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Assessment of Water Quality in Selangor, Malaysia during the Pandemic Movement Control Order

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Abstract

The COVID-19 lockdown reduced the amount of human activity in Selangor, resulting in improved water quality, less water pollution, and a restored ecosystem. The purpose of this research was to investigate water quality before and during the COVID-19 pandemic, as well as changes in water pollution. After acquiring all of the data from third-party sources, this study analyzed the data using a methodical and statistical approach to determine the impact of the COVID-19 pandemic in Selangor. The purpose of the data analysis was to determine whether the parameters in the water samples met the Malaysian water quality standard. To summarise, there were positive impacts on DO, TSS, ammoniacal nitrogen, and turbidity during the pandemic lockdown period, but negative impacts on BOD, COD, and pH levels. The National Water Quality Standards (NWQS) (2022) also indicated that typical water resources remained polluted and that moderation activities for pH, ammoniacal nitrogen, and turbidity parameter were required to assure improved water resources in 2023. This observation was further demonstrated and agreed upon as the impact of the blockade became evident and the anthropogenic impact on water quality became apparent. Based on observations and analysis, it is possible to highlight the positive and negative aspects of the pandemic lockdown period in terms of water quality and wastewater in Selangor.

Keywords

Water quality; movement control order (MCO); pandemic; Selangor Rivers; Malaysia

1. Introduction

The coronavirus (COVID-19) disease is a rapidly spreading pandemic that has prompted global containment efforts. This pandemic has wreaked havoc on several industries, including water and wastewater [1]. Selangor is a Malaysian province and one of the states that previously suffered from severe drought and water shortages, which is an appropriate location for assessing water quality before and after the COVID-19 outbreak.

As of late December 2020, water outages in Selangor, Malaysia, have been more frequent, with water contamination believed to be the primary culprit. Because Selangor's rivers and water treatment plants were unable to handle the high levels of pollution in raw water generated by industrial activities, the state decided to take action [2]. According to the Institution of Engineers of Malaysia (IEM), the public and authorities are responsible for ensuring the health of the water sources. The approaching COVID-19 has affected Selangor's water quality due to the ongoing problem. During the COVID-19 lockdown, people were told to "remain at home," limiting the number of human activities that polluted the environment [3-6]. As a result, water quality in Selangor affected by the COVID-19 lockdown is required to be assessed and analyzed.

As previously stated, the COVID-19 pandemic lockdown lasted for about two years, a period long enough to cause significant changes in the economy, culture, and environment [7-11]. Even though the unexpected lockdown hurt the economy, the environment's health continued to improve due to the lack of anthropogenic actions [12]. As a result, to provide a useful platform for a wide range of COVID-19 lockdown studies [13-17], this review focuses on the environmental impact of the lockdown period explored by previous researchers.

A recent study examined changes in river quality in Malaysia before and during the implementation of the Movement Control Order (MCO), however, the study only explored the calculation of the water quality index (WQI) and the cause of pollution in each of their study regions [18].

It is predicted that reducing the number of human activities will improve water quality and the ecosystem. People were required to reduce the number of human activities such as large gatherings and community gatherings during the COVID-19 lockdown to reduce the spread of the SARS-CoV-2 virus [19-22]. This separates nature from human activity for a short period, nonetheless, this time frame may be adequate for nature to regenerate and 'heal itself' [23, 24]. The objective of this study was to investigate the impact of COVID-19 on water quality in Malaysia's Selangor region and to explore whether water quality in Selangor has improved or worsened as a result of the pandemic lockdown.

If water supplies are polluted and people do not have access to clean water, they will be exposed to dangerous water-borne illnesses. To elaborate, some hospital wards suspended operations, and employees were reassigned to other COVID-19 units to further deal with the consequences of water-borne disease during the COVID-19 emergency [25, 26]. This increased the risk of waterborne infections, particularly the growth of Legionella in infrequently used water systems [27]. The majority of water-borne diseases are transmitted by faecal-oral transmission [28], which typically involves consuming or breathing in contaminated food and water as a result of inadequate sewage management and sanitation [29]. According to research on water quality, the main cause of some ailments, including cancer, congenital impairments, skin, lung, brain, kidney, and liver disorders, being several times more common in the study area than elsewhere in the nation is water contamination. Polluted water can also lead to the development of waterborne illnesses such as cholera, typhoid, dysentery, and diarrhoea. Therefore, there is a need for programs to monitor pollutants in the river water and sediments to regulate geogenic and anthropogenic causes of pollution [30] and prevent them from increasing to levels harmful to humans [31, 32].

