TREND STUDY ON COVID-19 PANDEMIC LOCKDOWN IMPACT ON RIVERS IN SELANGOR, MALAYSIA

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Aini Hidayati Shahrir[1,2], Gasim Hayder[1,3*]

[1]*Department of Civil Engineering, College of Engineering, Universiti Tenaga Nasional (UNITEN), 43000 Kajang, Selangor Darul Ehsan, Malaysia*

[2]*School of Civil, Environmental & Mining Engineering, The University of Adelaide, SA 5005, Australia*

[3]*Institute of Energy Infrastructure (IEI), Universiti Tenaga Nasional (UNITEN), Kajang 43000, Selangor Darul Ehsan, Malaysia*

[*]*Corresponding author: gasim@uniten.edu.my[1,3]*

ABSTRACT

According to the Department of Environment, numerous rivers, and streams in Selangor, and practically all rivers, are in the 'polluted' and 'slightly polluted' category even before the COVID-19 outbreak. Due to a lack of anthropogenic activities such as industrial discharge, agricultural, poultry, sediment, and silt erosion, the trend of pandemic lockdown on water quality parameters in Selangor is expected to decline. The goal of this research is to see if contamination of water resources and rivers increases or decreases during a pandemic by examining the trajectory of water quality parameters in relation to the COVID-19 pandemic, to figure out which parameters are affecting pollution in Selangor rivers, and to emphasize the water quality in each river for Department of Environment, utilizing data from 2016 to 2020. The results of the investigation revealed significant variations in water and wastewater quality over time as it shows anthropogenic activities decrease during pre-pandemic and pandemic lockdown periods. DO, TSS, ammoniacal nitrogen, and turbidity exhibited decreasing value on most water quality metrics except for BOD, COD, and pH levels during the lockdown period.

Keywords: COVID-19, Lockdown Period, Malaysia, Pandemic, Selangor, Water Quality

1.0 INTRODUCTION

The COVID-19 pandemic has taken the world by storm and caused unpredictable damaged towards all aspect including water resource in Malaysia. The management of water resource reflects the development of water quantity and quality in Selangor. The tendency for the water resource and their demands in Malaysia to rise was estimated to be 60% in 2010 and 113% in 2020 forecasted in 1995 [14].

The classification of water quality in Malaysia is reference to DOE and the contributing factors are determined with the comparison of water quality parameters [1]. Studying the water quality of rivers can identify the main source of pollution of the river such as anthropogenic, lithological, atmospheric, or climatic [2]. Polluted rivers caused toxic and disruption to the endocrine system of aquatic life [31].

It can be summarized that the source of contamination is mainly due anthropogenic activities which originated from industrial, agriculture, poultry, farming and soil erosion [14], [17]. There are much evidence of pollution and contamination in rivers in Selangor, one evidence can be seen that Klang River has heavy metal contamination in their water bodies[32]. It was found that Semenyih river in Selangor are highly polluted with PO_4 and faecal coliform [17]. The degradation of water quality in Selangor was associated with algal blooming and eutrophication especially in Selangor River [14].

The trend of COVID-19 pandemic lockdown towards the water quality in River in Selangor is predicted to decrease due to lack of anthropogenic activities mainly from industrial discharge, agriculture, poultry, sediment, and silt erosion. The study gap focused on pollution in most rivers in Selangor has been steadily expanding over the previous decade [13], raising the question of whether contamination in water resources and rivers increases or decreases during pandemics.

As there are lack of study in water quality parameter effects by the pandemic lockdown, this suffices the need for more research in this area. This research has societal benefits such as the study of water quality before and during the COVID-19 pandemic, the impact of the COVID-19 pandemic on the water and wastewater sector, changes in water pollution before and during the COVID-19 pandemic, recommendations for future rejuvenation strategies if needed, awareness of the importance of water quality in society, and justification of water quality importance. According to [21], only water and air quality have been examined as environmental implications for the lockdown period. The investigation of the influence of COVID-19 is still regarded innovative and a viable research platform. This study contributes the need of further rejuvenation and mitigation actions to increase the water quality classes for the rivers in Selangor to ensure there will availability of safe and clean water resources for future use.

