WATER QUALITY MONITORING OF TWO MAIN RIVERS DURING CONSTRUCTION PHASE OF HIGHWAY KETEREH TO KOK LANAS, KELANTAN

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WATER QUALITY MONITORING OF TWO MAIN RIVERS DURING CONSTRUCTION PHASE OF HIGHWAY KETEREH TO KOK LANAS, KELANTAN

ABSTRACT

River as source of freshwater to human and other living creatures. Construction activities are intensifying in Malaysia that revolve around river. River water quality are important during the construction phase to prevent pollution. This study was conducted to determine the water quality based on Water Quality Index (WQI) by Department of Environmental Malaysia of two main rivers during construction phase of highway Ketereh to Kok Lanas, Kelantan. The factors affected the water quality was identified during this construction phase especially the activity near to the river bank and river crossing, also any other external factor that affected river water quality. Control measures implemented by the contractor was determine to prevent the river pollution. Parameters in WQI taken into condition which are pH Value @ 25°C, Biochemical Oxygen Demand BOD-5 test @ 20° C (mg/I), Chemical Oxygen Demand (COD) (mg/I), Total Suspended Solids (mg/I), Ammoniacal Nitrogen : (mg/I), and Dissolved Oxygen : (mg/I), included E.coli. Lubok Sendong River located along the alignment of this highway project are considered as slightly polluted from year 2018 until 2020 within Class III and clean in the year of 2021 with the Class II. Meanwhile for Mahang River average condition within the Class III and considered as slightly polluted from year 2018 until 2021. The contractor of this highway project take extensive erosion and sedimentation control measures to prevent the both of river pollution by conducted Erosion and Sedimentation Control Measures approved by the local authority and designed by professional engineer. The maintenance of the control measures play important roles during this construction phase to ensure the effectiveness of sediment and soil loss into the rivers.

PEMANTAUAN KUALITI AIR BAGI DUA SUNGAI UTAMA KETIKA FASA PEMBINAAN LEBUHRAYA KETEREH KE KOK LANAS, KELANTAN

ABSTRAK

Sungai sebagai sumber air tawar kepada manusia dan kehidupan makhluk yang lain. Aktiviti pembinaan semakin rancak di Malaysia terutama di kawasan tepi sungai. Kualiti air sungai adalah sangat penting semasa pembinaan untuk mengelakkan pencemaran sungai. Kajian ini dijalankan untuk menentukan kualiti air berdasarkan Indeks Kualiti Air oleh Jabatan Alam Sekitar Malaysia, dua sungai utama semasa pembinaan Lebuhraya Ketereh ke Kok Lanas, Kelantan. Faktor-faktor yang mempengaruhi kualiti air dikenal pasti semasa fasa pembinaan terutama aktiviti berhampiran tebing sungai dan penyeberangan sungai, juga faktor luar lain yang menjejaskan kualiti air sungai. Langkah-langkah kawalan yang dilaksanakan oleh kontraktor adalah untuk mengelakkan pencemaran sungai. Parameter WQI yang dinilai dalam kajian ini adalah nilai pH @ 25°C, Permintaan Oksigen Biokimia BOD-5 @ 20° C (mg/I), Permintaan Oksigen Kimia (COD) (mg/I), Jumlah Pepejal Terampai (mg/I), Nitrogen Ammonia : (mg/I), Oksigen Terlarut: (mg/I), termasuk E.Coli. Sungai Lubok Sendong yang terletak di sepanjang jajaran projek lebuh raya ini dianggap sedikit tercemar dari tahun 2018 hingga 2020 dalam Kelas III dan bersih pada tahun 2021 dengan Kelas II. Manakala bagi keadaan purata Sungai Mahang dalam Kelas III dan dianggap tercemar sedikit dari tahun 2018 hingga 2021. Kontraktor projek lebuh raya ini mengambil langkah-langkah kawalan hakisan dan pemendapan yang meluas untuk mengelakkan kedua-dua pencemaran sungai dengan menjalankan Langkah-langkah Kawalan Hakisan dan Pemendapan yang diluluskan oleh pihak berkuasa tempatan dan direka bentuk oleh jurutera profesional. Penyelenggaraan langkah kawalan memainkan peranan penting semasa fasa pembinaan ini untuk memastikan keberkesanan kawalan sedimen dan kehilangan tanah ke dalam sungai.

ACKNOWLEDGEMENTS

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LIST OF SYMBOLS AND ABBREVIATIONS

NWQS	:	National Water Quality Standards for Malaysia
WQI	:	Water Quality Index
DOE	:	Department of Environmental
MCO	:	Movement Control Order
BOD	:	Biochemical Oxygen Demand
TSS	:	Total Suspended Solids
NH_3-N	:	Ammoniacal Nitrogen
COD	:	Chemical Oxygen Demand
DO	:	Dissolved Oxygen
MPC	:	Malaysia Productivity Corporation

CHAPTER 1: INTRODUCTION

1.1   General Introduction

Human and all other living creatures use freshwater in their daily life. Malaysia revolves around water and clean water is essential for healthy living and development of human civilization. Human activity especially construction activity near to the river can influenced the surface water quality. According to Malaysia Productivity Corporation (MPC) the construction industry plays an important role in any country's economic development. It provides great support to aggregate economy by backward and forward linkages with other sectors of economy. This industry needs professionalism, enthusiasm, and awareness in water quality during construction is done near the river.

According to Sisun et al. (2015), the development of land areas carried out in sensitive watersheds they normally caused negative effects on the river water quality. Furthermore, construction of highway will lead to exposing of the wide surface area to rain water droplets. If it happens within a period of long time and uncontrollable, it can lead to high penetration of sedimentary material into river and affected the quality of water (Razali, Syed Ismail, Awang, Praveena, & Zainal Abidin, 2018).

The construction of 6.2 km highway from Ketereh to Kok Lanas. This is the highway of Ketereh town and Kok Lanas town of Kota Bharu District in Kelantan will crossed two rivers namely Lubok Sendong River and Mahang River. Though this study, the effect of quality for the two rivers can be identified during the construction phase of this highway.

1.2   Problems Statements

The water quality of river are the most common problems in the Malaysia and several environmental river pollution episodes examples Kim Kim River and Selangor Rivers which has disrupted the activity of Malaysian citizen. Human and ecosystem survival depend on the water resources from river.

The Mahang River and Lubok Sendong River have been selected as the study of water quality, because the construction of highway will crossed these two rivers and it is importance to the community in Ketereh and Kok Lanas. However, with the

water run-off from the surrounding construction development area and the living water the water quality of the river has gradually deteriorated.

According to the Press Statement of Ministry of Environment and Water Malaysia on 18th April 2020, comparison of 29 automatic water quality monitoring stations (real-time) before and during Movement Control Order (MCO) due to covid-19, 28% water monitoring stations shown increased in Water Quality Index (WQI), 28% showed insignificant change and balance 44% shown slight decrease in water quality river. The press statement conclude that the main weather factor is monsoon transition which causes an increase in the frequency of rainfall up to contributes to increased levels of soil erosion and TSS concentration and also indicates that the temporary cessation of operations mostly industrial activities in the category of non-essential services and construction development projects during the period of MCO influence river water quality nationwide.

The pollution assessment of river using WQI as the basis for pollution load categorization and National Water Quality Standards for Malaysia (NWQS) as the designation of classes. The criteria that must be followed are pH Value @ 25°C, Biochemical Oxygen Demand BOD-5 test @ 20° C (mg/I), Chemical Oxygen Demand (COD) (mg/I), Total Suspended Solids (mg/I), Ammoniacal Nitrogen : (mg/I), and Dissolved Oxygen : (mg/I).

The source of pollution for the both rivers must be determined in order the control measures can be implemented.

1.3   Research Gap

The River Water Quality Report produced by Department of Environmental for year 2017 in Kelantan State does not included Mahang River and Lubok Sendong River. The construction of highway Ketereh to Kok Lanas is the biggest construction project on that area that could lead to the pollution of Mahang River and Lubok Sendong River.

However, the effect of river water quality using Water Quality Index (WQI) of Mahang River and Lubok Sendong River from construction of highway Ketereh to Kok Lanas have not been studied. The pollutant from construction activities could lead to the pollution of both rivers. It is important to address the association of

construction activities and the river water pollution. Thus, from the evaluation of Water Quality Index for the both rivers can be recognized and apply correct control measures to prevent the river water pollution.

1.4   Research Objectives

The research have the following objectives;

  I.   To determine water quality status at Mahang River and Lubok Sendong River
 II.   To obtain the factor that affected the water quality at the Mahang River and Lubok Sendong River
III.   To identify the control measures of river pollution

1.5   Scope of Study

The scopes of the study can be listed as follows;

  I.   This study of Mahang and Lubok Sendong Rivers water quality according to water quality index
 II.   Parameters in WQI was taken into condition which are pH Value @ 25°C, Biochemical Oxygen Demand BOD-5 test @ 20° C (mg/I), Chemical Oxygen Demand (COD) (mg/I), Total Suspended Solids (mg/I), Ammoniacal Nitrogen : (mg/I), and Dissolved Oxygen : (mg/I). And also parameter E.Coli.
III.   Monthly river water quality monitoring from January 2018 to February 2021.

1.6   Area of Study

The location of study is the town of Ketereh to Kok Lanas in Kota Bharu District in Kelantan State (Figure 1-1). The river water sampling sites for this study is at Mahang River located at Kok Lanas and Lubok Sendong River located at Ketereh.

Figure 1-1 Location Map for River Water Sampling

This study want to know the level of water pollution in Mahang River (WQ3 and WQ4) and Lubok Sendong River (WQ1 and WQ2) and its association with the construction activities of Highway Ketereh to Kok Lanas. The data of river water quality used by contractor for development and the construction of Highway Ketereh to Kok Lanas and apply the correct control measures to prevent the rivers pollution.

Figure 1-2 River Water Sampling Area at Lubok Sendong River

Figure 1-3 River Water Sampling Area at Mahang River

Location of river water sampling have been selected at Mahang River and Lubok Sendong River. These four number of sampling stations to represent the profiling of the river water location of monitoring within the study area at both rivers. The sampling times are in monthly basis from year 2018 until 2021.

The river water samples were monitored from two different sources which are Lubok Sendong River labeled with WQ1 and WQ2 refer Figure 1-2 and for Mahang River labeled with WQ3 and WQ4. River water analysis was conducted by consultant appointed by project proponent that are responsible for the construction of Project Highway Ketereh to Kok Lanas, Kelantan. The construction activities that could become sources of rivers pollution was observed during this study and any control measures implemented to prevent river pollution.

