذا البحث أنه كلما زاد محتوى CEC، زادت لون كثافة اللونين الأصفر والأحمر ومحتوى الطين. وأخيرًا، من أجل إكمال هذا البحث، تم إنشاء نظام تصنيف فعال يستخدم الخواص الفيزيائية والكيميائية كمؤشر لحالة جودة البحيرة الحضرية بناءً على كل من المسطحات المائية ونوع محدد من معالم التربة التي تؤثر على تكوين المعادن الثقيلة.

APPROVAL PAGE

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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LIST OF ABBREVIATIONS

%	Percent
ml	Mililitre
<	Less than
ICP-MS	Inductively coupled plasma mass spectrometry
>	More than
°C	Degree celcius
Kg	Kilogram
Al	Aluminium
L	Liter
ANOVA	Analysis of Variance
mg/kg	Milligram perkilogram
BOD	Biochemical Oxygen Demand
mg/L	Miligram perliter
Mg	Magnesium
Cd	Cadmium
CEC	Cation exchange capacity
Mn	Manganese
COD	Chemical Oxygen Demand
Cr	Chromium
Cu	Copper
DO	dissolved oxygen
NH_3N	Ammoniacal Nitrogen
Ni	Nickel
Fe	Iron
Pb	Lead
pH	Power of hydrogen
HNO3	Nitric acid
USEPA	United States Environmental Policy Agency
HCL	Hydrochloric acid
QC	Quality control
Zn	Zinc
NAHRIM	National Institute of Hyraulic Research Malaysia
DOE	Department of Environment
NWQS	National Water Quality Index
ULQI	Urban Lake Quality Index
SS	Suspended Solid
MPS	Multiprobe System
us/cm	microSiemens per sentimetre
TDS	Total Dissolved Solid
BOD_5	BOD value from the 5 day test
PFA	peruoroalkoxy polymer
Co	Cobalt
Ni	Nickle
QC	Quality Control
ppb	Part per billion

mm	millimetre
MS	Malaysia Standard
FAS	Ferrous Ammonium Sulphates
g	Gram
TOC	Total Organic Carbon
CEC	Cation Exchange Capacity
K	Kalium
Ca	Calcium
K_2SO_4	Pottasium Sulfate
TSS	Total Suspended Solid
YR	Yellow Red
WQI	Water Quality Index
OC	Organic Carbon
Y	Yellow
*	Highly significant
cmol/kg	centimol per kilogram

CHAPTER ONE

INTRODUCTION

1.1 RESEARCH BACKGROUND

A good environmental management in gaining Allah blessings is one of the core concepts in shariah compliance in built environment and encompasses the way of life in Islam. It also covers the method and system developed in water quality monitoring as to minimize the adverse impact on our natural resources especially waters that take over 75 % area of the earth. Shariah compliance and good environmental management are very deep and long standing connections between faith as well as our role as stewards of the earth. As mentioned in the Quran:

> "It is He (Allah) that has appointed you (mankind) as inheritors in the Earth…"
>
> (Qu'rán, 35:39)

Identifying the environmental impact into account and the way to mitigate the corruption appeared must be a concern as a moral duty with the concept of environmental stewardship to uphold the human relationship to the natural habitat (Posas, 2007).

As Malaysia is actively growing to become an industrial country, many water bodies are rapidly turning into a wastebasket for chemicals, sewage disposal, and pollutants too. About 60% of the 90 selected lakes and reservoirs were eutrophic and primarily contain nitrates and phosphates resulted from runoff fertilizers and pesticide use in agriculture point sources (Sharip & Suratman, 2017). These substances are believed to be channelled constantly to the water bodies and then transmitted into organic and inorganic particles, nutrients, pesticides and herbicides which directly affect the aquatic ecosystem. In fact, the water contaminants do not only harm aquatic

ecosystem, it also influences the water safety for human use as well. Soil properties are significant subject that connected to hydrological composition through transmission of physico-chemical properties from soil to water bodies.

1.2 PROBLEM STATEMENT AND ISSUES

There were three major issues that affecting the urban lake status in Malaysia. The first issue is, National Institute of Hydraulic Research Malaysia reported that more than 60% lakes from 90 numbers that were reviewed experiencing eutrophication. The source of pollutant generally transmitted from manmade surface run off in urban area and also natural surface run off such as soil as a medium to channel the pollutants into the water body. The second issue is regarding the anthropogenic source of contaminants. According to Malaysia Environmental Quality Report, the most influenced source of water pollution in Malaysia was recorded from suspended solid (SS), ammoniacal nitrogen (NH_3N) and biochemical oxygen demand (BOD). Another important issue is regarding the naturogenic influences. According to Department of Agricultural Malaysia 53% was categorized as suitable type of soil and another 47% was categorized as unsuitable soil that includes peat, acid sulphate soil, sandy beach ridges, sand tailing and steep land. Variety of soil type in Malaysia has contributed to the difference of soil properties dissolved in the water and the concern of soil problem in Malaysia involving from laterite, sandy, acid sulphate and organic soil type (Radzi, 2014). According to the review, laterite soil has covered 46% soil problem area in Malaysia, followed by organic soil 21%, acid sulphate soil 18%, and sandy soil 15%.