Despite being Malaysia's most developed state, Selangor continues to be one of the most affected states when it comes to water shortages. Selangor has been identified as the state with the most water supply concerns, with 49.5 percent in 2016 and 62.4 percent in 2017 [6]. With the pandemic in full swing, a scarcity of water means a lack of cleanliness, which increases the danger of virus transmission. In recent years, Malaysia's water resource concerns have risen in scope and complexity. This is due to the fact that Malaysia has converted a large portion of its land from agriculture to urban–industrial–commercial use [31].

The study focuses on the impact of COVID-19 pandemic period towards the water quality and wastewater in Selangor district only. Given that water contamination is common in Selangor, it has wreaked havoc on the state's water supply. This is a comprehensive study of the physical, chemical, and biological characteristics of both water and wastewater to investigate the differences in water quality before, during, and after the MCO period, which coincided with the global lockdown to stop the spread of SARS-CoV-2 viral transmission of COVID-19 in the state.

The aims of this paper are to study the trend of water quality parameters with the effect of COVID-19 pandemic and to identify which parameter was the most significant contributor to contamination in the rivers in Selangor.

2.0 METHOD

2.1 Description of Study Area

Selangor is located on the West Coast Peninsular Malaysia ranging the total area of 8,104 km^2. Selangor has around 413 rivers according to Selangor Water Management Authority (LUAS). The average annual rainfall is 2236 mm with 88.0 inch per year. The study areas comprised on 19 rivers in Selangor which are Ampang River, Balak River, Buloh River, Chuau River, Damansara River, Gombak River, Guntong River, Keroh River, Klang River, Kundang River, Langat River, Penchala River, Rambai River, Rawang River, Selangor River, Sembah River, Semenyih River, Sepang River, and Serendah River.

2.2 Data Collection and Timeline

The data is collected from the Department of Environment and undergo standard water sampling collection and the period of the data ranges from 2016 until 2020. The timeline for the study was from 2016 to 2020. The data of 2021 was available during the writing of this paper. However, there are certain data of rivers that only provide 2017 to 2020 data. The years 2016-2018 are referred as before pandemic lockdown, 2019 as pre-pandemic lockdown, and 2020 as pandemic lockdown in this study.

2.3 Water Quality Parameters

The water quality parameters studied in this paper consist of Dissolved Oxygen (DO) percentage, Dissolved Oxygen (DO) concentration, Biological Oxygen Demand (BOD) concentration, Chemical Oxygen Demand (COD) concentration, Total Suspended Solids (TSS) concentration, pH value, Ammoniacal Nitrogen (NH_3-N) concentration and turbidity concentration as provided by DOE. These parameters were used to calculate Water Quality Index (WQI) by DOE. WQI has been used in Malaysia for around 28 years and recommended by The Department of Environment Malaysia. It is a collection of water quality recommendations that classify water quality classes based on the quality of water for public use, such as raw water sources, recreational uses, irrigation and aquaculture [24].

3.0 RESULTS & DISCUSSION

3.1 Trend of COVID-19 Lockdown Period and Water Quality Parameters

Figure 1 represents the trend of dissolved oxygen (DO) between the rivers in Selangor. The DO percentage and concentration can be seen decreasing throughout 2016 until 2018 which is before the pandemic period. However, it gradually increased during per-pandemic lockdown and pandemic lockdown period. This is a positive impact as dissolved oxygen is important especially for aquatic lives. If DO is too low, aquatic lives cannot survive as there is not aeration and it leads to higher temperature of water. Since the recent years showed drastic improvements of DO percentage, it can be justified that the COVID-19 lockdown brings significant positive impact towards DO. Nevertheless, the value of average DO throughout the years is still falls underclass I , IIA and IIB for the NWQS (2022) for Malaysia, hence it is still feasible for Malaysian standard for water supply and recreational use.