CHAPTER 2: LITERATURE REVIEW

2.1   The Importance of River

According to Department of Irrigation and Drainage Malaysia in their website, river is the source of natural that we must preserved for future generation and the main function of the river are is to flow water and sediments from its catchment area to the ocean. Human life socially and economically depend on the river, resulted settlement of human community concentrated along the bank of the river in addition, the river is source of food and water supply. River as main source for all life form including human, animals, plants and other including source of hydroelectric power turbine. To monitor the healthy condition of the river using the selected parameters the total suspended solid (TSS), dissolved oxygen, pH, ammoniacal nitrogen, chemical oxygen demand and biochemical oxygen demand in the data to be included in the calculation of Water Quality Index. Water Quality Index can be used in identification of the river water quality and the construction activity at the river can effected the quality of river because of the exposed soil in wide area can transport the pollution during the raining season to the river (H. H. Hasan, Jamil, & Aini, 2015). The Water Quality Index as a benchmark level in identification of river pollution in Malaysia. According to Pak, Chuah, Tan, Yong, and Snyder (2021) in the their research study that the Water Quality Index method introduced by Department of Environmental generally used to identify the quality of rivers in Malaysia need to improve with additional standard steps since this method are limited in the assessment of the missing values of the data and capitalization of the main information. Excessive input of the sedimentation from human activity pose a major threat issues to the lotic system at the river furthermore degrading the ecosystem with the high velocity of the river flow (Stone et al., 2021). According to the Xiao et al. (2021) the midstream the highest polluted river due to most of the human activities located at the midstream of Lijiang River and supported by Luo et al. (2021) in their research conducted at Yangtze River got the same result of the midstream river polluted with heavy metals. 21% of eroded soil at Swiss Midland contributed in water bodies' pollution (Remund, Liebisch, Liniger, Heinimann, & Prasuhn, 2021), numerous activities of anthropogenic with the rapid development increase the soil erosion at the river bank increase the pollution of river at Iju river of southwestern Nigeria. Okeke, Azuh, Ogbuagu, and Kogure (2020) concluded that disturbance of the river bank by the activities of urbanisation,

agriculture, sand mining and dredging of the riverbeds lead to the high sedimentation in the Iju River.

Detention pond with the designed according the Urban Storm water Management Manual by Department of Irrigation and Drainage play an important role for water quality in treat the storm water run-off before release to the streams and creeks, but recent year shown the development of surrounding the detention pond effected run-off water quality and shown that several parameters within Class II to III is the quality of water is slightly polluted (Awang Ali & Bolong, 2021). This study shown that improper control measures for erosion and sedimentation could lead to the pollution of the rivers.

Most the big city had been developing near to the river because of human used river for transportation, water resources, and source of food. The quality of river can be affected by human activities such as land development and agriculture activity. Lack of awareness in the importance of river among human increased the number of polluted rivers every year. Most human didn't realize that their activities can be source of the pollution to the river example most villager people directly connected municipal wastewater to the home drainage then this drainage connected to the main drainage that going to the river. Even certain farmer at the village in small scale of livestock for chickens, goats, cows, pigs and ducks directly discharge the effluent waste to the river or drainage. This untreated municipal wastewater could affect the quality of river. The finding concluded that from mass production of livestock to the small industries of breeding at the small farm with the improper treatment of wastewater can polluted the river water quality (Wenchao Li et al., 2020). Even in certain premises such as restaurant in the town by pass their sink piping flow for dish washes directly to the monsoon drain without grease trap. Indirectly/directly human activities could lead to the pollution of river. Lee Goi (2020) concluded that during sudden stoppage of human activities during the Movement Control Order (MCO) on 18th March 2020 in Malaysia has increased the quality of most rivers in Malaysia.

2.2   Water Quality Parameter

The factors contribute of river water quality are the presence pollutant in the river. The range of water parameter generally collected in the assessment of river water quality. The water parameters generally divided in the group of chemical, biological and physical characteristics. The different group of water parameters, chemical,

biological and physical can be measured to monitoring the river water quality according to the standard practice according to the different regulatory bodies (Gupta, Pandey, & Hussain, 2017). In Malaysia, Department of Environmental introduces the standard in measuring river water quality called National Water Quality Standard for Malaysia (NWQS). Some specific of river water quality selected in this research the total suspended solid (TSS), dissolved oxygen, pH, ammoniacal nitrogen, chemical oxygen demand and biochemical oxygen demand present in to Water Quality Index for pollution class which has relation in the quality of water measured and identification in source of pollution. Phosphorus play an important role for the algae growth in the river ecosystem, according to Temporetti, Beamud, Nichela, Baffico, and Pedrozo (2019), the low concentration of phosphorus due to the high pH reading, and it's important to ensure the pH value within the standard limit avoid any degrading of the algae growth population. Further study by Yin et al. (2021) of the high organic pollutant at Minjiang River, China as reason the high concentration of Total Suspended Solid and lead to the toxicity of the water. Insufficient of dissolved oxygen in the river lead to the decreasing of fish productivity and breeding activity (Qiang et al., 2019). Human depend on the fish as source of food, decreasing of fish population in the river effect the fish supply in the food of chain for human and other life. The wastewater release to the waterbody without treating the ammoniacal nitrogen and other source of pollutant become major problem to the fisheries industry indirectly affected the ecosystem in the river (Patil, Bhandari, & Ranade, 2021). The oxygen gas that dissolved in river or water refer to dissolved oxygen (DO), the main source of DO from aquatic plants and phytoplankton, the important purpose of the DO used to indicate the quality and health of river, fresh water, and the stream (Kibria, 2017). Miller Neilan (2013) study shown the low concentration of DO level in the river water quality reduce the population of fish in the ecosystem. Zhang et al. (2017) stated in the study at Hai River Basin, China that ammoniacal nitrogen and chemical oxygen demand (COD) can fluctuate the reading of dissolved oxygen and affected the quality management of river. Park and Allaby (2017) defined that the domestic waste water come from the human daily activity such as kitchen, bath, washing machine and other activity which are widely known as wash water that could lead to the increasing of chemical oxygen demand and chlorine demand in the water basin without treatment according to the Teng, Luo, Zhou, Wang, and Hapeman (2021) in their study.

2.3   Significant in Selection of River Water Quality Parameter

a.   The factors Total Suspended Solid (TSS)

Weight-dried of particles in the suspended form in the water called Total Suspended Solid (TSS). These particles in the suspended form of solid physical characteristic are not dissolved in the water or flow of river and can be trapped using the filter then can be analysed using filtration apparatus to measure the quantity being trapped in unit of mg/L. Amin (2020) stated that this water quality parameter the Total Suspended Solid (TSS) are the group of solid form organic and mineral in the size of particulate matter that can be filter or trap using the filter paper and not through the filter which are contain sediment, the soil or silt materials, clay from muddy area, metal oxides the metal materials including the sulphides, algae in the water, bacteria in the water and also the fungi. Asyhar and Widodo (2012) the pollution of Surabaya River come from industrial area discharge of untreated wastewater to the river and also the individual home (non-industrial category) and the data collected is only Total Suspended Solid (TSS) no other water quality parameters. The National Water Quality Standard for Malaysia stated that the parameter of Total Suspended Solid (TSS) must be measure to monitor the quality of river. The standard in Malaysia is below 25 mg/L and categorized as natural condition Class I. The quality of river can be measured by the concentration of TSS at the surface water of the river and become a standard by the regulatory to monitor the river water quality as stated by Kusari (2017).

b.   Dissolved Oxygen

The amount of oxygen gas dissolved is the one of the water quality parameter to be measured called Dissolved Oxygen (DO). The all form of life in the aquatic ecosystem are depend to the Dissolved Oxygen (DO) for the importance role of chemical and biological process with the river, lake, ocean, and other water bodies. The source of Dissolved Oxygen mainly from diffusion of oxygen at the atmosphere to the water body and also the oxygen gas released during the process of photosynthesis by aquatic

plants. In measuring of pollutant using the Dissolved Oxygen is essential in measuring of river pollution (Wenjing Li et al., 2020). The measurement of oxygen gas demand substances in the water such as biodegradable of organic matter and nutrient particles that caused of river water pollution. The Malaysia National Water Quality Standard for Dissolved Oxygen (DO) is below 7 mg/L in the Class I (Natural Condition). Dissolved oxygen as a measurement in river water quality performed better with the Artificial Intelligent modelling such as GEP provide optimum input result (Kisi et al., 2013).

c. Ammoniacal Nitrogen

One of the parameter for river water quality is Ammoniacal Nitrogen. The analysis of this parameter of nitrogen and phosphorus are the importance element of nutrient for aquatic plant and aquatic animals for their growth and food. The high concentration of this nutrient increase the production of aquatic plant especially the algae. Uncontrollable of algae growing in the river because of the high nutrient can form the phenomena of algae bloom (Whitehead, Cooke, & Chapman, 1967). The high concentration of algae in the river can make the sun light not easily to through and other aquatic plant cannot do the photosynthesis process and live age of the algae is very short are bloom condition of algae will make them die in huge quantities. The decomposition process of algae will decrease the oxygen level in the river and affected other aquatic animals who using the oxygen for breathing purpose. The algae decompose process also will increase the bad odor, change the color of river to the black color and will not suitable as fresh water for human usage in their daily life. It is importance for us to monitor the quality of river by using this ammoniacal nitrogen parameter to monitor the pollution of river. In Malaysia standard must below 0.1 mg/L in Class I the natural condition. According to Nuruzzaman, A.A, and Salleh (2017) the monitoring of Ammoniacal Nitrogen during process of Pusu River Rehabilitation are main component in the success of this process.

d. Chemical Oxygen Demand

The water quality parameter of Chemical Oxygen Demand (COD) is generally being used the susceptible level of oxidation for compound organic and also the inorganic naturally exist in the river or other water body. The high level of COD in the river will effect to the human health and the algae bloom from organic waste including the contamination of source of food in this case is seafood consumption. The increasing level of COD in the water body can reduce the amount of Dissolved Oxygen (DO) that are important to the aquatic life and created the dead zone of the area. The pollutant from land to the water body increase the concentration of COD (Chi et al., 2020). The standard of National Water Quality Standard for Malaysia, the COD concentration in the river is 10 mg/L classified as Class I. The important index of water parameter in measuring the organic pollutant is chemical oxygen demand that widely used in certain countries to monitor the river water quality (Latif & Dickert, 2015).

