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THE ASSESSMENT OF WATER QUALITY IN TWO MAIN RIVERS IN KUANTAN, PAHANG

BY

FATIN KHAIRUNNISA ZAINUTDIN

A thesis submitted in fulfilment of the requirement for the degree of Master of Health Sciences (Biomedical Science)

Kulliyyah of Allied Health Sciences
International Islamic University Malaysia

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ABSTRACT

Despite the enforcement of Environmental Quality Act in 1974, water quality of rivers in Malaysia is still deteriorating. Information collected regarding water quality in rivers especially in the state of Pahang is still insufficient. Therefore, the objectives of this study were to detect the occurrence of *Cryptosporidium* oocysts and to assess the physico-chemical and heavy metal parameters in Kuantan River and Balok River. Six water samples were collected from Kuantan River and Balok River. Water samples were filtered followed by the purification of *Cryptosporidium* oocyst using the immunomagnetic separation technique and stained by fluorescein isothiocyanate–staining. Physical parameters were measured directly at the sampling locations using the handheld multi-parameter instrument while the assessment of chemical and heavy metal were done in the laboratory. Results obtained were then compared with the Interim National Water Quality Standards (INWQS) which is the standard parameters used to assess the water quality in surface water in Malaysia. Kuantan River and Balok River were contaminated with *Cryptosporidium* oocysts and chemical contaminants. However, water quality in both Kuantan River and Balok River varies depending on the sampling points. *Cryptosporidium* oocysts were detected in all water samples. With regards to INWQS, our results reported a lower level of dissolved oxygen (<5 mg/L) and elevated level of chemical oxygen demand (>50 mg/L), biological oxygen demand (>4 mg/L), nitrite (>1 mg/L) and chloride (>200 mg/L) at certain sampling locations. Of 23 elements measured, only 9 elements were detected (aluminium, boron, calcium, cobalt, iron, potassium, magnesium, sodium and strontium). The presence of heavy metals; aluminium (>0.5 mg/L) and iron (>0.8 mg/L) at several locations were beyond the INWQS safety limit range. Results obtained from this study will be very useful for future river management. Further studies on molecular characterization of *Cryptosporidium* species in river is highly recommended. Besides that, more parameters can be added in the future for more extensive information. It is hoped that this study can provide new data to the growing body of literature on the presence of *Cryptosporidium* oocyst as well as the physico-chemical assessment in Kuantan River and Balok River.

خلاصة البحث

على الرغم من تطبيق قانون الجودة البيئية في عام 1974، لا تزال جودة مياه الأنهار في ماليزيا في تدهور، ولا تزال المعلومات المجمعة بشأن جودة المياه في الأنهار غير كافية، ولا سيما تلك التي في ولاية باهانغ. بهذا هدفت هذه الدراسة للكشف عن وجود بويضات الكريبتوسبوريديوم وتقييم المعايير الفيزيائية والكيميائية والمعادن الثقيلة في نهر كوانتان ونهر بالوك. تم جمع ستة عينات مياه من نهر كوانتان ونهر بالوك. تم تصفية عينات المياه ومن ثم تنقيتها من بويضات الكريبتوسبوريديوم باستخدام تقنية الفصل المناعي المغناطيسي، وبعدها تم صبغ العينات بالفلوريسين والإيسوثيوسيانيت. تم قياس المعايير الفيزيائية مباشرة في مواقع جمع العينات باستخدام آلة القياس المتعددة المعايير المحمولة، في حين تم إجراء تقييم مستويات الكيماويات والمعادن الثقيلة في المختبر. تمت مقارنة النتائج التي تم الحصول عليها مع المعايير الوطنية المؤقتة لجودة المياه (INWQS) وهي المعايير القياسية المستخدمة لتقييم جودة المياه السطحية في ماليزيا. كان نهر كوانتان ونهر بالوك ملوثين ببويضات الكريبتوسبوريديوم وبملوثات كيميائية، غير أن جودة المياه في نهر كوانتان ونهر بالوك كانتا مختلفتين باختلاف نقاط جمع العينات. تم الكشف عن بويضات الكريبتوسبوريديوم في جميع عينات الماء المجمعة. مقارنة بمعايير الـ INWQS أشارت نتائجنا إلى انخفاض مستوى الأكسجين المذاب (<5 ملغم/لتر)، وارتفاع مستوى متطلبات الأكسجين الكيميائية (>50 ملغم/لتر)، ومتطلبات الأكسجين البيولوجية (>4 ملغم/لتر)، والنتريت (>4 ملغم/لتر) والكلوريد (>200 ملغم/لتر) في بعض مواقع أخذ العينات. من بين 23 عنصرا تم قياسه، تم الكشف عن 9 عناصر فقط (الألومنيوم، والبورون، والكالسيوم، والكوبالت، والحديد، والبوتاسيوم، والمغنيسيوم، والصوديوم، والسترونتيوم). وجود المعادن الثقيلة كالألومنيوم (>0.5 ملغم / لتر) والحديد (>0.8 ملغم/لتر) قد تخطى حدود نطاق السلامة لـ INWQS. ستكون النتائج التي تم الحصول عليها من هذه الدراسة مفيدة جدا لإدارة الأنهار مستقبلا. من الموصى بشدة إجراء المزيد من الدراسات حول التوصيف الجزيئي لأنواع الكريبتوسبريديوم في الأنهار. وبالاضافة الى ذلك، بالإمكان إضافة المزيد من المعايير مستقبلا للحصول على معلومات أكثر شمولا. من المأمول أن توفر هذه الدراسة بيانات جديدة إلى المؤلفات المتزايدة المتعلقة بوجود بويضات الكريبتوسبوريديوم في نهر كوانتان ونهر بالوك وكذلك التقييم الفيزيائي والكيميائي لمياهها.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Health Sciences (Biomedical Science).

