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Research article

Impact of COVID-19 on the environment sector: a case study of Central Visayas, Philippines

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Abstract: The pandemic has underscored the importance of the environment. In this study, the environmental condition of Central Visayas, Philippines has been assessed and evaluated before and during the onset of the COVID-19 pandemic to deal with a possible association between the environmental indicators and the pandemic. The relationships between environmental key variables namely: air quality, air pollution, water quality, water pollution, and solid waste management have been quantified. The study utilized secondary data sources from a review of records from government agencies and LGUs in Region 7. This study also provides a framework which is the pandemics and epidemics in environmental aspects. The paper concludes by offering researchers and policymakers to promote changes in environmental policies and provide some recommendations for adequately controlling future pandemic and epidemic threats in Central Visayas, Philippines.

Keywords: environment sector; air pollution; water pollution; solid waste management; pandemic

I. Introduction

The COVID-19 pandemic has highlighted the need not only to protect our health from the threat of the virus but even more so to our environment. There have been many discussions on the dynamics of COVID-19 virus transmission, according to the World Health Organization, evidence suggests that SARS-CoV-2 is primarily transmitted between people via direct, indirect, or close contact with infected people via infected secretions such as saliva and respiratory secretions, or via respiratory droplets expelled when an infected person coughs, sneezes, talks, or sings. Some outbreak reports involving indoor crowded spaces have suggested the possibility of aerosol transmission in conjunction with droplet transmission, such as during choir practice, eating at restaurants, or fitness classes. Many reports have documented environmental contamination; people can likely become infected by touching these surfaces and then touching their eyes, nose, or mouth before washing their hands [1].

As of mid-May 2020, more than 4.5 million people are confirmed to have been infected by coronavirus disease 2019 (COVID-19) and about 300,000 people have died from COVID-19 in the world. Because of the rapid transmission of the COVID-19 virus, the use of personal protective equipment (PPE), such as face masks and protective clothing, has increased dramatically. Thus, insufficient, inadequate, and improper handling may result in grave public health consequences and a substantial impact on the environment [2]. The lockdown imposed by the government last 2020 has improved air quality as a result of the decrease of mobility, however, with this restriction within the community, waste generated has also been seen to have increased at the household level and soaking up the environment due to improper waste disposal. The increased household and medical waste generation have raised concerns among the community as piles of garbage may prove to have long-term environmental problems.

Even before the onset of the COVID-19 pandemic, there are already a lot of environmental concerns. At the beginning of the 21st century, there has been swift urbanization, economic growth, and the industrial revolution [3]. The subsequent rise in overexploitation of natural resources has produced concern regarding environmental hazards, generation of a great amount of municipal wastes, a scarcity of landfill sites, and shrinking urban spaces [4]. Only 53 percent of the global population residing in cities is provided with adequate urban services including municipal solid waste management (MSWM) by the local administration [5]. In the systematic review of Houessionon et al., (2021) [6] from 2005–2017, found out that recycling electronic wastes from different countries contaminated the soil, water, and sediments, where the concentration of heavy metals was above the given international standards. These underscore the risk and vulnerabilities of the community when it comes to waste management especially in highly urbanized areas, thus a lack of waste management initiatives will have a long-term effect on society, especially in this time of the pandemic.

Gas emissions from various sources, such as industrial manufacturing, traffic activities, and household heating have significantly deteriorated urban air quality in recent years. The growing concern is that these citizen activities have a discernible impact on deteriorating urban air quality, with often negative consequences for the lives and health of all city residents [7]. Thus, public authorities must take air quality management actions by effectively monitoring urban air quality and analyzing the source terms of the major atmospheric pollutants [8].

The Philippines, like many other countries, faces major challenges to its environment as a result of rapid population growth, destruction of tropical rainforest and catchment areas, severe water pollution, excessive groundwater extraction, and poor resource management. To conserve the nation's water resources, the state has taken ownership of all water resources and implemented a tariff-based rationing system. However, despite all regulatory efforts to create a socially conscious but efficient water pricing system, the Philippines has yet to achieve a system that secures the country's goal of sustainable raw water supplies [9].

The pre-pandemic and pandemic environmental conditions have motivated the researchers to assess and evaluate Central Visayas, the Philippines to deal with a possible association between the environmental indicators and the pandemic. In the paper of Bashir et al., (2020) [10], they have indicated significant findings on the correlation between environmental pollutants (e.g., particulate matter) and COVID-19 in California. Xu et al., (2020) [11] presented that the COVID-19 pandemic had a significant impact on the air quality in three cities in Hubei Province, China.

In the year 2015, the United Nations (UN) released the Sustainable Development Goals (SDGs) Agenda 2030, agreed upon in October 2016, during the 3rd UN Conference on Housing and Sustainable Urban Development. The 17 objectives and 169 goals are intended to guide national policies and international cooperation activities by the year 2030. All 193 UN state members adopted Agenda 2030 for sustainable development in each country. Among the goals set by the UN, SDG 11 highlights urban space solid waste management and SDG 6 highlights clean water and sanitation, which includes increasing inclusive, participatory, and sustainable urbanization and prioritizing management programs that are aimed at reducing negative environmental impacts, with special attention to air quality, municipal waste management, and sanitation.