e. Biochemical Oxygen Demand

In the river, Biochemical Oxygen Demand (BOD) being used in measure the biochemically degradable of the chemical organic compound and the load of carbon. Commonly the Biochemical Oxygen Demand (BOD) is the amount where the oxygen dissolved in the amount of water required by aerobic biological organism to break organic chemical compound in this context is the river within certain temperature and period of time. In river water sample the BOD is the approximate of biochemical degradable of organic compound (Silva Pinheiro, Bertacini de Assis, Sanches, & Moreira, 2020). BOD 1.0 mg/L according to the National Water Quality Standard for Malaysia classified the in Class I in natural environment condition. This parameter value of BOD is commonly used as robust surrogate in measuring of river quality for the degree of the pollution organic compound the impact of high BOD will effect of the ecosystem in the river. The pollution in the natural ecosystem of the river represented by the BOD in process measured the organic pollutant which has caused serious pollution in the river (Chee, 2011).

f. E-coli

E-coli come from waste discharge from animals and also human end up in water resources that include rivers and lakes. This e-coli could be found in the contaminated water supply to the local population. The contaminated water with e-coli could get people sick with diarrhea. Pini and Geddes (2020) stated in their research study wastewater pollution due to increasing population of the human and urbanization at the city, could affect the ecosystems of the Chicago River water and increase the contaminants of abiotic and biotic the e-coli.

g. pH

The pH of water parameter is use to read the acid and alkali indicator in the water. The range of scale for the parameter pH is between zero (0) to fourteen (14), the lowest zero (0) is very acidic and fourteen (14) is very alkaline. The pH shown seven (7) is neutral condition. The natural condition of river is range of 6.5 to 8.5 pH categorized Class I according to National Water Quality Standard for Malaysia by Department of Environmental. The pH value in the river affected the production sperm for male in aquatic fish and affect the reproduction of fish species in the river according to Gupta et al. (2017). The selection of pH as a parameter in measuring river water quality is very significant to ensure the pH within the standard limit and protecting the balance in natural ecosystem of aquatic life. The pH parameter are crucial in monitoring of water quality and the safety of the aquatic ecosystem (Qin et al., 2018).

2.4   Water Quality Index

According to the Press Statement of Ministry of Environment and Water Malaysia on 18th April 2020, comparison of 29 automatic water quality monitoring stations (real-time) before and during Movement Control Order (MCO) due to covid-19, 28% water monitoring stations shown increased in Water Quality Index (WQI), 28% showed insignificant change and balance 44% shown slight decrease in water quality river. The press statement conclude that the main weather factor is monsoon transition which causes an increase in the frequency of rainfall up to contributes to increased

levels of soil erosion and TSS concentration and also indicates that the temporary cessation of operations mostly industrial activities in the category of non-essential services and construction development projects during the period of MCO influence river water quality nationwide.

Abdul Karim and Kamsani (2020) in their research stated that the Department of Environmental Malaysia (DOE) use the Water Quality Index (WQI) formula in measure the status of quality for the rivers and water for people drinking in Malaysia as a standard practice. The six (6) parameters of water which are total suspended solid (TSS), dissolved oxygen, pH, ammoniacal nitrogen, chemical oxygen demand and biochemical oxygen demand will be collected and analysis in the accredited laboratories by National Laboratory Accreditation Scheme (SAMM). These parameters will be embedded into the standard calculation or formula to measure Water Quality Index (WQI). The result value from this formula or calculation can use to measure the Class of the formula and this class can show the status of river water quality.

Nowadays the river pollution become a very hot topic among Malaysia citizen since the polluted river because of pollution from effluent release affected in fresh water supply to the local people in Selangor. This issue has drastically increased the awareness among the citizen that important of river and what the activities can pollute the rivers as source of fresh water supply. wan ahmad and Mohd Yusof (2013) in their research stated river without properly manage can give a negative impact to human life and health condition, aquatic ecosystem and also the environmental surrounding, the study at Kangar River in Perlis state using the Method of formula the Water Quality Index (WQI), data collected from three (3) stations for period of three (3) months shown that station no. 3 is the lowest quality because of the wet market nearby discharge the waste water directly to the river as classified as Class IV to V compare to the station no. 1 and station no. 2 the results classified as Class II to IV. These data show that Station no. 3 the quality is in the polluted range whereas Station no. 1 and station no. 2 are in the class slightly polluted. The assessment of river water quality using six (6) crucial parameters and analysing the data using Water Quality Index and its formula can be used to determine the condition of the rivers and the water quality (Wu, Lai, & Li, 2021).

The water quality of UTM river being measured using WQI that used 6 type of parameter which is DO, COD, BOD, pH, turbidity and TSS, the result shown that the river is slightly polluted because of the activity from horse farm, sanitary from household and also construction activity without improper control measures to prevent the river pollution (Ang & Ma'arof, 2015) in fact this study supported by A. Othman (2021). Anthropogenic factors are the main reason for the WQI at Langat Basin within class II to class III (Hoo, Samat, & Othman, 2021). The Water Quality Index become the indicator in measuring the quality of the river in Malaysia (I. Abidin, Juahir, Azid, Dasuki, & Azaman, 2015).

According to Zainudin (2010) Water Quality Index ascribes quality value to an aggregated set of measured parameters that usually summarise the data of water quality to a specific simple term and easily to the local people to understand the result. F. Othman, Mohamed Elamin, and Mohamed (2012) in their study stated that parameter of river water quality are important to be monitored and preserved by evaluation of Water Quality Index, and during the development of Kuala Lumpur and Selangor, the river quality will be affected by point and non-point source of the pollution. The application of Water Quality Index in study the pollution of River Landzu demonstrated promising result in determine the pollution condition of the river because of the effluent discharge from industries of cottage, sewage waste water, agriculture activities and also the urban water discharge from drainage system at the town near to the river (Yisa, 2010).

2.5   River Pollutant and Water Quality

River pollution is the changes of chemical, biological and physical characteristic of the water from its natural condition because of the waste and other substances. According to National Geographic (2012), human used 2.5% overall raw water in this world as a water resources for 70% in agriculture, 22% in various factories industry and 8% for daily household. However, human daily activities affected the river water quality. The river water quality affected by improper waste disposal, activities from agriculture, service and industrial sector, as well land clearance development which contributes to the increase of the sedimentation and erosion to the river. Study at the Linggi river by Razak, Aris, Zakaria, Wee, and Ismail (2021), indiscriminate discharge of effluent and waste water increase the heavy metal in the river. Improper treatment of wastewater or run-off water from development area could affect the river

water quality (I. Lee et al., 2017). Study of pollution of Langat River Basin by Ahmed, Mokhtar, and Alam (2020) because of the lack of awareness among the public and industry and government policy enforcement in the sustainability of the water resources increase the pollution of the river and this study supported by (Awang, 2006); Azmin and Amiruddin (2021). The pollution of Langat River increased the WQI and effected the river water quality (Syaiffudin & Toriman, 2020). Failure of regulatory policy and naive water safety implementation by the local government lead to the increasing of river pollution in Malaysia (H. Hasan, Parker, & Pollard, 2021). Two third out of total rivers in Malaysia are slightly polluted or polluted and lead to the loss of the river ecosystem (Khalid, Mokhtar, Jalil, Rahman, & Spray, 2018). Erosion and sedimentation from natural process and other human activities such as mining, household, construction and industrial activity lead to the high heavy metal sediment in the riverbed (Effendi, Kawaroe, Mursalin, & Lestari, 2016). Every year the construction activities and land reclamation increased near to the river and effected the river water quality by the pollutant of sediment from construction activities and reduce the size of river estuary (X. G. Wang et al., 2019). Sisun et al. (2015) stated that land development activities are carried out in sensitive watersheds they normally caused negative effects on the source of the water catchment area. Soil erosion especially at the river bank can increased the sedimentation in the river and will affect the quality of river, without proper control measured the sediment will directly into the water body (R. Z. Abidin, Sulaiman, & Yusoff, 2017). Near to the river bank during the construction of bridge in the highway project, various activity of earth work, pilling, excavation work and concrete activity without proper control of erosion and sedimentation, the sediment will directly to the receiving body and affect the river water quality. Furthermore, construction of highway will lead to exposing of the wide surface area to rain water droplets. The surface area without erosion stabilization in the period of long time and uncontrollable, it can lead to high penetration of sedimentary material into receiving water body and lead to water pollution (Eisakhani, Abdullah, A Karim, & Malakahmad, 2011). Sedimentation control measures and management strategies are important to control and reduce the high sediment discharge to the main river in prevention the continuous pollution because of the human activity (Ai-jun, Xiang, Zhen-kun, Liang, & Jing, 2020; Ren, Zhang, Wang, Yuan, & Guo, 2021).

The Project involves the construction of a 6.2 kilometre Highway from Kampung Buluh Poh, Ketereh at CH 18700 to Kampung Sokor, Kok Lanas at CH 25000. The main objective of this construction project is to build a new road based on 4-way 2 lane. Project activity and environmental issues concerned was sedimentation from earthworks including land clearance and excavation work could lead the potential impact of increasing in erosion and sedimentation were the main cause of rivers pollution. Other potential impacts were improper management of construction materials stockpiles, oil spill and leaks, and the indiscriminate waste disposal. With that, improper control measures of earthwork activities and land clearance such as deforestation could lead to the pollution of nutrient and organic at the Bentong river (Shehab, Jamil, Aris, & Shafie, 2021), construction of road and buildings and so on were activities that can cause deterioration of the water quality as happened at the Telom River and Bertam River in Cameron Highlands (Weng & Mokhtar, 2011). Jia, Zhou, Lei, Jing, and Shen (2020) in their study stated that the large scale construction of expressways crossing the Three- River Headwater Region effected the environmental surrounding especially the quality of rivers and the ecosystem, this kind of variety of impact without the proper planning and environmental protection and control measures applies during this mega construction project.