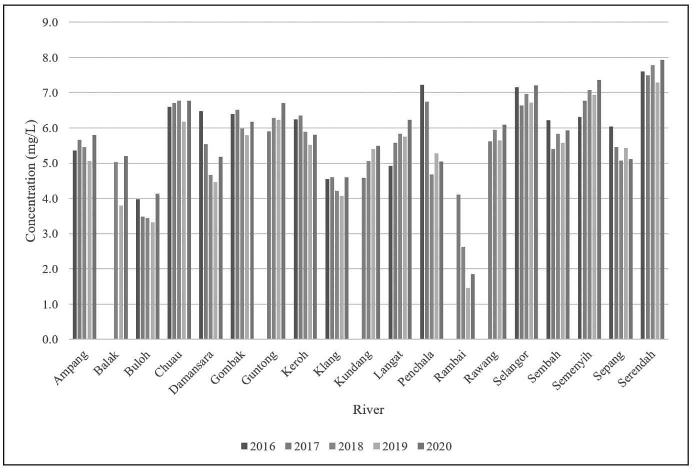

Figure 1: Dissolved Oxygen (DO) Trend

For BOD, there is an uneven trend before the pandemic lockdown period and it gradually increase in pre-pandemic lockdown and during the pandemic lockdown period as shown in Figure 2. This is one of the negative impacts for water quality parameters. Higher BOD is caused by organic pollution and more oxygen is needed for oxygen-demanding species in the water bodies. Thus, it led to lower level of water quality. The increase during the period of lockdown may be due to decaying plants or organic waste that are not treated. Since the majority of water sector are put on hold during the lockdown, this includes the sanitation of water resource to ensure it stayed in it standardised quality. The average BOD falls under the range of class III and IV of NWQS (2022) for water supply but needed extensive treatment and irrigation respectively.

Next, COD concentration gradually increase during the before the pandemic lockdown period but decrease in pre-pandemic lockdown period and increased again during the pandemic lockdown period as illustrated in Figure 3. Similar to BOD, it is considered a negative impact as higher COD means lower DO in the water bodies. As said previously, DO is crucial for aquatic lives. The COD level relates to the concentration of organic matter in water bodies and it may cause unpleasant smell of the water sources and it contain decaying plants and organic wastes. The COD average falls under the class IIA, IIB and III for NWQS (2022) which is still suitable for water supply and recreational use.