Soil is a transmitting agent of soil movement from the water run off to the water body. To assess the level of water quality, there are many factors need to be measured which related to the water quality standard. However, Malaysia has limited,

less comprehensive references, no specific national standard or index, no policy and recommended from agencies, no accessibility data and no enforcement in evaluating urban lake water quality for specific soil area.

1.3 RESEARCH GOAL

To assess Urban Lake Water Quality and physico chemicals properties at laterite, sandy and acid sulphate soil land area.

1.4 RESERCH OBJECTIVES

a) To identify the soil character and soil problem in Malaysia

b) to characterise water and soil physico-chemical properties of the urban lake located at laterite, sandy and acid sulphate soil area

c) To evaluate the relationship of cation exchange capacity and water quality in urban lake located at laterite, sandy and acid sulphate soil area.

1.5 RESEARCH GAP

In Malaysia, evaluating the water quality status for urban lake using specific type of soil has never been tested. Moreover, the existing guideline such as National Lake Water Quality Index Criteria and Guideline, Urban Stormwater Management Manual for Malaysia and National Water Quality Index Standard never used the combination of soil properties factor and water quality parameter in measuring water quality status. In addition, it has open as a new niche area in evaluating urban lake water quality status by discovering the two significant factors which were water and soil physico chemicals properties for urban lake assessment. According to Sharip & Zakaria (2008), National Hydraulic Research Malaysia has reported urban lake pollution in

Malaysia has been a great growing concern to the community and environmental sustainability. Therefore, this research will focus on the urban lake area to be as a case study as it is closely connected to community and the selected area will be focusing on the three type of soil problem in Malaysia which are laterite soil, sandy soil and acid sulphate soil area for further assessment on urban lake quality as well as physico chemicals properties that contributes to the status of urban lake quality.

CHAPTER TWO

LITERATURE REVIEW

2.1 WATER AND ISLAMIC PERSPECTIVE

2.1.1 Water in Islam

Islam had accredited water as a basis of life-giving for a whole universe system. This is based on some evidence that has been emphasized in the Quran that mentioned the important aspects of water.

Allah S.W.T has created all living things in a perfect way which has been mentioned in the Quran in Surah "Al Anbiya" verses 30:

> " Do not the unbelievers see that the heavens and the earth were joined together, before we clove them asunder ? We made from water every living thing. Will they not then believe?"
>
> (Quran, 21:30)

2.1.2 Water is a Basis Unit for All Living Things

In that verse, Allah S.W.T has mentioned on the creation of heaven and earth as one entity but had separated by the water in order to produce living things. Al Quran has advanced knowledge about the universe before the scientist found it. In fact, why do water is consider as one of the renewable resources? This is to show that, this resource is significant to ensure the survival of the on-going process of the living things. For instance, in Surah Al Nahl verse 10, mentioned that Allah has created the water as a drinking water for human, animals, and growing plants:

> "It is He who sends down rain from the sky; from it is drink and grows the vegetation on which to feet your cattle."
>
> (Quran, 16:10)

Besides, it also to nourish the earth in order to have a balanced ecosystem as mentioned in Surah Al Rum verse 24:

> "And of His signs is [that] He shows you the lightning by way of fear and hope, and He sends down rain from the sky and with it gives life to the earth after it is dead. Verily that are sign for those who are wise."
>
> (Quran, 30:24)

On the other hand, water is also can be as a cleansing agent for physical, spiritual, and religious need. It has been mentioned in Surah Al Mudathhir verse 4:

> "Keep free from stain"
>
> (Quran, 74:4)

Hence, it is important to ensure the quality of water is preserving as what Allah gift to us.

2.1.3 Religious Duty for Water Management

Water is a medium of understanding, faith and wisdom and a key to the practice of Islam physically and spiritually. It is important to show how our path of Islam protecting and cherishing the planet (Abdul Matin & Elisson , 2010). Water transfixes us with its beauty and frightens us with its awesome powers of destruction that prove constant and reliable sign of the creator. Across the Islamic Jurisprudence aspect, water is a vital element that privileges all the living things. In fact, Al Qardawi has come out the principles of Islamic Jurisprudent regarding the environment that associated with water by the Quran with five component which are *Tashjir and Takhdir* (Planting and Greening), *'Imarah and Tathmir* (Sustainable Development), *Nazafah and Tathir* (Cleanliness and purification), natural resources and biodiversity conservation and health sustenance as cited in Istajib & Abdullah (2014).