The result of Water Quality Index and fish resources in Sungai Galas in Kelantan state are beneficial studies to identify the river water quality from human activities and effect of fish population (Hashim & Ismail, 2015). Human are depend on the water from river especially as source of food. The fishing industry in certain area depends from river as their main source of fish. Poon, Herath, Sarker, Masuda, and Kada (2016) in their research study concluded that activities from human at the development area discharge the effluent without proper treatment effected the fish population in the ecosystem of the river and affected the source of food for human. The anthropogenic activity at east coast of Terengganu offshore water lead to the micro plastic pollution in the fish population at that area and lead to the human health effect (Taha, Md Amin, Anuar, Nasser, & Sohaimi, 2021). Human health are mainly depend on the clean water resources, urbanization without improper control could lead to the river water pollution (Murad & Pereira, 2019). The east coast area of Malaysia are depending the tourism industry, Azam, Mahmudul Alam, and Haroon Hafeez (2018) in their study stated that the environmental pollution decreased the number of tourist. The activity of agriculture industry will polluted the bottom of the

river without improper control measures for the parameters of nitrate and ammonia at the Bagan Pasir, Perak (Joni et al., 2021). The source of pollution at the upstream due to the development of economic activity, lead to the heavy metal pollution of Kelantan River (A.-j. Wang et al., 2017). The Citarum River at West Java continuous to deterioration and pollute by the activities of agriculture, industrial and hydro power plant without proper control measures of water discharge, Terangna Bukit (1995) recommend the small domestic water treatment plant and centralized treatment plant for water pollution prevention in that area. A study conducted by Mustakim, Ramli, and Chan (2019) showed high level awareness of river pollution at Penang River and the cause of the pollution, but there is no action taken by the local people to prevent the continuous pollution of the river from waste disposal activity and according to the Syofyan (2019) local people at the upstream and downstream of the river bank play an important role in preserved the quality of river by prevent the cause of the river pollution. The level of education shown differentiate the behavior of local people live the near to the river on pollution control of river (Alias, 2019; Alias & Amin, 2019). Government main role in the enforcement according to the law in protect the river from pollution and not affect the economy of the local people who are depend to the river (Abdul Rahman, 2020). The main economy of people in Ketereh and Kok Lanas in Kelantan state were produced of rice (Terano, Mohamed, & Din, 2016). The paddy field in Ketereh and Kok Lanas Kelantan depend on the rivers and connected to the KADA drainage for paddy field area. Even a study conducted by M. Othman, Samat, and Sulaiman (2021) at Burung River, Selangor showed an increase in several parameters such as pH, DO, COD, BOD, TSS and turbidity when the water pass the paddy fields. Even a study conducted by Lin (2021) that major pollution in UTM river are source from the construction activity such as earthwork, land clearance, river bed digging, the river bank erosion from bridges and tunnel construction, slope failure during road construction and other infrastructure. The further study by A and Subramanyam (2021) at UTM river suggested the drastic control measures must be implemented to prevent the continuous pollution of the river. The Lubok Sendong River and Mahang River has been chosen for the research study area since the biggest construction project in Kelantan State of highway Ketereh to Kok Lanas will be crossed these rivers. The studies has been done at river in Korea shown that river water quality can be affected by construction activity (Im, Kim, Nishihiro, & Joo, 2020). The construction project without proper control measures will affect the river water quality because of the heavy sedimentation from earth work activity. The

erosion and sedimentation control with proper design and correct implementation strategies in preventive the pollution of river by the run-off water from site activity are critical and main part for the development process of the areas (Parker, 2014). The river water quality data collect in this research will be presented in Water Quality Index. The chosen rivers of Lubok Sendong River and Mahang River can be measure the level of water quality and source of the pollution. This data can help the contractor and project proponent to improve their control measures of sedimentation and erosion in ensuring the heavy sedimentation from earth work activity not affected the quality of both of rivers. The river water quality status from this research can be measured and in case of pollution to these River of Lubok Sendong River and Mahang River can affected the local people along the river and paddy field area in Ketereh and Kok Lanas area in Kelantan state since both river connected to the drainage system of KADA.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Water Quality Monitoring

In the determination of water quality status at Mahang River and Lubok Sendong River, the results collected from Environmental Monthly Monitoring Report of the Project Highway Ketereh to Kok Lanas, Kelantan prepared by Environmental Monitoring Consultant.

Water quality sampling conducted by environmental monitoring consultant appointed by the project proponent as detailed in the following Standard Operation Procedure (SOP):

- Only sterile collection bottles be used for water sampling;
- The inner sides, the opening or inside of the cap of the collection bottles not be touched to avoid any contamination that will effected the quality of the results;
- The collection bottles rinsed with water at the sampling point before water samples are collected;
- The collection then be sealed and labelled once the sample is collected;
- Label of the bottles include date, time, place, weather conditions, (e.g. dry, wet or heavy rain) and name of the person who collected the sample;
- Potential impacts causing activities, water flow condition and other physical characteristics of the area being noted for reference; and
- The sample of water be chilled or kept cooled in an icebox (temperature approximately 4°C) for temporary storage and sent to the laboratory as soon as possible or within 48 hours of collection where transport of samples in the insulated container.

Analysis of sample carry out at a Skim Akreditasi Makmal Malaysia (SAMM) accredited that have been appointed by consultant. Analysis of water quality for the river or drainage system by following the Standard Method for the Examination of Water and Wastewater (1990) 20 Editions APHA, AWWA as tabulated in Table 5.10.

The standard test method used for Water Quality Sampling and Analysis as table below;

Table 3-1: Standard Test Method

Parameter	Standard Test Method
Chemical Oxygen Demand (COD)	APHA, 5220 C
Biochemical Oxygen Demand (BOD)	APHA, 5210 B
Total suspended solid (TSS)	APHA, 2540 D
Ammoniacal Nitrogen (NH3-N)	APHA 4500-NH3 C
pH Value	APHA 4500 –H+B
Dissolved oxygen (DO)	APHA, 4500-O G
E. Coli	USEPA, 1603

3.2 Parameter

The water quality parameter below tested by environmental consultant appointed by

the project proponent of Project Highway Ketereh to Kok Lanas Kelantan.

3.2.1 Accredited Laboratory:

   a. Chemical Oxygen Demand (COD)

   b. Biochemical Oxygen Demand (BOD)

   c. Total suspended solid (TSS)

   d. Ammoniacal Nitrogen (NH3-N)

   i. E. Coli

3.2.2 In Situ:

   e. pH Value

   f. Dissolved oxygen (DO)

3.3 Location, frequency and the duration of water quality monitoring

The location of this study are the Lubok Sendong River and the Mahang River which are located in this highway of Ketereh to Kok Lanas, Kelantan. The location of this water sampling presented in Table 3-2 and Figure 3-1.

Table 3-2: Location, frequency, duration and Sampling Coordinates

ITEM	SAMPLING COORDINATES			LOCATIONS	FREQUENCY	DURATION
WATER QUALITY	WQ1	5°56'54.2"N, 102°16'13.0"E	Upstream	Lubok Sendong River	Monthly	January 2018 – February 2021
	WQ2	5°57'02.1"N, 102°16'25.2"E	Downstream			
	WQ3	5°54'24.1"N, 102°16'01.7"E	Upstream	Mahang River		
	WQ4	5°54'21.9"N, 102°16'12.4"E	Downstream			
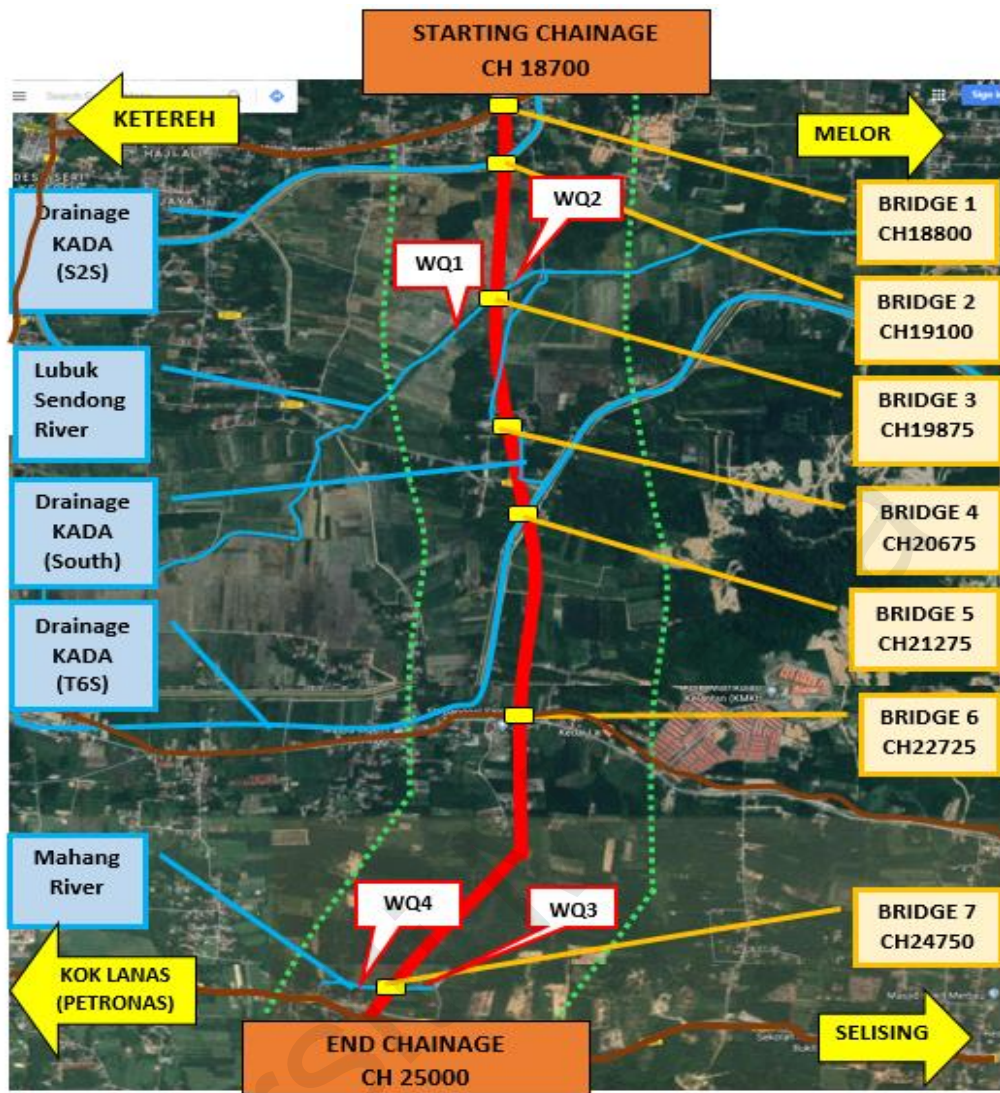
Figure 3-1: Location of Water Sampling

Table 3-3: Legend of Figure 3-1

	Highway Alignment
	Current Road
	1 km distance from project
	River and KADA drainage
	Bridge
WQ	Water Quality Station

3.4   Data Analysis

Indicative value produces by Water Quality Index and compared to the given standard by Department of Environmental. Then both rivers, the quality can be estimated. The collect data will be used to calculate the subindex and Water Quality Index using the formula given by the Department of Environmental. Observation of the construction activity and its surrounding area and also the river pollution control measures implemented by the contractor will be recorded for data analysis.