As the years go by, the population is also seen to increase exponentially. The expected upsurge of the global urban population to 66 percent demands an efficiently planned proactive system to manage waste [12]. Effective planning for promising municipal solid waste management (MSWM) requires a supply chain comprising coherent field operations and organizational flows. Unfortunately, most MSWM businesses do not consider the resource consumption of their value chains, causing barriers to the implementation of environmental protection and savings programs. Therefore, the idea of a sustainable and circular economy has motivated the appraisal of environmental and energy losses mediated by MSWM supply chain activities [13]. The principal challenge for MSW management is the high waste generation rate, and the sub-optimal, if not wholly inadequate, methods of dealing with solid wastes in many (mainly developing) countries.

This study intends to determine the most significant risk factors for COVID-19 spreading in the environment, in order to assist policymakers in preparing for probable future waves. According to Baniasad et al., (2021) [14] real-world data analysis, particularly for an epidemic disease with complex dynamic interactions in daily life, is difficult, and a bias-free analysis would be impossible without accurate high spatiotemporal resolution data. Nonetheless, they attempted to address the role of various parameters in driving the COVID-19 pandemic and evaluated various strategies that countries can employ to exit the pandemic condition without overburdening healthcare capacity. Among the variables studied, they discovered that mobility was the most effective in limiting virus spread and weather-related parameters were discovered to be ineffective in driving the COVID-19 cases. Due to deteriorating water concerns, strict regulations and control have increased rapidly in surface water body monitoring in recent years [15]. Aside from effluent regulations and, on occasion, national water quality guidelines, few developing countries include water quality within a meaningful national water policy context. Whereas water supply is regarded as a national issue, pollution is primarily felt and addressed at the local level. With few exceptions, national governments have little information on the relative importance of various types of pollution (agriculture, municipal, industrial, animal husbandry, aquaculture, etc.) and thus have no idea which is of greatest economic or public health significance [16].

This paper points out possible factors that can pose harm to the environment and how they can be mitigated. Additionally, this intends to look into the environmental situation in Central Visayas, Philippines, and how pandemics affected this sector. This allows the identification of risks and vulnerabilities that will help future-proof the region from future pandemics and will recommend strategies.

2. Methodology

2.1. Sample and data

The present study was conducted in Central Visayas (Region 7) (see Figure 1). It is located at the central part of the Visayas island group in the Philippines with a land area of 15,875 km^2. It is bordered by the Visayan Sea and the province of Masbate in the north, Mindanao Sea in the south, Negros Occidental in the west, and the island of Leyte in the east. It consists of four (4) provinces, namely: Cebu, Bohol, Negros Oriental and Siquijor. It includes three (3) independent cities, namely: Cebu City, Mandaue City, and Lapu-Lapu City. Cebu City is its regional center.

Figure 1. The regional map of Central Visayas, Philippines which is taken from the National Nutrition Council of the Philippines.

The study utilized secondary data sources from a review of records from government agencies (e.g., Environmental Management Bureau, Department of Environment and Natural Resources, and Department of Health) and local government units in Region 7. The dataset was taken from the pre-pandemic year to 2021 to examine and compare the impact of environmental key indicators in Central Visayas. It is all about quantifying the relationships between environmental key variables namely: air quality and air pollution, water quality and water pollution, and solid waste management.

2.2. Measures of variables

The quantitative method of the study utilized a descriptive survey focusing on the review of records and data on identified environmental indicators. It is a survey of the relevant trends and profile of the indicators established in the environment sector. The data that was being collected either on a local and regional level and some of the indicators or variables utilized proxy data. The data collection tool utilized the review of records checklist that indicates the different data to be collected from existing validated reports and published information or to be requested from government and non-government agencies in Central Visayas, Philippines. The environmental indicators were chosen based on the assumptions that viruses can be transmitted and can be found possibly in air, water, and solid wastes.

2.3. Data analysis

Analysis of quantitative data was focused on the comparative analysis of the findings based on trends and profiles from other provinces or regions in the Philippines. The data were also compared with existing standards to determine how Central Visayas situated itself from the sectoral profile to be analyzed. After the analysis, critical environmental indicators which were deemed to have fallen short of the expected requisites or standards were identified. The findings of the quantitative analysis will serve as a basis for identifying risks and vulnerabilities that will limit Central Visayas in the prevention or mitigation of pandemics early. It will also provide future-proofing strategies in the region. Results were presented as numbers (percentages) for categorical variables.

3. Results and discussion

Figure 2 shows the interconnectedness of the chosen environmental key indicators starting with solid waste management. This framework summarizes how the Environment Sector can affect the Health Sector.