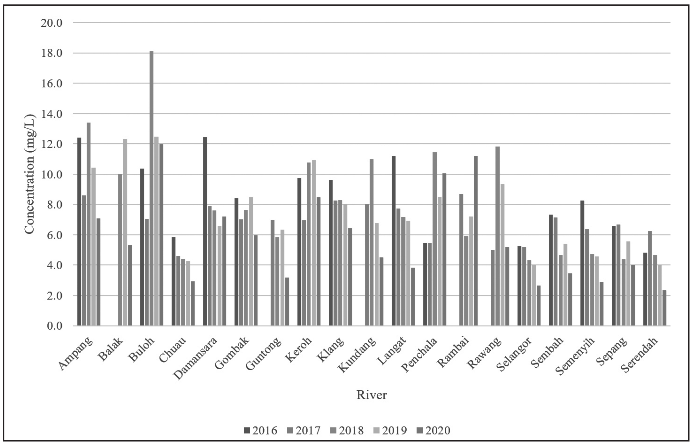

Figure 2: Biochemical Oxygen Demand (BOD) Trend

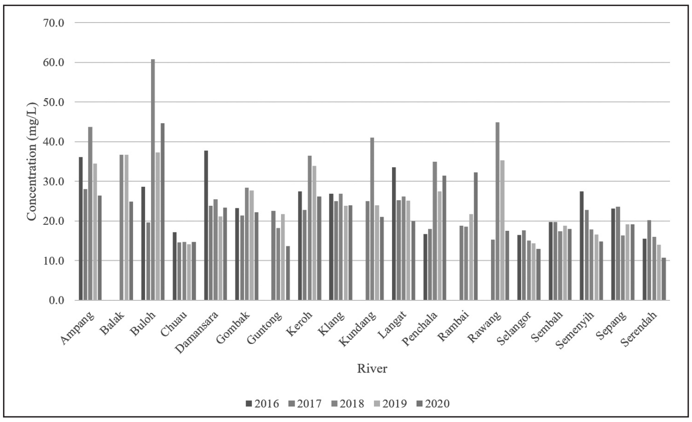

Figure 3: Chemical Oxygen Demand (COD) Trend

Figure 4 exhibits the total suspended solids (TSS) trend, TSS concentration presented an uneven trend during before the pandemic lockdown period but it gradually decreased during pre-pandemic lockdown period and lockdown period. This is a positive impact as lower level of TSS means increase in DO and also help reduced the temperature of water bodies as lesser suspended particles absorbing heat from solar radiation entering the water surfaces. This is a results of lower anthropogenic activities as the it is suspended during lockdown. Lesser particles

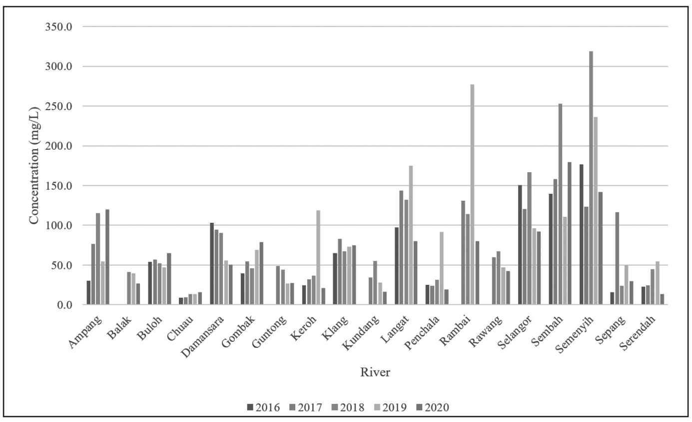

Figure 4: Total Suspended Solids (TSS) Trend

are discharged and lesser pollution that comes from pesticides, industrial effluent and metals being discharged into the water. The TSS falls under the class I of NWQS (2022) which is suitable for water supply without the need of treatment.

As for the pH value shown in Figure 5, the value remained in a susceptible level as it only experienced minor changes in decimals. The pH level gradually decrease throughout the before the pandemic lockdown, pre-pandemic lockdown period and lockdown period. As pH decrease, hydrogen ion increased and caused the water bodies to become acidic. However, the results of the pH values showed it ranges from the lowest alkaline, neutral and the lowest acid and it falls under class I, IIA, IIB, III, IV which is still under a controlled level of pH value. However, mitigation actions should be put under consideration as the trend seemed to be decreasing throughout the year and it is likely to become more acidic later on.

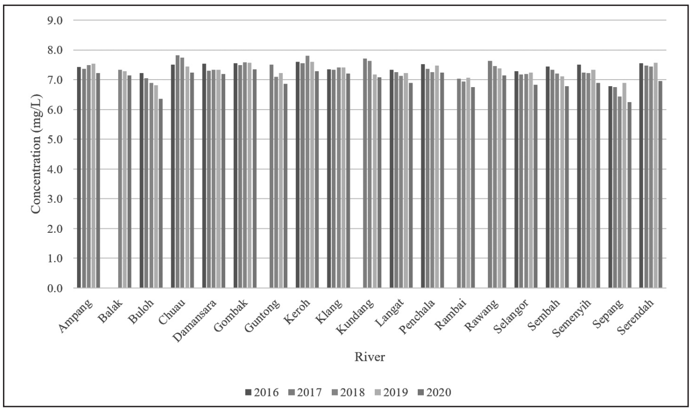

Figure 5: pH Value Trend

The ammoniacal nitrogen trend gradually increased in before the pandemic lockdown and pre-pandemic lockdown period then it decreased during the pandemic lockdown period as presented in Figure 6. Ammoniacal nitrogen is a form of measurement of the level of ammonia in the water bodies. Ammonia typically found in leachate and organic waste. The reduced level of ammoniacal nitrogen is a positive impact of the lockdown. Similar reasons can be concluded as lower anthropogenic activities due to lesser particles are discharged ranging from pesticides, industrial effluent and metals being discharged into the water. Ammoniacal nitrogen falls under the class V of NWQS (2022) which is not suitable for water supply, irrigation and recreational uses. Even though the value is decreasing, further mitigation actions is required to ensure the level of water resources is suitable for use for the coming years.