3.5   Identification of Factor effected the water quality

Identification of factor effected the water quality by conduct observation at both river bank, the factor and construction activity that could lead to the water pollution and this study also used the secondary data analysis of Environmental Monthly Monitoring Report from the registered consultant appointed by project proponent. Observation of the control measures implemented by project proponent in control run-off water from construction area to the river basin. Interview with contractor appointed by project proponent also done to find out the impact of construction activity to the river water quality and with the local rice farmer because of the surrounding site and river are rice fields.

3.6   Identification of Control Measures to prevent the water pollution

To prevent the water pollution from construction site activities especially near to river bank that could lead the pollution of river, project proponent should apply the control of erosion and sedimentation and also the run-off water from site. Project proponent already conducted the Environmental Impact Assessment of this construction project to identify the impact of land disturbance and earth work activity that could lead to the environmental pollution. Environmental Management Plan and Erosion and Sedimentation Control Plan are the plans established by the project proponent in controlling the environmental pollution during the construction phase of this project. In addition the observation at site

and meeting with the project proponent were also conducted to find out the current control measures are following the Environmental Management Plan and Erosion and Sedimentation Control Plan during the planning phase of this highway project.

CHAPTER 4: RESULTS AND ANALYSIS

4.1 Water Quality Status and Analysis

4.1.1 Lubok Sendong River

Two (2) locations from Lubok Sendong River along the proposed alignment of the Highway Ketereh to Kok Lanas, Kelantan were identified for water sample collection where the water samples collected were analyzed for a set of parameters from year 2018 until 2021 as shown in the Table 4-1, Table 4-2, Table 4-3 and Table 4-4. There are seven parameters analyzed for water quality monitoring in this construction project. pH, BOD, COD, TSS, NH_3-N, DO and E.coli.

All the red color results in the Table 4-1, Table 4-2, Table 4-3 and Table 4-4 indicates exceed the limit of recommendation DOE standard for water quality and ND were not detected. All parameters complied with DOE limit at the two (2) locations of monitoring points except in year 2018 for the month of January, August, September and October BOD, COD, TSS and NH_3-N for WQ1 then WQ2 are BOD, TSS and NH_3-N. In year 2019 to 2020, parameters of BOD, COD, TSS, NH_3-N and DO exceed the limit by DOE standard. For year 2021 only one (1) parameter exceed the limit in the month of January which is BOD at the location WQ1 and for the location of WQ2 two (2) parameters exceed the limit which are BOD and COD in the month of January and for February only one (1) the BOD. The high TSS level might cause high BOD level in the same station because high suspended solids might be the reason of high oxygen demand supported by Jingsheng, Tao, and Ongley (2006) in their study. Most of suspended solids are made up of the inorganic materials, though bacteria and algae can also contribute to the total solids concentration, according to Buehler et al. (2012) use TSS as indicator for algae mass at Deer Creek Reservoir. These solids include the anything drifting or floating in the water, from sediment, silt and sand plankton and algae. Organic particles from decomposing materials can also contribute to the TSS concentration and supported by Daraigan et al.

(2007) in their research study. The concentration for DO already high at the upstream the WQ1, the concentration of DO also will be high at the downstream the WQ2 this refer to the table 4-2 for the month of May in year 2019 but for the month of August the low DO might be because of the excessive algae in the river. The concentration for BOD already high at the upstream the WQ1, the concentration of BOD also will be high at the downstream the WQ2 this refer to the table 4-1 for the month of May, September and October in year 2018, refer to the Table 4-2 for the month of March and September for year 2019, refer Table 4-3 for the month of January, February, May, July, October, November and December for year 2020. Refer Table 4-2 in month of Jun 2019 and Table 4-4 in month of January 2021 the WQ2 exceed the limit by DOE standard because of high sedimentation in the Temporary Earth Drain from site to the Lubok Sendong River because of excavation activity nearby the river. The concentration for NH_3-N already high at the upstream the WQ1, the concentration of NH_3-N also will be high at the downstream the WQ2 this refer to the table 4-1 for the month October in year 2018, refer to the Table 4-2 for the month of April, September and October for year 2019. According to Zhou, Li, and Huang (2021) the high level of NH_3-N could be because of the fertilizer for crops of agriculture development since the Lubok Sendong River located along the paddy field area at the Ketereh and oil, waste water from residential area source from bathroom and kitchens. The concentration for TSS already high at the upstream the WQ1, the concentration of TSS also will be high at the downstream the WQ2 this refer to the table 4-1 for the month of January in year 2018, refer to the Table 4-2 for the month of July and September for year 2019, refer Table 4-3 for the month of June and October for year 2020. Table 4-2 for the month of July of for year 2019, WQ1 is 60 but the WQ2 is higher with the value is 203 because of the construction of temporary bridge by the contractor. The downstream the WQ2 this refer to the table 4-2 for the month of January and February in year 2019, the TSS value are 53 and 56 exceed the limit by DOE because of monsoon

season in the east coast area and Silt trap installed by the contractor full will sediment, contractor have been request to do the maintenance of silt trap and result shown for the month of March is comply with the DOE limit after maintenance of silt trap. Soil erosion at the river bank because of the construction activity could lead to the high sedimentation flow into the river and Diwakar and Thakur (2012) stated the sedimentation from soil eroded alter the river water quality. The suspended solid cause the river water to be cloudy correlate with the high level of turbidity and cause of deterioration of river water quality status and lead to several issues to the local communities and aquatic life (Bilotta & Brazier, 2008). It is understandable because there are lot of non-point sources along the sampling stations so the pollution might not because of the construction activity at the site since the project contractor installed the soil and erosion control measures to prevent the water pollution. During the monsoon seasons for the month of November to January, the paddy field areas will be received more rains compare to the other months, this will lead the paddy field farmers to release the cloudy water with brownish color into the river to avoid flood in their paddy fields. This is of the major factor contributing the parameters exceed the limit by DOE standard and according to Azman, Ramli, Che Othman, and Shafiee (2021) during the monsoon season in Peninsular Malaysia contributed the higher amount of debris in the water stream.

The water sampling not conducted on month of March until April for year 2020 refer table 4-3 due to the Movement Control Order (MCO) by Government of Malaysia because of the Covid-19 pandemic.

Table 4-1 Water Quality Status for Lubok Sendong River for year 2018

Year		Year 2018											
Parameter		Jan (Baseline)	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Unit		mg/l unless otherwise stated											
WQ1	pH	6.25	6.30	6.93	6.35	6.39	6.70	6.22	6.33	6.32	6.59	6.51	Abundant Water
	BOD	ND	ND	ND	ND	7	ND	ND	5	8	6	ND	
	COD	16	13	10	6	25	10	13	19	29	22	16	
	TSS	345	45	28	17	26	15	37	18	45	44	9	
	NH_3-N	0.11	0.13	0.09	0.11	ND	0.18	0.11	ND	0.07	0.41	0.18	
	DO	6.25	6.26	6.31	6.33	6.21	6.34	6.27	6.24	6.20	6.25	6.8	
	E. coli	40	55	35	<10	15	<10	<10	70	50	80	15	
WQ2	pH	6.58	6.09	6.59	6.25	6.33	6.61	6.18	6.24	6.12	6.61	6.48	Abundant Water
	BOD	ND	ND	ND	ND	ND	ND	ND	ND	ND	5	ND	
	COD	10	16	19	6	9	13	10	16	16	19	16	
	TSS	65	47	31	14	22	11	37	59	41	69	12	
	NH_3-N	ND	0.16	0.09	0.26	ND	0.17	0.09	0.09	0.41	0.37	0.17	
	DO	6.29	6.26	6.29	6.38	6.32	6.27	6.32	6.25	6.29	6.28	6.27	
	E. coli	95	45	30	<10	<10	<10	<10	<10	55	70	25	

Table 4-2 Water Quality Status for Lubok Sendong River for year 2019

Year		Year 2019											
Parameter		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Unit		mg/l unless otherwise stated											
WQ1	pH	7.58	6.67	7.61	7.09	6.93	6.99	6.89	7.42	7.62	7.58	7.23	8.11
	BOD	ND	ND	6	ND	ND	5	5	3	6	5	4	4
	COD	13	13	10	13	13	19	19	13	22	19	10	10
	TSS	45	46	14	48	44	42	60	22	54	34	24	38
	NH_3-N	ND	ND	0.23	0.39	0.13	0.21	0.21	0.19	0.58	0.30	0.07	ND
	DO	6.35	7.31	6.02	4.74	8.16	4.92	5.09	4.03	4.12	5.50	4.15	4.74
	E. coli	95	140	20	ND	15	50	20	60	30	15	ND	ND
WQ2	pH	7.46	6.57	7.33	7.02	6.83	7.03	7.02	7.38	7.58	7.40	7.20	7.98
	BOD	ND	ND	ND	5	ND	8	3	5	3	4	5	4
	COD	10	16	13	19	10	32	13	20	13	16	16	13
	TSS	53	56	16	38	31	47	203	27	52	39	38	42
	NH_3-N	ND	ND	0.23	0.53	0.20	0.15	0.15	0.22	0.51	0.60	ND	ND
	DO	6.29	7.20	6.08	4.94	8.10	4.08	5.09	3.82	4.04	5.10	3.91	4.69
	E. coli	180	120	15	240	25	90	20	80	95	25	25	20