The world population is increasing every year while water resources are decreasing year by year, so more and more people are at risk of not having access to safe drinking water [33]. Based on past literature, most water quality parameters showed a significant decrease in pollution and anthropogenic activities during the lockdown compared to the pre-pandemic lockdown [34]. Therefore, our objective was to investigate whether the COVID-19 lockdown led to improved water quality, less pollution, and a restored ecosystem by reducing the number of human activities in Selangor.

2. Literature Review

Malaysia, being a developing country, relies on acceptable water quality to meet urbanization and consumer needs. On the other hand, there are growing concerns about the cleanliness and water quality of natural resources as a result of rapid development [35]. Water scarcity appears to be a typical issue in Malaysia. In recent years, Malaysia's water resource challenges have grown in breadth and complexity [36], because most of the land in Malaysia has been transformed from agriculture to urban–industrial–commercial use [37].

The WQI has been used in Malaysia for approximately 28 years and has been endorsed by the Malaysian Department of Environment (DOE). It is a set of water quality recommendations that divides water into groups based on the quality of water for public consumption, such as raw water sources, recreational purposes, irrigation, aquaculture, and so on [38-41]. The current Malaysian WQI is based on a questionnaire and public opinion survey [42]. The time window for pollutant migration into a water body is unpredictable, depending on the features of the pollutant [43].

Because Malaysia's rivers supply virtually all of the country's water, water contamination in river systems poses a serious public health risk. The river system consists of the riverbed and its tributaries, which transport a significant amount of particulate and dissolved elements from both anthropogenic and natural sources in a one-way flow. Water supply is critical to the health of a community and the long-term success of the industry, business, and agriculture. Selangor is the most populous and industrialized state in Peninsular Malaysia. As the state's most populous state, Selangor's rivers are being badly damaged by anthropogenic activity.

The contamination came from a variety of sources, including industrial, agricultural, animal farming, and erosion [44]. The need to identify the ambient water quality status to detect changes caused by anthropogenic activity has grown as water supplies have been depleted. Surface water supplies are polluted by urbanization, increased industrial activity, intensive farming and abuse of fertilizers in agricultural activities, and untreated wastewater and sewage outlets [45-47].

It's vital to investigate the water quality of the river utilizing typical methods for measuring water-quality features to provide real-time information on contamination levels [48-51]. The Langat River Valley in Selangor is a major hub for industrial firms, attracting people from all across the country in search of job opportunities. The Langat River plays a significant role in the ecosystem of the basin, providing potable drinking water to households, industry, agricultural areas, and the densely populated Klang Valley.

On the other hand, recent development activities in the basin are threatening the river's water quality [6, 23, 52] and may jeopardize its ability to meet water demands. Furthermore, pollution from industries, manufacturers, commercial organizations, and animal farms along the river has the potential to worsen the degradation of water quality [53]. According to past studies, the water from the Langat River should be used with caution for irrigation and requires significant treatment before it can be used as a domestic water source [54, 55].

3. Method

The methodology flowchart is shown in Figure 1. Data collection is a type of secondary data collection. All of the criteria will be based purely on third-party data. The third-party data will be retrieved via a formal letter sent through the institution. Third-party data is vital in this study, and the majority of the data before and during the COVID-19 pandemic is derived from it, as will the development of future data via predictive modelling. The creditability of samples plays a vital impact on the study's results, hence this section is the most important in the approach.

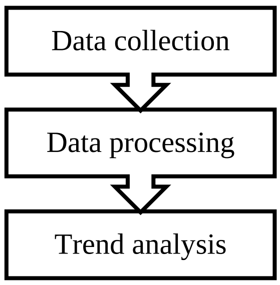

Figure 1 Flowchart of Methodology.