……..
Afzan Mat Yusof
Supervisor

……...…
Muhammad Lokman Md Isa
Co-Supervisor

…….……..
Muhammad Ibrahim
Co-Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of (Biomedical Science).

……..
Mohd. Shukri Baba
Internal Examiner

……..
Mohamed Kamel Abd. Ghani
External Examiner

This thesis was submitted to the Department of Biomedical Science and is accepted as a fulfilment of the requirement for the degree of Master of Health Sciences (Biomedical Science).

……..
Zaitunnatakhin Zamli
Head, Department of Biomedical Science

This thesis was submitted to the Kulliyyah of Allied Health Sciences and is accepted as a fulfilment of the requirement for the degree of Master of Health Sciences (Biomedical Science).

……..
Suzanah Abdul Rahman
Dean, Kulliyyah of Allied Health Sciences

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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This thesis is dedicated to my beloved parents for laying the foundation of what I turned out to be in life.

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LIST OF EQUATIONS

LIST OF SYMBOLS

Al	Aluminium
B	Boron
Ca	Calcium
Cl	Chloride
Co	Cobalt
F	Fluoride
Fe	Iron
HCl	Hydrochloric Acid
K	Potassium
Mg	Magnesium
Na	Sodium
NaOH	Sodium Hydroxide
NH_3-N	Ammoniacal Nitrogen
NO^{2-}	Nitrite
NO^{3-}	Nitrate
cm^3	Centimetre Cubic
g	Gram
mg/L	Milligram per Litre
mL	Millilitre
nm	Nanometre
µL	Microlitre
µS/cm	Micro Siemens per Centimetre
ppt	Parts per Trillion
ºC	Degree Celcius
±	Plus Minus
>	More than
<	Less than

LIST OF ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
APHA	American Public Health Association
BOD	Biological Oxygen Demand
CDC	Centres for Disease Control and Prevention
CFC	Continuous Flow Centrifugation
COD	Chemical Oxygen Demand
DOE	Department of Environment
EQA	Environmental Quality Act
FITC	Fluorescein Isothiocyanate
GPS	Global Positioning System
HIV	Human Immunodeficiency Virus
ICRACU	Integrated Centre for Research Animal Care and Use
IMS	Immunomagnetic Separation
INWQS	Interim National Water Quality Standards
SD	Standard Deviation
TDS	Total Dissolved Solid
USEPA	United State Environmental Protection Agency
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Water is a vital and valuable source for all living things. In Malaysia, Department of Environment (DOE) is responsible for monitoring and controlling the water quality by enforcing the Environmental Quality Act (EQA) where the quality of water is compared with the Interim National Water Quality Standards (INWQS) for Malaysia (Hezri & Nordin Hasan, 2006; Mamun & Zainudin, 2013). In order to maintain the health of human population, obtaining safe water supply is very important. Contaminated public water supply may possess serious human health risk and might even lead to death. People have been using water for various purposes such as for drinking, irrigation, industrial, recreational, and fisheries (Al-Badaii, Shuhaimi-Othman & Gasim, 2013). Proper management and treatment of water supply are essential to ensure the water is safe and free from any contaminants for public consumption. Due to that, regular monitoring of water quality is highly important and indirectly protects this natural water resources from contamination (Kumar et al., 2014).

Rapid development and urbanization have caused some changes in the environmental resources. Human activities such as deforestation, agriculture, logging, industrialization, and open burning would affect the water quality, soil quality and air quality. Uncontrolled and illegal waste disposal into the river body also affect the water quality hence make it unsafe for daily usage (Podmore, 2009; Kumar & Prabhahar, 2012; Karija, Shihua & Lukaw, 2013). This has become the greatest environmental threat which needs to be controlled and resolved as it may be affecting

the quality of life and interfere with the aquatic ecosystem (Ngah & Othman, 2011; Kumar et al., 2014).