Table 4-3 Water Quality Status for Lubok Sendong River for year 2020

Year		Year 2020											
Parameter		**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Unit		mg/l unless otherwise stated											
WQ1	pH	7.01	7.00	MCO	MCO	6.76	6.71	8.09	7.78	7.56	6.12	5.94	7.19
	BOD	8	8			8	4	13	5	5	7	8	7
	COD	22	22			25	13	44	16	16	26	29	25
	TSS	13	11			11	56	46	10	10	106	8	17
	NH$_3$-N	0.19	0.10			0.01	0.20	0.20	0.13	0.12	0.16	0.29	0.21
	DO	6.25	6.43			4.63	4.36	5.25	4.72	4.28	5.84	5.31	5.86
	E. coli	30	10			10	0.1	ND	20	40	20	ND	ND
WQ2	pH	6.92	6.97	MCO	MCO	6.75	6.63	7.77	7.75	7.57	6.28	6.16	7.26
	BOD	5	8			5	4	11	5	5	8	10	10
	COD	13	22			16	13	38	19	19	29	35	35
	TSS	11	30			14	77	39	10	12	35	292	24
	NH$_3$-N	ND	0.14			0.12	30.00	0.22	0.11	0.12	0.17	0.12	0.21
	DO	6.22	6.50			4.65	4.34	5.41	4.65	4.55	5.36	5.76	5.90
	E. coli	40	ND			ND	ND	40	200	25	65	80	ND

Table 4-4 Water Quality Status for Lubok Sendong River for year 2021

Year		Year 2021	
Parameter		**Jan**	**Feb**
Unit		mg/l unless otherwise stated	
WQ1	pH	7.45	6.75
	BOD	4	3
	COD	16	10
	TSS	25	14
	NH$_3$-N	0.21	0.09
	DO	5.97	5.52
	E. coli	70	20
WQ2	pH	7.19	6.60
	BOD	8	4
	COD	28	13
	TSS	13	15
	NH$_3$-N	0.21	0.08
	DO	5.84	5.26
	E. coli	70	150

Figure 4-1 shown the abundant of Lubok Sendong River to the paddy field areas and construction area of Project Highway Ketereh to Kok Lanas during the monsoon seasons.

After the monsoon season the paddy field farmer will remove the abundant water in their paddy field areas into the river and this also could affected river water quality results. Figure 4-2 shown the normal condition of Lubok Sendong River with the natural vegetative along the river bank but certain areas we can see the exposed slope because of natural condition that could lead to erosion and sediments flow into the river affected the river water quality results. Land disturbance area with the exposed slope without vegetative could lead to erosion and sediments fall into the river and lead to the river pollution (Pfeiffer, Küstner, Erdenesukh, von Tümpling, & Hofmann, 2021) .

Figure 4-1 Abundant of Lubok Sendong River during monsoon season

Figure 4-2 Normal Condition of Lubok Sendong River

4.1.2   Mahang River

There are seven (7) parameters analyzed which are pH, BOD, COD, TSS, NH_3-N, DO and E.coli. for water quality monitoring in two different location of monitoring station at Mahang River another river along the alignment of Highway Ketereh to Kok Lanas, Kelantan from year 2018 until 2021 as shown in the Table 4-5, Table 4-6, Table 4-7 and Table 4-8. A few parameters shown not detected (ND). All parameters complied with DOE limit except for the red color highlighted in the Table 4-5, Table 4-6, Table 4-7 and Table 4-8. The sampling location WQ3 from year 2018 until 2021, a few parameters exceed the limit standard by DOE, the BOD, COD, DO, TSS and NH_3-N. The highest TSS level recorded at monitoring station WQ4 on month of February 2021 which are 2791 mg/l and March 2018, the concentration shown 479 mg/l. The main factor of contribution the high reading of TSS because of the pilling activity of temporary bridge for river crossing on that time March 2018 in the middle of the river and river bank widening activity on February 2021 for the preparation beam launching activity. For the

month of September 2020, the parameter E.coli recorded with the highest reading 440 mg/l. The main source of high E.coli reading because of the upstream of the Mahang River, there is activity of small facility of cattle breeding activity by local people and observed that sewage water from cowsheds flow directly into the river without any treatment. According to the United States Geological Survey in their website, the e-coli concentration in the river as a strong indicator the contamination are from sewage or animal waste especially from animal farm without proper treatment of sewage discharge (Agency, 2018). In year 2019 from the month of April to May, condition of the river is dry during the hot season cannot conducted any river water sampling compare to month of December 2018 during the monsoon season the abundant of water from Mahang River and lead to the flood in that area. The concentration for NH_3-N already high at the upstream the WQ3, the concentration of NH_3-N also will be high at the downstream the WQ4 this refer to the table 4-5 for the month July, September and October in year 2018. The concentration for BOD already high at the upstream the WQ3, the concentration of BOD also will be high at the downstream the WQ4 this refer to the table 4-5 for the month October in year 2018 and refer to the table 4-7 for the month November in year 2020. The concentration of BOD at the downstream the WQ4 is higher compare to WQ3 this refer to the table 4-7 for the month October and December in year 2020 might be because of high concentration of bacteria that used the dissolved oxygen. The concentration for DO already high at the upstream the WQ3, the concentration of DO also will be high at the downstream the WQ4 this refer to the table 4-6 for the month May in year 2019 and table 4-7 for the month February in year 2020. The concentration for COD already high at the upstream the WQ3, the concentration of COD also will be high at the downstream the WQ4 this refer to the table 4-5 for the month October in year 2018. The concentration of COD at the downstream the WQ4 is higher compare to WQ3 this refer to the table 4-7

for the month November and December in year 2020 might be because of high concentration of organic materials in the river example spillage of oil from machinery.

Table 4-5 Water Quality Status for Mahang River for year 2018

Year		Year 2018											
Parameter		Jan (Baseline)	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Unit		mg/l unless otherwise stated											
WQ3	pH	7.29	6.39	7.14	6.64	6.81	ND	6.55	6.56	6.66	6.96	6.37	Abundant Water
	BOD	ND	ND	ND	ND	ND	ND	ND	ND	ND	7	ND	
	COD	16	10	10	6	12	ND	6	16	13	26	6	
	TSS	48	8	8	19	8	ND	7	7	15	12	10	
	NH_3-N	0.09	0.18	0.07	0.14	ND	ND	0.39	0.14	0.44	0.40	0.20	
	DO	6.28	6.31	6.32	6.28	6.27	ND	6.34	6.24	6.32	6.26	6.30	
	E. coli	80	120	<10	<10	35	ND	60	35	50	95	110	
WQ4	pH	6.86	6.84	6.59	6.61	6.71	ND	6.54	6.50	6.55	6.91	6.41	Abundant Water
	BOD	ND	ND	ND	ND	ND	ND	ND	ND	ND	5	ND	
	COD	12	13	45	13	9	ND	6	13	6	5	13	
	TSS	41	8	479	8	8	ND	7	7	40	9	9	
	NH_3-N	0.04	0.17	0.29	0.15	ND	ND	0.16	0.17	1.03	0.17	0.18	
	DO	6.27	6.27	6.22	6.22	6.30	ND	6.27	6.25	6.33	6.32	6.27	
	E. coli	160	55	15	<10	<10	ND	40	40	50	90	55	

Table 4-6 Water Quality Status for Mahang River for year 2019

Year		Year 2019											
Parameter		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Unit		mg/l unless otherwise stated											
WQ3	pH	7.02	6.47	7.36	River Dry	7.10	7.22	7.00	7.40	7.41	7.94	7.42	7.65
	BOD	ND	ND	ND		ND	ND	3	3	3	3	4	4
	COD	13	10	10		10	6	13	13	13	13	10	10
	TSS	16	18	13		19	8	10	9	13	10	10	15
	NH_3-N	ND	ND	0.07		0.10	0.09	0.11	0.15	0.15	0.10	ND	0.07
	DO	6.48	7.12	6.45		8.68	4.47	5.36	4.85	5.17	6.30	4.59	4.56
	E. coli	40	10	20		ND	20	45	25	95	80	ND	ND
WQ4	pH	7.05	6.49	7.68	R...	R...	6.73	6.98	7.42	7.41	7.33	7.29	7.59

Parameter										
BOD	ND	ND	ND	ND	4	3	5	3	3	4
COD	13	13	10	6	16	13	19	13	13	10
TSS	17	15	12	9	21	13	11	18	13	11
NH$_3$-N	ND	ND	0.09	0.09	0.09	0.15	0.15	0.14	ND	ND
DO	6.46	7.21	6.33	4.97	5.53	5.08	5.17	6.27	4.60	4.95
E. coli	60	0	0	120	40	30	190	30	230	150

Table 4-7 Water Quality Status for Mahang River for year 2020

Year		Year 2020											
Parameter		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Unit		mg/l unless otherwise stated											
WQ3	pH	7.47	6.95	MCO	MCO	6.60	6.75	7.46	7.36	7.63	6.37	6.21	6.83
	BOD	5	6			4	4	5	3	4	4	6	5
	COD	16	16			13	13	19	10	13	16	22	16
	TSS	9	11			11	8	11	9	8	8	11	8
	NH$_3$-N	0.13	0.08			0.01	0.16	0.08	0.10	0.12	ND	0.10	0.12
	DO	6.75	8.02			5.02	4.07	4.84	5.23	4.53	5.77	5.59	5.74
	E. coli	ND	15			ND	190	45	45	40	95	ND	10
WQ4	pH	7.38	6.09	MCO	MCO	6.88	6.82	7.46	7.32	7.63	6.50	6.33	6.98
	BOD	5	5			4	3	7	3	3	6	8	10
	COD	13	13			10	10	25	10	10	22	29	35
	TSS	9	10			10	9	9	17	8	78	22	9
	NH$_3$-N	0.13	0.10			0.04	0.10	0.09	0.10	0.09	0.11	0.11	0.18
	DO	6.79	7.09			4.74	4.46	5.02	4.18	4.88	5.65	5.45	5.45
	E. coli	ND	ND			ND	30	20	320	440	15	15	45

Table 4-8 Water Quality Status for Mahang River for year 2021

Year		Year 2021	
Parameter		Jan	Feb
Unit		mg/l unless otherwise stated	
WQ3	pH	6.88	6.94
	BOD	4	3
	COD	16	10
	TSS	8	11
	NH$_3$-N	0.19	0.07
	DO	5.77	5.31
	E. coli	20	ND

WQ4	pH	6.93	6.35
	BOD	5	6
	COD	16	22
	TSS	9	2791
	NH$_3$-N	0.19	0.59
	DO	5.02	5.80
	E. coli	15	180

Figure 4-3 Mahang River near to the cowsheds owned by locals

Figure 4-4 shown the Mahang River with the normal condition which are the calm flow of water with the clear color condition and during the monsoon season Figure 4-5, the fast flowing of river with high sediment concentration. The high sediment concentration during the monsoon season with the brownish color is common condition because of the erosion from the surrounding area of slope failure along the river bank and any other water stream. According to the M. Lee, Tanaka2and, and Chong (2016),

monsoon season increase the slope failure and sediment flow directly into the river. The damage sediment control measures installed by the project contractor also could lead the sediment flow from exposed area at the construction site into the river during the monsoon season.