In this scenario, the data were collected from a population in Selangor. The secondary data provided by a third party were instantly used. Data collection was the process of gathering information for the research question, hypotheses, and outcomes of the study before, during, and after the COVID-19 pandemic.

After acquiring all of the data from third-party sources, the data were subsequently subjected to thorough statistical processing in order to evaluate it to determine the impact of the COVID-19 pandemic in Selangor. The purpose of data analysis is to determine whether the parameters in the water samples meet the Malaysian water quality standard. Trend analysis can be created as a result of the process to show the worst-case scenario if the situation worsens in terms of water and wastewater quality owing to the COVID-19 pandemic. This examination can also determine whether the number of human activities is reduced and whether the water quality, wastewater, and ecosystem can be rejuvenated.

Annual data based on water quality and related properties for 2016 to 2020 were collected and obtained from a third party. Because the Environmental Quality Report for 2021 was not available during the authoring of this study, the DOE had stated that water quality data could only be provided for the years up to 2020. Data were analysed using descriptive statistics such as mean, minimum, and maximum values for the different parameters. The analysis was carried out manually in an Excel spreadsheet. For this study, the periods were before lockdown, pre-lockdown and during the lockdown periods. The years 2016 until 2018 were under the category of before lockdown period while 2019 is the pre-lockdown period and 2020 is the lockdown period [56].

4. Results & Discussion

The average, minimum and maximum values of the relevant parameters (DO, BOD, COD, TSS, pH, NH_3-NL and Turbidity) are presented in Table 1. The recorded values of parameters were within NWQS for Malaysia. These standards are categorized into 5 water classes: Class I – Conservation of the natural environment, Class II – Conventional treatment and recreational use in contact with humans, Class III – Extensive treatment required, Class IV-Irrigation, and Class V – None of the above [57, 58].

From the values in Table 1, the average, maximum and minimum values of DO were respectively between class I-III, class I and class IV-V. From Figure 2, the maximum values of DO from 2016 to 2020 were between 7.60 mg/l to 7.93 mg/l. From 2016, until 2018, when the pandemic began in 2019, the average concentration of DO decreased. Then, a gradual increase in DO levels was observed before and during the pandemic lockdown, which had a favorable effect because dissolved oxygen is essential for aquatic life. Aquatic life cannot survive if DO is too low since without aeration and the water temperature will rise. The increase in DO value could be the result of restricted measures, such as the reduction of anthropogenic activities (i.e., agriculture, industrial and commercial effluents into the rivers) during the lockdown.

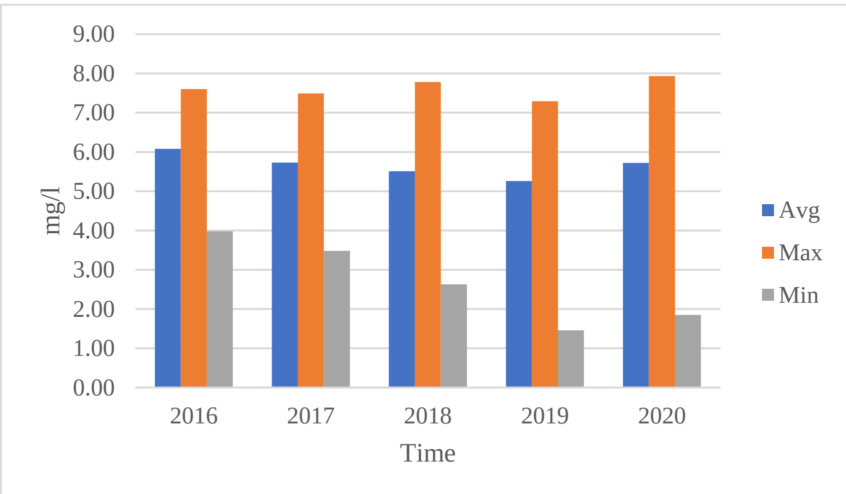

Figure 2 DO average, maximum and minimum values.

Table 1 The average, minimum and maximum values of water quality-related parameters.