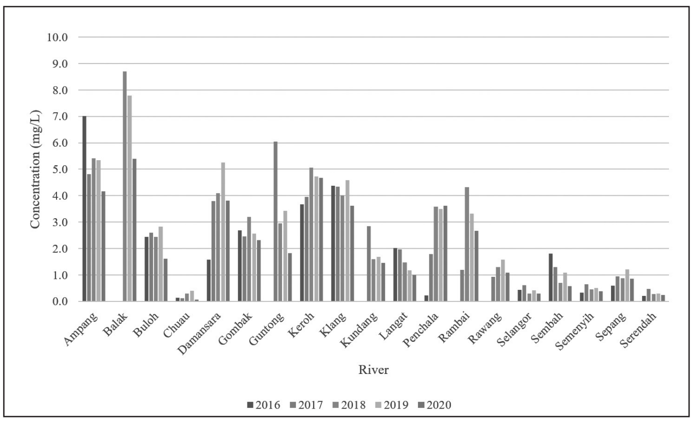

Figure 6: Ammoniacal Nitrogen (NH_3-N) Trend

The average turbidity trend showed uneven trend during before the pandemic lockdown but it then gradually decrease in pre-pandemic lockdown period and lockdown period as shown in Figure 7. Turbidity is affected by DO, TSS, particles and organic matter that are in the water bodies. Lower turbidity level is also a positive impact of lockdown as it signifies lower bacteria, virus and parasites in water bodies. These organisms tend to attached with suspended particles which lead to contamination and pollution of water bodies. This is also the effects of lower anthropogenic activities during the lockdown period. The turbidity however did not fall under any classes of NWQS (2022) hence the level of turbidity is still above the standardised level and further mitigation to reduce the level of turbidity is needed to ensure water resource in Selangor is not polluted.

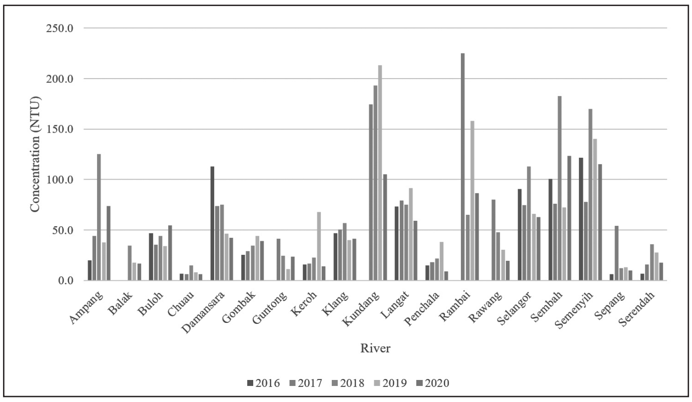

Figure 7: Turbidity Trend

The charts presented had shown significant changes of water and wastewater quality throughout the period. Nevertheless, it is showed positive changes throughout the pre-pandemic and pandemic lockdown period. In water quality parameter perspectives, DO, TSS, ammoniacal nitrogen and turbidity showed positive impacts during the pandemic lockdown period while BOD, COD and pH level have decreased. Even with the positive impact, the turbidity level still above the standardised level of NWQS (2022) and it signifies that the average water resources is still polluted based on the parameter perspective. Mitigation actions is required especially for pH level, ammoniacal nitrogen and turbidity parameter to ensure improved water resources for the coming years. However, there is a possibility for the decreasing value of these parameters may not only be due by anthropogenic activities but also due to external factors that are not studied in this paper.