Figure 4-4 Normal Condition of Mahang River

Figure 4-5 Fast flow of Mahang River after heavy rain during monsoon season

4.2   Water Quality Index

Water Quality Index (WQI) calculation is to change the complexity of the water quality data into information that is public understandable refer table 4-9. WQI is a calculation tool used to summarize the complex and technical water quality data into easy understand message to the public. The WQI is a measurement tools used by Department of Environmental Malaysia to measures the water quality status (Abdul Karim & Kamsani, 2020).

Table 4-9 Water Quality Index

Sub Index & Water Quality Index	Index Range		
	Clean	Slightly Polluted	Polluted
Water Quality Index (WQI)	81 – 100	60 – 80	0 – 59

4.2.1   Water Quality Index of Lubok Sendong River for WQ1 and WQ2

Refer to Figure 4-6 Water Quality Index for WQ1 at the Lubok Sendong River from year 2018 until 2021, the lowest WQI is in the month January 2019, the index shown 55.40 polluted. For Figure 4-7 Water Quality Index for WQ2, the lowest are in the month of January for year 2018 and 2019, which are 54.76 and 55.45. During the monsoon season, the heavy rain caused erosion at the river bank and the surface run-off water full with sediment flow into the Lubok Sendong River and also the paddy field farmers will dewatering the muddy stagnant water in their paddy field areas to avoid flood. The damage of erosion and sedimentation control measures installed by the project contractor due to the heavy rain and fast flowing river during the monsoon season is one of the factor lead the river pollution and the damage control measures immediately repair by the project contractor to avoid further pollution. Joshi, Navalgund, and Shet (2021) stated that improper management of control measures to prevent the river pollution at

construction site will increase the unwanted materials and sediment into the river. The average WQI for monitoring station of WQ1 in year 2018 until 2021 are 70.82, 70.95, 64.68 classified Class III and 84.67 classified as Class II. The average is slightly polluted from year 2018 until 2020 and clean on 2021. For WQ2 refer to the Figure 4-7 the average WQI from year 2018 until 2020 are 61.45, 68.52, and 62.12 shown slightly polluted classified as Class III and WQI clean, 85.32 for year 2021 classified as Class II.

Water Quality Index for WQ1

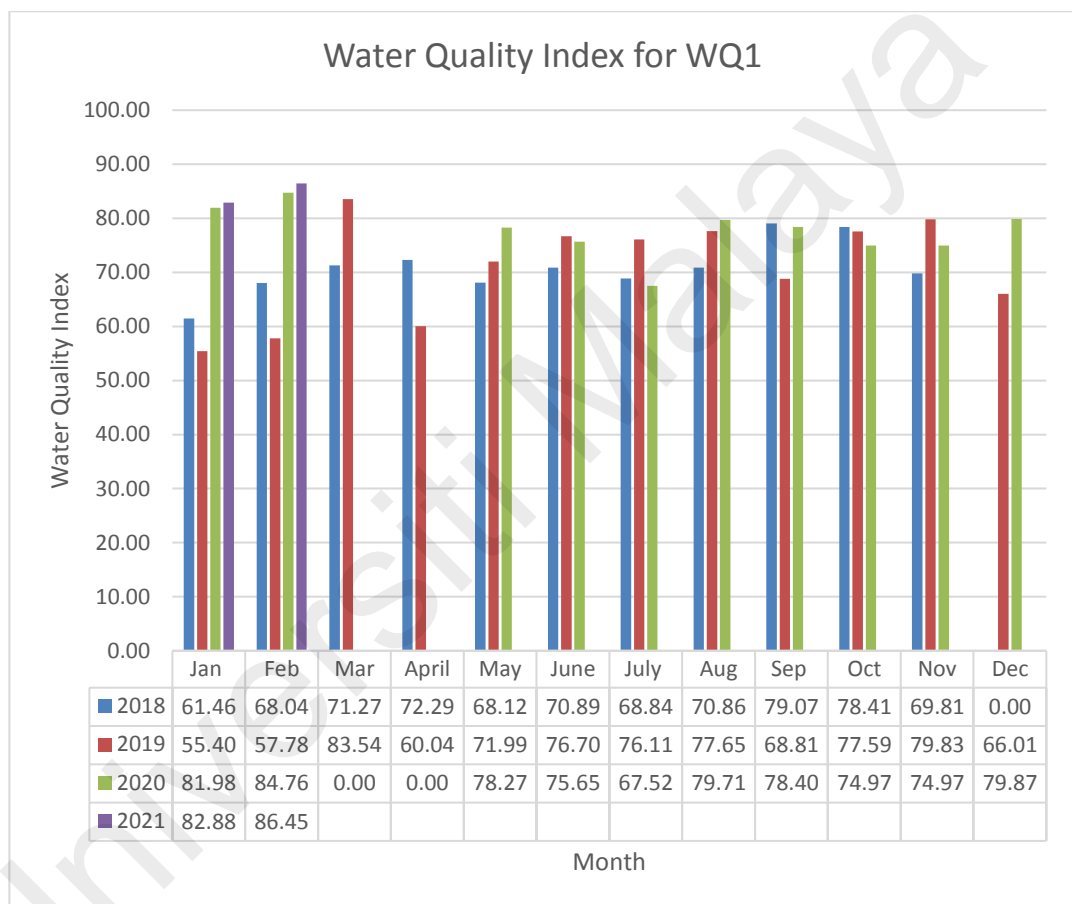|	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
2018	61.46	68.04	71.27	72.29	68.12	70.89	68.84	70.86	79.07	78.41	69.81	0.00
2019	55.40	57.78	83.54	60.04	71.99	76.70	76.11	77.65	68.81	77.59	79.83	66.01
2020	81.98	84.76	0.00	0.00	78.27	75.65	67.52	79.71	78.40	74.97	74.97	79.87
2021	82.88	86.45										

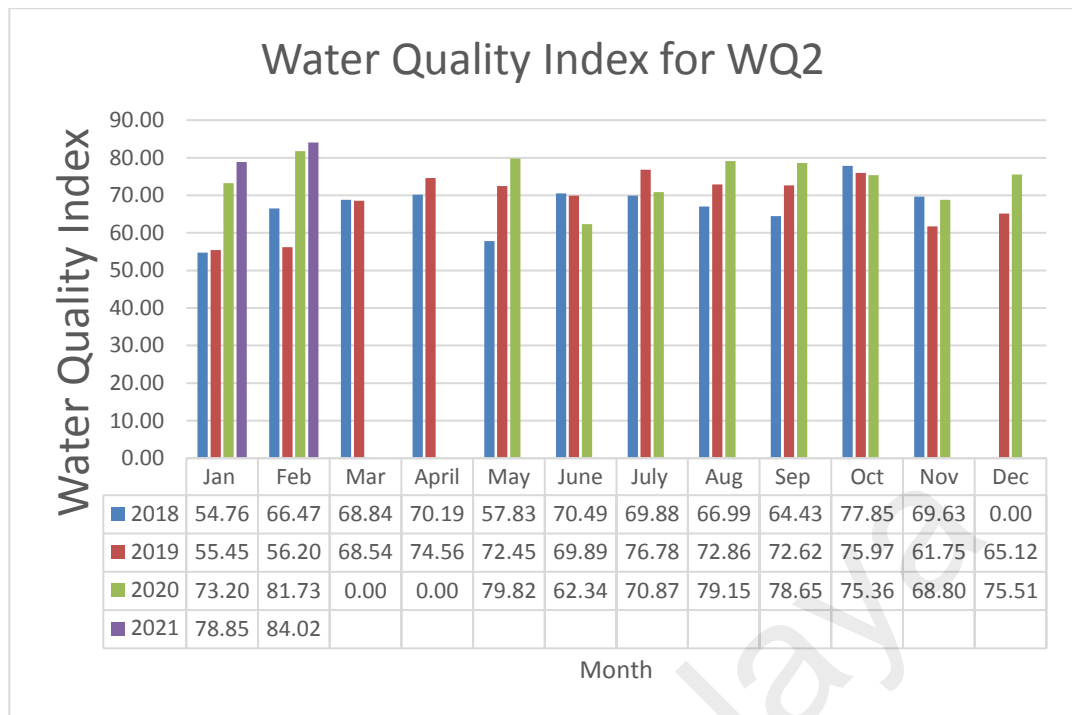**Figure 4-6 Water Quality Index for WQ1**

Figure 4-7 Water Quality Index for WQ2

4.2.2 Water Quality Index of Mahang River River for WQ3 and WQ4

Water Quality Index (WQI) for Mahang River from year 2018 until 2021 refer to Figure 4-8, the lowest is 58.42 for location WQ3 and 58.27 for WQ4 in month of January for year 2019. The main reason of low WQI in the month of January 2019 is because of the monsoon season at east coast area. The heavy rain will increase the flow of the river and lead to the erosion at the river bank and heavy sediment transfer from high flow of surface run-off water into the Mahang River, this also supported by R. Z. Abidin et al. (2017) in their study at Langat River. The damage erosion and sediment control measures because of heavy rain and fast flowing river make the river polluted with high sediment concentration. The project contractor take immediate rectification action to repair any damage erosion and sediment control to prevent continuous pollution into the Mahang River, study conducted at Sungai Kelantan by Zainuddin (2007) shown that erosion and sediment control play important role to prevent river pollution. The average WQI for WQ3 are 58.56, 68.62, 67.32 classified as Class III with the slightly polluted and 85.32