	DO			**BOD**			**COD**			**TSS**			**pH**			**NH_3-NL**			**Turbidity**		
Year	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**
2016	6.08	7.60	3.98	8.4	12.4	4.8	25	38	16	90	403	9	7.4	7.6	6.8	2.0	7.0	0.1	71	413	6
2017	5.73	7.49	3.48	11.3	87.3	4.6	31	188	15	148	1131	9	7.4	7.8	6.8	2.6	7.2	0.1	66	245	6
2018	5.51	7.78	2.63	11.1	59.8	4.3	37	186	15	116	552	13	7.3	7.8	6.4	3.2	14.3	0.3	81	393	12
2019	5.26	7.29	1.46	10.9	72.7	4.0	35	217	14	101	284	14	7.3	7.6	6.8	4.5	37.3	0.3	61	213	8
2020	5.72	7.93	1.85	11.0	111.5	2.3	37	322	11	67	179	14	7.0	7.4	6.3	3.2	24.7	0.1	48	123	6

The average, maximum, and minimum values of BOD in Table 1 are in between class III-IV, class V and class II-III, respectively. As can be seen in Figure 3, the average and minimum values from 2016 to 2020 were below 20 mg/L. Moreover, BOD remained at a controlled low value compared to other parameters. This may be due to higher BOD due to organic pollution, and the need for more oxygen for aerobic species in the water bodies. The small rise during the lockdown could have been caused by decomposing plants or untreated organic waste. The cleanliness of water resources was put on hold during the lockdown since the majority of the water sector was suspended. This ensured that the water resource was kept in standard condition. The average BOD was within the NWQS (2022) for class III and IV water supply but required substantial treatment and irrigation.

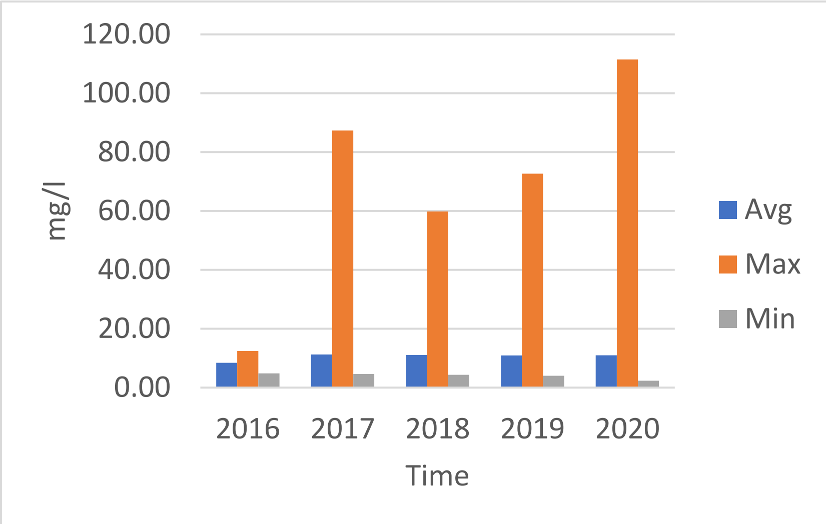

Figure 3 BOD average, maximum and minimum values.

As for COD, its average, maximum and minimum values were between class II-III, class II-V, and class I-II, respectively (Table 1). During the period leading up to the pandemic lockdown as can be seen in Figure 4, COD concentrations steadily climbed during the pre-pandemic lockdown period, decreased in the period before the pandemic lockdown, and then increased again during the pandemic lockdown period. COD has a negative impact, similar to BOD because more COD causes lower DO in aquatic bodies and as previously stated, DO is essential for aquatic life. The COD level refers to the amount of organic matter present in water bodies, which can generate an unpleasant odor by containing rotting plants and organic wastes. For NWQS (2022), the average COD values fall into classes IIA, IIB, and III, indicating that it is still suitable for water supply and recreational use.