3.2 The Parameters that Significantly Affected During Pandemic Lockdown

3.2.1 pH Value

Pollution is typically a factor in anthropogenic pH variations. Point source pollution is a frequent cause that, depending on the chemicals involved, can produce an increase or drop in pH. These substances may arise from industrial runoff, sewage discharge, or agricultural runoff. Detergents and soap-based items in wastewater discharge might make a water supply too basic. Typically, the pH of freshwater lakes, ponds, and streams ranges from 6 to 8 depending on the bedrock and soil in the area. The pH of water in deeper lakes where stratification (layering) takes place is often higher near the surface (7.5-8.5) and lower (6.5-7.5) at greater depths.

Temperature differences inside a body of water, where each layer of water does not mix with the layers above or below, are typically the source of stratification. Thermoclines (temperature divides) or chemoclines, which split these layers, exist (chemistry gradients). Oxygen, salinity, or other chemical variables that don't cross the cline, including carbon dioxide, can be the basis for chemoclines. Stratification can result in different pH values along a cline as a result of CO2's impact on water's pH. Due to increasing CO2 from respiration and breakdown below the thermocline, pH values in different water layers differ. The saturated CO2 that has been accumulated in the lake's lower strata is what has caused this huge reduction.

When the pH of water falls below 5.0 or rises above 9.6, harmful repercussions are evident. Due to their adaption to a higher pH, saltwater fish are more susceptible to the negative effects of acidification. Fish are more prone to fungus infections and other physical harm when the pH is below ideal levels. The solubility of calcium carbonate decreases as water pH rises, preventing aquatic creatures from developing shells. At pH values below 5.0, fish reproduction generally suffers, and many species will depart the area. When the pH falls below 4.0, fish start to perish.

Heavy metals may become more soluble at low pH levels. Metal cations including aluminium, lead, copper, and cadmium are released into the water rather than being incorporated into the sediment as the concentration of hydrogen ions rises. The toxicity of heavy metals rises along with their concentration. At levels as low as 0.1-0.3 mg/L, aluminium can inhibit growth and reproduction while raising mortality rates. Additionally, mobile metals can enter organisms during respiration and harm their physiological systems. On the other end of the scale, high pH levels can kill aquatic species at levels over 10.0 by harming their skin and gills. Even at usual concentrations (9.0), ammonia in the water can cause death. Ammonia and water mix to form an ammonium ion at low and neutral pH values.

3.2.2 Ammoniacal Nitrogen

Some types of nitrogen, such as nitrate-nitrogen and ammoniacal nitrogen, can be harmful to aquatic life in very high amounts. Commercial fertilisers and other industrial uses need the production of ammonia. The breakdown of organic waste, gas exchange with the atmosphere, animal and human waste, and nitrogen fixation activities are all examples of natural sources of ammonia. Ammonia can enter the aquatic environment both directly and indirectly. Direct entry points for ammonia include municipal wastewater discharges, animal excretion of nitrogenous waste, and air deposition. The inability of aquatic species to sufficiently expel the toxin when ammonia levels in the water are high enough causes toxic accumulation in internal tissues and blood, which may result in death. Ammonia toxicity to aquatic creatures can be influenced by environmental conditions including pH and temperature.

Ammonia, nitrate, and nitrite are the three major chemical states of nitrogen found in streams. Depending on the dissolved oxygen content of the water, some ammonia contained in river water is transformed to nitrate. As was previously said, nitrate is not particularly hazardous, but if it is present in excess, it begins to transform into nitrite, which is extremely damaging even at low concentrations.

The main cause of the high concentration of ammonium nitrogen in the river was the excessive and ongoing intake of nitrogen pollutants. High concentrations of organic and ammonium nitrogen prevented nitrification from occurring. The nitrifying bacteria may be inhibited by the oxygen-consuming organics and poisonous substances present in river water, which could result in an accumulation of ammonium nitrogen. Additionally, due to the high pH of river water, a large concentration of non-ionic ammonium nitrogen was present, which would inhibit the action of nitrifying bacteria and lower nitrification rates. In addition, low river discharge, low SS content, and poor nitrifying bacterial activity contributed to the high ammonium nitrogen level of the river during the dry season.