According to the World Health Organization (WHO), it is estimated globally that 3.4 million people die every year from water-related diseases due to the consumption of contaminated water (WHO, 2014). Faecal contamination of water from infected human or animals is a major cause of waterborne diseases (Feng et al, 2011; Julio et al., 2012; Forstinus et al., 2016). Infected animals like rodent, monkey or birds may defecate in or near the surface water causing the bacteria, parasites or helminthes to contaminate the water bodies. Other than that, wastewater from anthropogenic activities and runoffs from agricultural land also contributes to the contamination of water (Agrawal, Pandey & Sharma, 2010).

Water contamination may affects humans and animals in many ways depending on the type of contaminants. Pathogenic parasite such as *Cryptosporidium* can contaminate water system, causing cryptosporidiosis to those infected (Rossle & Latif, 2013; Ryan & Hijjawi, 2015). Meanwhile, exposure to toxic chemicals can cause serious health problems such as kidney failure, nervous system damage and cancer (El-Kowrany et al., 2016). The aquatic ecosystem will be affected as aquatic life depends solely on water (Owa, 2014).

1.2 STATEMENT OF THE PROBLEM

Despite the remarkable advancement in water treatment technology, the occurrence of *Cryptosporidium* is still a growing problem worldwide (Mahmoudi et al., 2015; Zainutdin et al., 2017). The occurrence of *Cryptosporidium* in water sources have been reported throughout the world in the past years (Mons et al., 2009; Feng et al., 2011; Julio et al., 2012; Gertler et al., 2015; Kumar et al., 2014; El-Kowrany et al., 2016; Kumar et al, 2016). Based on the current review of waterborne parasites in Malaysia, *Cryptosporidium* species or *Cryptosporidium* spp. are commonly detected in both human and animal population. From a total of 174 river water samples in Malaysia, 11.5% were found positive for *Cryptosporidium* oocysts with the concentration ranging from 0.4-246 oocysts per litre (Lim, Ahmad & Smith, 2008). Defecation from animals or human infected with *Cryptosporidium* in water can contaminate the water system. Therefore, a proper sewage treatment is very important to ensure that the water is safe for consumption.

In Malaysia, studies on the detection of waterborne parasites and physico-chemical assessment of water sources have not been clearly established. Most of the studies were focusing either on the detection of *Cryptosporidium* or assessment of physical and chemical parameters in water. In 2004, the first study on physical assessments and the occurrence of *Cryptosporidium* in water was done in recreational rivers located in Selangor (Azman, Init & Wan Yusoff, 2009). The occurrence of *Cryptosporidium* oocyst also has been reported in selected rivers in Selangor, Pahang and Perak (Lee et al., 2014). While research was done by Onichandran et al. (2013) only focused on the detection of waterborne parasites in selected recreational lakes in Selangor. Recently, Afzan et al. (2015) have studied on the occurrence of *Cryptosporidium* in selected rivers in Kuantan, Pahang. However, their research was

done only at the downstream water samples. There is no chemical assessment and heavy metal parameters done yet. Therefore, the information regarding the river quality of Pahang is not sufficient enough.

Kuantan River flows from the northwest to east coast in Kuantan. The water flows from Lembing River through the Kuantan city, small villages, agricultural areas as well as the forests. Kuantan River is a vital source of water supply for industrial, agricultural and domestic purposes (Kozaki et al., 2016). Meanwhile, the area of Balok River in Kuantan is an industrial area where most of the industrial activities are based on petrochemical and also the activity in expanding of residential areas. Balok River flows through Balok town. The activity in Gebeng industrial area and resident nearby the river contributes to the pollution of the Balok River (Abdullah et al., 2015). In the end, both Balok River and Kuantan River will flow towards the South China Sea.

These industrial and agricultural activities can cause pollution to the river water as the wastewater is discharged into the river. Other than that, the occurrence of pathogenic microorganisms in water such as parasites and bacteria can possess a great threat to the human and animal population if affected (Azman et al., 2009; Lee et al., 2014). Due to that, researches involving water quality assessment especially in surface water need to be done to ensure the safety of our water supply. Although a previous study on water quality assessment has been done in Kuantan, information and data pertaining to the chemical and heavy metal assessment of the rivers has not been collected yet (Afzan et al., 2015). Therefore, this study was carried out to determine the water quality of two main rivers in Kuantan by evaluating the biological, physical and chemical parameters. It is hoped that this study can provide a new data on

physico-chemical assessment and detection of *Cryptosporidium* in Kuantan River and Balok River.

1.3 RESEARCH OBJECTIVES

This study attempts to achieve the following activities:

1.3.1 General objective

1. To determine the water quality of Kuantan River and Balok River in terms of their biological, physical and chemical assessments.

1.3.2 Specific objectives

1. To detect the occurrence of *Cryptosporidium* in Kuantan River and Balok River.
2. To measure and compare the physical measurements in Kuantan River and Balok River.
3. To measure and compare the chemical measurements in Kuantan River and Balok River.
4. To measure and compare the concentration of heavy metal in Kuantan River and Balok River.

1.4 RESEARCH HYPOTHESIS

River contaminated with *Cryptosporidium* has lower water quality status. There are also differences in terms of physico-chemical measurement between Kuantan River and Balok River.