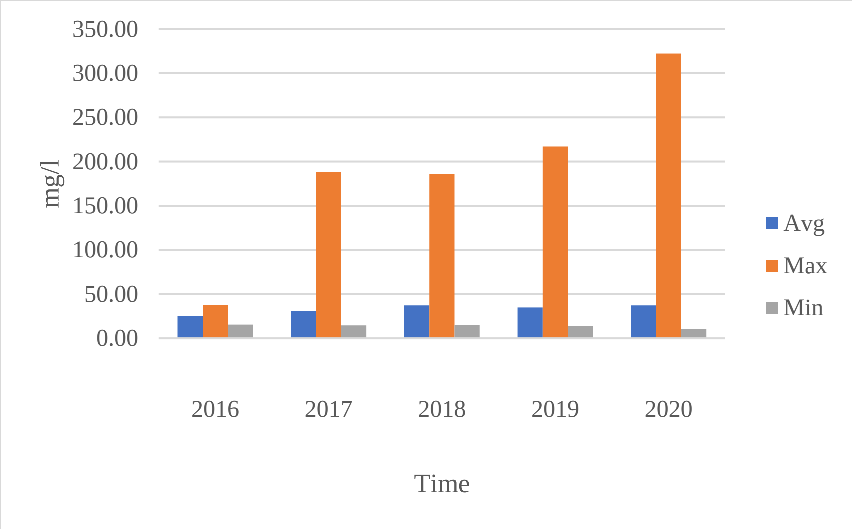

Figure 4 COD average, maximum and minimum values.

Next, according to Table 1, the average, maximum, and minimum values of TSS were in the class II-III range, the class IV range, and the class I range, respectively. TSS concentrations had an irregular pattern prior to the pandemic lockdown period but gradually decreased during the pre-pandemic lockdown and lockdown periods as illustrated in Figure 5. This has a good influence since a lower level of TSS equals a higher level of DO, and DO helps to reduce the temperature of water bodies by absorbing less heat from solar radiation penetrating the water's surface. Because human activities were halted during the lockdown, fewer pesticides, industrial waste, and metals were dumped into the water, resulting in less pollution. The TSS is classified as NWQS (2022) class I, which means it is safe drinking water that can be used without treatment.

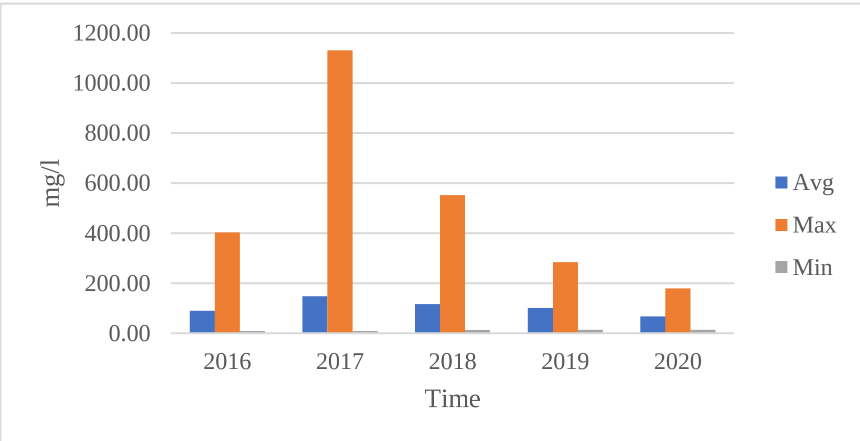

Figure 5 TSS average, maximum and minimum values.

The average, maximum, and minimum values of pH were all within the class II range (Table 1). As illustrated in Figure 6, the pH value changed throughout the years with just slight decimal variations. Moreover, the average pH level gradually decreased over the years to 7.4, 7.4, 7.3, 7.3 and 7.0. The hydrogen ion grew as the pH decreased, causing the acidic water bodies. The pH values, on the other hand, span from the lowest alkaline to the lowest acid, and they fall into classes I, IIA, IIB, III, and IV, all still within a safe pH range. However, because the trend appeared to be declining during the year and it is anticipated to become more acidic, moderation activities should be considered.