classified as Class II with clean river and for WQ4 are 62.74, 61.06, 68.17 and 72.48 classified as Class III with slightly polluted from year 2018 until 2021.
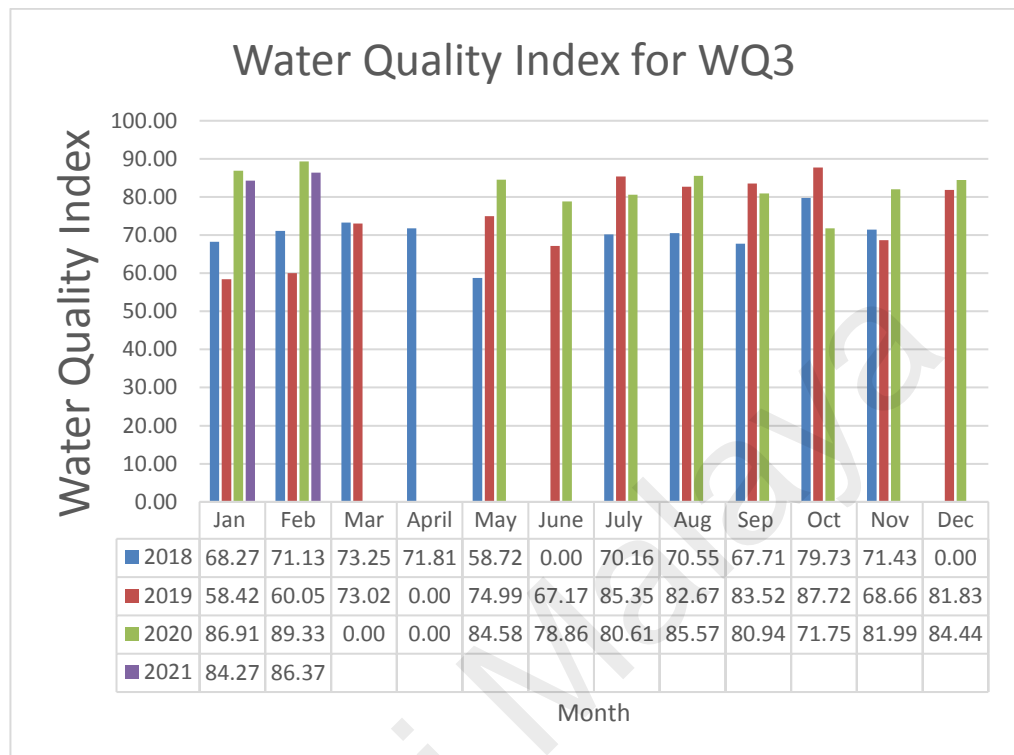

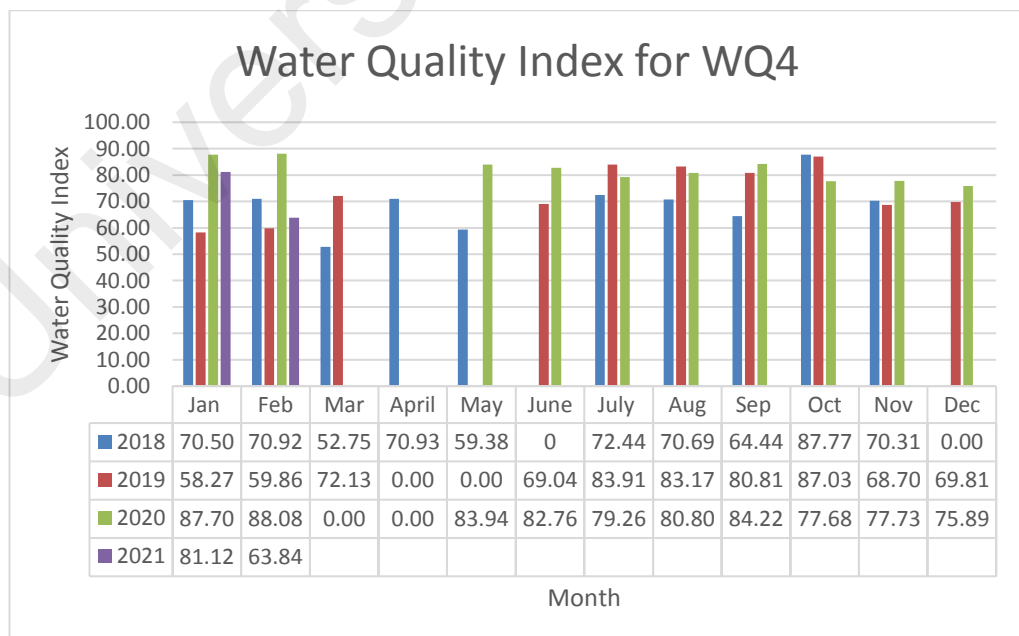**Figure 4-8 Water Quality Index for WQ3**

	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
2018	68.27	71.13	73.25	71.81	58.72	0.00	70.16	70.55	67.71	79.73	71.43	0.00
2019	58.42	60.05	73.02	0.00	74.99	67.17	85.35	82.67	83.52	87.72	68.66	81.83
2020	86.91	89.33	0.00	0.00	84.58	78.86	80.61	85.57	80.94	71.75	81.99	84.44
2021	84.27	86.37										

Figure 4-9 Water Quality Index for WQ4

	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
2018	70.50	70.92	52.75	70.93	59.38	0	72.44	70.69	64.44	87.77	70.31	0.00
2019	58.27	59.86	72.13	0.00	0.00	69.04	83.91	83.17	80.81	87.03	68.70	69.81
2020	87.70	88.08	0.00	0.00	83.94	82.76	79.26	80.80	84.22	77.68	77.73	75.89
2021	81.12	63.84										

4.3   Identification of Control Measures to prevent river pollution

The construction activities nearby the river bank of Lubok Sendong River and Mahang River are operation of heavy machineries, material and equipment storage, earth work and land clearance activity, gabion wall installation, river widening, excavation work, process of deepening the rivers, permanent bridge construction, temporary bridge construction, pilling work, bored pile work, and maintenance work for equipment and machinery refer table 4-10 for details explanation.

Table 4-10 Description of Construction Activity and the Control Measures

Description of Construction activity	Environmental Aspect	Environmental Impact	Identification of Control Measures
Material and equipment storage, Operation of heavy machineries, and maintenance work for equipment and machinery.	Potential of oil and chemical spillage during operation of machinery and equipment	Water pollution example high COD level in the river	Fuel burning equipment must be put on the secondary containment avoid any spillage into the river and the maintenance work must be done far from river and designated maintenance area
Earth work and land clearance activity	Exposed soil	Water pollution example high TSS level in the river	Temporary Earth Drain (TED) connected with sediment pond, silt trap and also check damp. Silt fence installed along the work area
Gabion wall installation	Slope or river bank integrity	Water pollution example high TSS level in the river	Slope cover with canvas or geotextile. Silt

			fence installed along the work area
River widening and Process of deepening the rivers	Slope or river bank integrity	Water pollution example high TSS level in the river	Slope cover with canvas or geotextile and also turfing
Excavation work, Temporary bridge construction and Permanent bridge construction	River water churned and Slope or river bank integrity	Water pollution example high TSS level in the river	Slope cover with canvas or geotextile and also turfing. Sheet pile installed along the construction area at the river bank or in the middle of river. Silt fence installed along the excavation area
Pilling work and bored pile work	Potential of Chemical spillage example bentonite	Water pollution example high COD and TSS level in the river	Bentonite spillage can be capture by the check damp or silt trap/pond then spillage of bentonite should be clean immediately avoid directly into the river. The dike wall and bund wall can be installed surrounding the bored pile area that can contain the bentonite avoid spillage into the river

The control measures of erosion and sediment play an important role to prevent river water pollution especially during the construction phase. The most common Best Management Practices (BMPs) in erosion and sedimentation control categorized into three (3) types which are erosion control, sediment control and surface water run-off management. Selection of control measures implemented at construction site are based on natural function and design objectives of each facility constructed. The importance of sediment basin and silt trap to prevent river pollution by trapping the sediment from water discharge into the river (Zainuddin, 2007). The correct selection of soil erosion control at the slope area and along the river bank can prevent the soil lose into the river that will increase sedimentation concentration and suspended solid value (Wen & Zhen, 2020). The erosion control measures emphasize the provision of cover protection to soil and slope. Sediment reduction in the Yellow River since year 2000 because of the effectiveness of soil erosion control (Zhao et al., 2021). This construction project, the project contractor constructed the spot or closed turf for slope protection along the highway alignment and river bank and also cover with plastic canvas or geotextile for the temporary slope erosion control. While for surface water run-off management are temporary facilities provided to minimize channel erosion at construction site by provided the Temporary Earth Drain (TED) along the highway alignment and berm drain installed at along the slope. Improper management of channel erosion control increased the soil erosion and concentration of sediment in the river (Shi et al., 2021). Excessive sediments from activity of construction during excavation work and earth work activity will generated high sedimentation concentration in the water discharge. The high sedimentation trapped by providing sedimentation control measures such as silt fence, silt trap and also check damp in the TED. Contractor also installed the sheet pile and wall of sandbag along the disturbance area at the river bank to protect the soil and sediment directly into the river. The design of this erosion and control measures as part of

functioning the runoff discharge from construction site bring minimal effect to Lubok Sendong River and Mahang River and other water streams.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1   Conclusion

Objective of the research successfully achieved by the current study of water quality monitoring during construction of Highway Ketereh to Kok Lanas , Kelantan. The three (3) Objectives as stated in Chapter 1, 1) Determine the water quality status at Mahang River and Lubok Sendong River, 2) Obtain the factor affected the water quality at the Mahang River and Lubok Sendong River and 3) identify the control measures of river pollution.

Lubok Sendong River located along the alignment of this highway project are considered as slightly polluted from year 2018 until 2020 within Class III and clean in the year of 2021 with the Class II. Meanwhile for Mahang River average condition within the Class III and considered as slightly polluted from year 2018 until 2021. According to the National Water Quality Standard by Department of Environmental Malaysia, river water with Class II is suitable use as water supply and required conventional raw water treatment and sensitive aquatic species can live in this river but for Class III river water can also use in water supply but required extensive raw water treatment plant and this river also suitable for livestock drinking water and tolerant of aquatic species can survive in this water.

The contractor of this highway project take extensive pollution control measures to prevent deteriorated of both river water quality. The erosion and sedimentation control measures and construction work with good management and plan play important to ensure the river water quality in good condition.

5.2   Recommendation

The water quality of Lubok Sendong River and Mahang River should be monitored systematically by consultant appointed by contractor of this highway project. Any control

measures implemented at site shall be maintain regularly by contractor to prevent any pollution to the rivers. Local people should be educate with the importance of river and how to love and preserved our nature.

The source of pollution should be track down and immediately rectify the issue by stop the pollution and improve any control measures implemented at construction site and other local communities surrounding the rivers. Inspect to each outfall or water discharge into the both rivers by conducting scheduled water quality monitoring during dry season and rain season also by visual monitoring. Any course of pollution during this inspection must be stop immediately to prevent continuous pollution into the rivers.

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