3.2.3 Turbidity

Sediment frequently tops the list of contaminants or compounds that cause turbidity. Any watershed, however, has a variety of sources for the contaminants or natural elements that can have an impact on the clarity of the water. These can be separated into sources that are caused by humans and by the natural world. Erosion from upland, riparian, stream bank, and stream channel areas are examples of natural sources; however, measurement is challenging because of agriculture and development activity. Erosion can speed up due to human activity. Turbidity is a result of the water becoming coloured by tannic acids, which are frequently found in peat bogs and bog environments. Turbidity can also come from algae that feed on nutrients that enter the stream as a result of leaf breakdown or other naturally occurring decomposition processes. Sediment can also be released by stream channel movement.

Various sources of phosphorus can encourage the growth of algae, which raises turbidity levels. Sources of phosphorus may include bottom sediment, nutrient runoff from other sources, cropland, and wastewater treatment plants. Turbidity may be exacerbated by organic materials from sewage flows, particularly during treatment plant bypasses. Programs to conserve soil and water have long focused on reducing soil erosion on cropland. Urban stormwater runoff from building sites, impermeable surfaces, or other sources is acknowledged as another significant source of silt. In other words, excessive turbidity can negatively affect recreation and tourism by drastically reducing the visual value of lakes and streams. It may raise the price of treating drinking water and food processing water. By diminishing food sources, destroying breeding grounds, and interfering with gill function, it can kill fish and other aquatic species.

4.0 CONCLUSION & RECOMMENDATIONS

In conclusion, our study revealed significant changes as shown in the results in water quality in Selangor rivers throughout time. Nonetheless, it showed positive changes during the pre-pandemic and pandemic lockdown periods. DO, TSS, ammoniacal nitrogen, and turbidity exhibited positive effects on water quality metrics during the pandemic lockdown period, however BOD, COD, and pH levels had increase. To answer the paper's goal, water quality characteristics do have an impact on the COVID-19 pandemic. Because there is no anthropogenic activity during the lockdown period, the positive effects outweigh the bad ones. Despite the positive impact, the turbidity level remains above the Malaysian specified threshold, showing that the average water resources are still polluted in terms of parameters.

Next, pH, ammoniacal nitrogen, and turbidity were the factors that were seen to have significant changes and required more attention. Mitigation and rejuvenation activities are needed in the coming years to ensure improved water supplies, notably for pH, ammoniacal nitrogen, and turbidity, to ensure that these parameters increase to the acceptable level.

In summary, this paper answered the objectives of this paper where the study measured the trend of water quality parameters with the effect of COVID-19 pandemic and identified which parameter was the most significant contributor to contamination in the rivers in Selangor. The study's limitations are that it only focuses on DO, BOD, COD, TSS, pH value, NH_3-NL, and turbidity, and the data provided by DOE only covers the years 2016 to 2020. This paper suggested further attention on the role of policy makers to induce actions towards the needs of safe and clean water resource. This paper also highlight the need of more study towards other water quality parameters and their effects from the COVID-19 pandemic.

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PROFILES

AINI HIDAYATI SHAHRIR graduated with Bachelor of Civil Engineering (Hons.) from Universiti Tenaga Nasional. She is currently pursuing Master of Engineering (Civil & Environmental) in University of Adelaide. She is a registered Graduate Engineer under the Board of Engineers Malaysia (BEM). Her research interests are Environmental Engineering, Water Resource Engineering and Climate Change.
Email address: aini.hidayati@gmail.com

GASIM HAYDER, PhD, is a Chartered Engineer (CEng) and a senior lecturer at the Universiti Tenaga Nasional (UNITEN). He also served as the Head of Environment and Sustainable Development Cluster, Head of Postgraduate & Laboratory Services Unit in the Institute of Energy and Infrastructure (IEI), Head of Water & Environmental Engineering Unit in the Department of Civil Engineering, and senior researcher for Sustainable Engineering Group at UNITEN. He has several publications, patents and awards in both national and international levels. His research interests are Environmental Engineering, Wastewater treatment, Biological processes, and Solid Waste Management.
Email address: gasim@uniten.edu.my