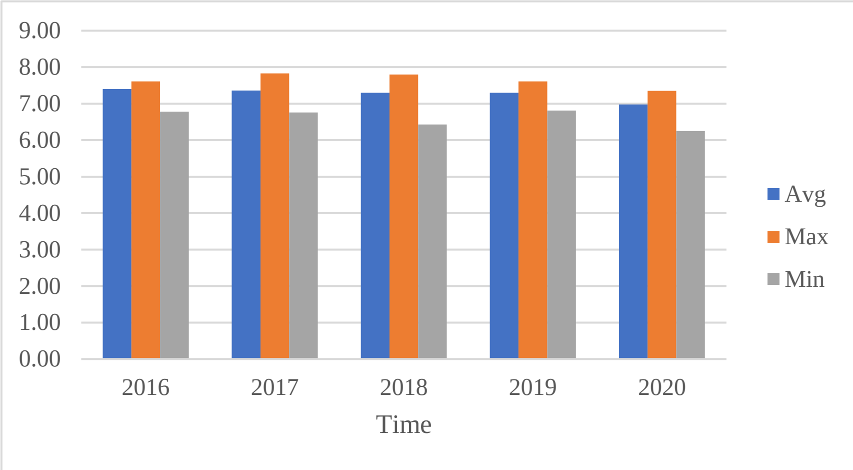

Figure 6 pH average, maximum and minimum values.

Furthermore, the average and maximum values of NH_3-NL ranged between class III-V, and the minimum values ranged between class I-II water classes (Table 1). Before the pandemic lockdown and during the pre-pandemic lockdown period, the ammoniacal nitrogen trend progressively climbed, then reduced during the pandemic lockdown period as seen in Figure 7. Ammoniacal nitrogen is a method of determining the amount of ammonia in a water body, which is commonly found in organic waste and leachate. The lockdown has a favorable effect on the ammoniacal nitrogen level. Similar conclusions can be drawn from decreasing anthropogenic activities due to the reduction in particulate matter discharged into the water, such as pesticides, industrial effluent, and metals. Ammoniacal nitrogen is classified as class V of the the NWQS (2022), which means it cannot be used for drinking water, irrigation, or recreational purposes. Although the NH_3-NL value is declining, additional moderation measures are required to ensure that the water resources are at levels suitable for use in the next years.

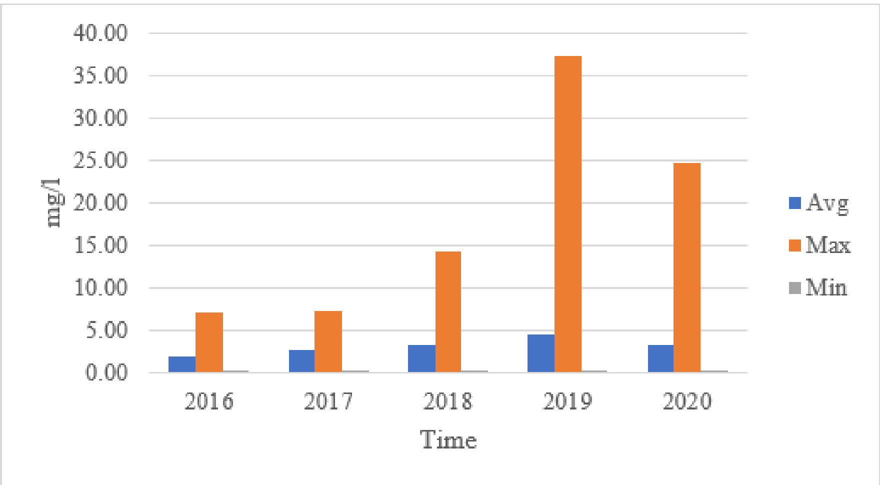

Figure 7 NH_3-NL average, maximum and minimum values.

Finally, from Table 1, the minimum values of the turbidity water were in class I, and the average and maximum values were in class II. Before the pandemic lockdown, the average turbidity trend was inconsistent, but it gradually decreased during the pre-pandemic lockdown and lockdown periods as shown in Figure 8. DO, TSS, particulates, and organic matter in the water bodies all affect turbidity. Lower turbidity indicates fewer germs, viruses, and parasites in water sources, which is a beneficial effect of lockdown. These organisms tend to attach themselves to suspended particles, contaminating and polluting water sources. Lower anthropogenic activities during the lockdown period had a similar effect. However, because the turbidity did not fall into any of the NWQS (2022) classes, the turbidity level still exceeded the prescribed threshold, and more moderation is needed to reduce the level of turbidity to ensure that Selangor's water resources are not contaminated.

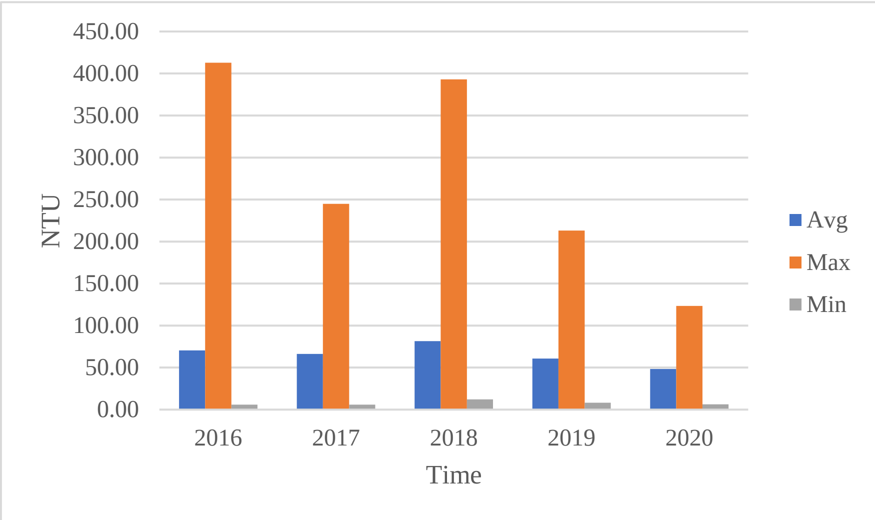

Figure 8 Turbidity average, maximum and minimum values.

The COD values increased during the COVID-19 pandemic, and these changes in hospital effluent COD and ammonia coincided well with the local COVID-19 pandemic development and control major events, reflecting well the pandemic fighting activities. Hospital sewage treatment facilities may also be responsible for the effects of the lockdown. Next, the intrinsic periodicity and trend of COD and NH3-NL, which are related to both periodic human activity and the natural environment, played a part in the temporal collective behaviours of the wastewater treatment plant community. Due to the increased use of domestic waste (i.e., sewage waste) as a result of the lockdown, both COD and NH3-NL values increased during the lockdown [59].

To summarise, during the pandemic lockdown period, there was a positive impact on DO, TSS, ammoniacal nitrogen, and turbidity, but a negative impact on BOD, COD, and pH levels. Despite the positive impact on turbidity, the turbidity level still exceeds the standardized threshold of NWQS (2022), indicating that the average water resources are still polluted from a parameter standpoint. To assure enhanced water supplies in the next years, regulation, particularly of pH, ammoniacal nitrogen, and turbidity is needed.

The country-wide lockdown caused by the COVID-19 pandemic has significantly changed the overall quality of river water, which has turned out to be a positive situation for nature's restoration. While the lockdown period water quality has significantly improved due to restricted economic activities. The water quality of the Selangor River has been declining due to industrial effluents from chemical plants, power plants, and cement manufacturers. High concentrations of DO, BOD, COD, TSS, pH, NH_3-NL, and turbidity negatively impacted river ecological functions and human health [60].

Anthropogenic activities are not the only factor affecting the water quality outcomes at the sample region during the lockdown. According to this study, one explanation may be the self-cleaning/healing ability of the river and the lower concentration of contaminants in upstream areas [61]. However, there is a correlation between industrial activities, and pollution from natural river sedimentation can also change the hydrological characteristics of water bodies. Numerous factors, including precipitation, water and soil conservation initiatives, reservoir development, carbonate weathering, and dilution, can affect sediment movement [5].

It is evident that the water quality improved after months of lockdown and is now in very good condition, without the industrial effluent mixed in. The environment's overall health benefited from the temporary lockdown [62]. In addition, residential wastewater, agricultural practices, and industrial effluents can all significantly affect surface water quality, possibly because domestic wastewater discharges, as well as runoff and drainage from agricultural lands continued to damage rivers and streams [63].

Additionally, the unpredictability of water quality indicators after the lockdown caused a change in the river's turbidity, which is directly related to the regional pollutant discharge, basic environmental conditions of the river, and self-purification capacity, a finding that is consistent with other investigations [64]. It is noted that the effects of human activity on the ecosystem may take some time and they are not likely to be seen right away. The detection and monitoring of these changes might take days, weeks, or even longer. Since rainfall and human pollution discharge have a significant impact on river turbidity, collecting completely correct physical and chemical data on rivers through in situ samplings can be challenging. A potential option is a long-term detection and monitoring based on remote sensing data [65, 66].

Last but not least, sustainable development is crucial for both continued economic growth and the ecological restoration of various environmental components. Nevertheless, a variety of non-point sources, including agricultural runoff, urban sewage, industrial pollution, and waste dumping, are contaminating the river water [67].

5. Conclusion & Recommendations

The goal of this research was to evaluate whether the COVID-19 lockdown in Selangor has reduced the number of human activities, thereby improving water and wastewater quality, reducing pollution, and regenerating the ecosystem. In this study, the beneficial effects of the COVID-19 lockdown on water quality outweighed the adverse effects. The idea that anthropogenic effects on water quality became increasingly noticeable as the impact of the lockout became apparent was further demonstrated and agreed upon in this study. Agricultural activities, industrial waste discharge into rivers and other water resources, sewage contamination, residential areas, and landfills are examples of anthropogenic impacts that harm the water supply.

The graphs provided revealed significant changes in water and wastewater quality over time. However, when it comes to specific water quality metrics, the trend cannot be categorized because it changes with time. Nonetheless, DO, TSS, ammoniacal nitrogen, and turbidity had favorable influences on water quality parameters during the pandemic lockdown period, but BOD, COD, and pH levels had negative effects.

Next, the effects of the lockdown have been both positive and negative, with the positive impact of reduced anthropogenic activities that endanger clean water resources, pollution, industrial activities that discharge harmful chemicals to the rivers, dumping of organic and chemical waste dumping into the river, improved water quality, and increased awareness of the need for clean water; prioritization of good hygiene and better sanitation access has contributed to ecological restoration in Selangor. Meanwhile, the negative impacts are that it caused obstacles and restrictions on the water and wastewater industry, increasing the generation of wastewater for residential and municipal use and increasing the water demands for sanitation access.

The following are the limitations observed in this current study. Firstly, more data are needed as evidence to indicate and understand the impact of COVID-19 on wastewater. Future studies can focus more on wastewater issues. Second, a reliable and universal predictive model is needed to indicate a more accurate magnitude of COVID-19 impacts on a variable in an area. Therefore, future studies can develop a model to forecast the scenarios of post-pandemic with the implementation of SDGs. Moreover, the presence of SARS-CoV-2 in river water bodies or wastewater was not studied in this paper, hence the persistence and spread of the virus in wastewater were not adequately studied. Future studies study on the presence of SARS-CoV-2 in water resources in collaboration with biologists and biotechnologists. Furthermore, only some of the parameters were analyzed in this study, while more water quality parameters would increase the accuracy of the water quality and wastewater level in Selangor. Future studies can include a more comprehensive range of water quality parameters, including physical, biological, and chemical. Moreover, no water samplings were performed, and the data relied entirely on historical collective data from a third party. Future studies can venture into sampling methods to obtain more accurate raw data. Lastly, this study focused on the duration of the COVID-19 pandemic lockdown and its impact on water quality and environmental regeneration, although these findings were not related to COVID-19 cases. Future studies can collaborate with the ongoing COVID-19 cases and water use for hygiene and sanitation.

Finally, the recommendations and rejuvenations strategies highlighted in this paper are: continuous water and wastewater quality monitoring, constructing predictive models on water management crisis, investing in improved sanitation and wastewater treatment technologies, mapping groundwater and sustainable resources, investing in biotech and ecological approach on the environment rejuvenation strategies, increasing water security through water infrastructures and law enforcement, investing in rainwater harvesting and stormwater technologies as alternative water sources and normalize routine cleaning, sanitation and disinfection practices.

Based on observations and analysis of the results, the positive and negative impacts of the pandemic lockdown period on water quality and wastewater in Selangor may be highlighted. And the beneficial outcomes are interconnected.

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Author Contributions

A.H.S collected and analyzed the results, G.H. writing, review, and editing. All authors reviewed the manuscript.

Competing Interests

The authors have declared that no competing interests exist.

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