3.1. Air quality and air pollution

One of the important environmental indicators to future-proof Central Visayas against pandemics and epidemics is air quality and air pollution. This data is important to aid us on the right type and time to use PPEs, specifically masks. Air quality can be determined using five (5) air pollutants as criteria parameters namely; Particulate Matter (PM), Carbon Monoxide (CO), Oxides of Nitrogen (NO_x), Oxides of Sulfur (SO_x), and Volatile Organic Compounds (VOC's) [17]. Air pollution may occur from three (3) major sources namely; Stationary, Mobile, and Area sources. Stationary sources are sources of air pollution which are immobile or fixed structures emitting air pollutants. Mobile sources are those from vehicular activities that use combustion processes for mobility. Area sources are those sources that occur within a locale.

Figure 3 shows the comparison of the air quality in Cebu from 2018 to 2021. The broken lines are the PM_{10} average values: a.) 50.24 $\mu g/NCM$ for 2018; b.) 42.06 $\mu g/NCM$ for 2019; c.) 33.31 $\mu g/NCM$ for 2020, and d.) 25.00 $\mu g/NCM$ for 2021. These values are within the Good criteria for air quality as presented in Table 1. Cebu has a value of 75.00 for Total Suspended Particulate as of

2021 which is within the Good criteria. The decreasing trend can have a positive impact on air quality because of the decreasing presence of air pollutants. Low values are depicted in 2020 because of the imposed lockdown by the government due to the COVID-19 pandemic which resulted in closures of some establishments and businesses, restrictions in travel (i.e., land, sea, and air), and movement in the community is limited. Greenhouse gas emissions are also reduced due to decreased mobility of people [18], however will not support the reduction in the long run once the economic activities and energy consumption will resume [19].

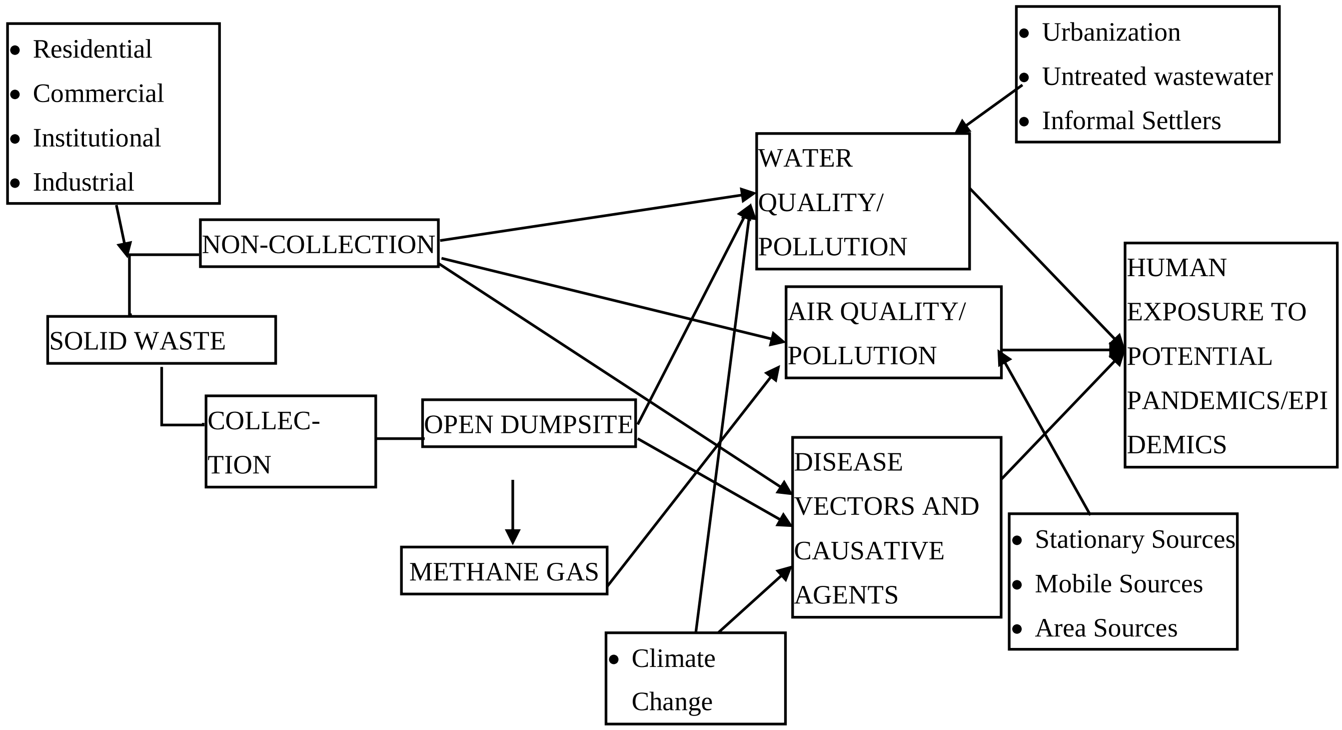

Figure 2. Framework of Environment Sector.

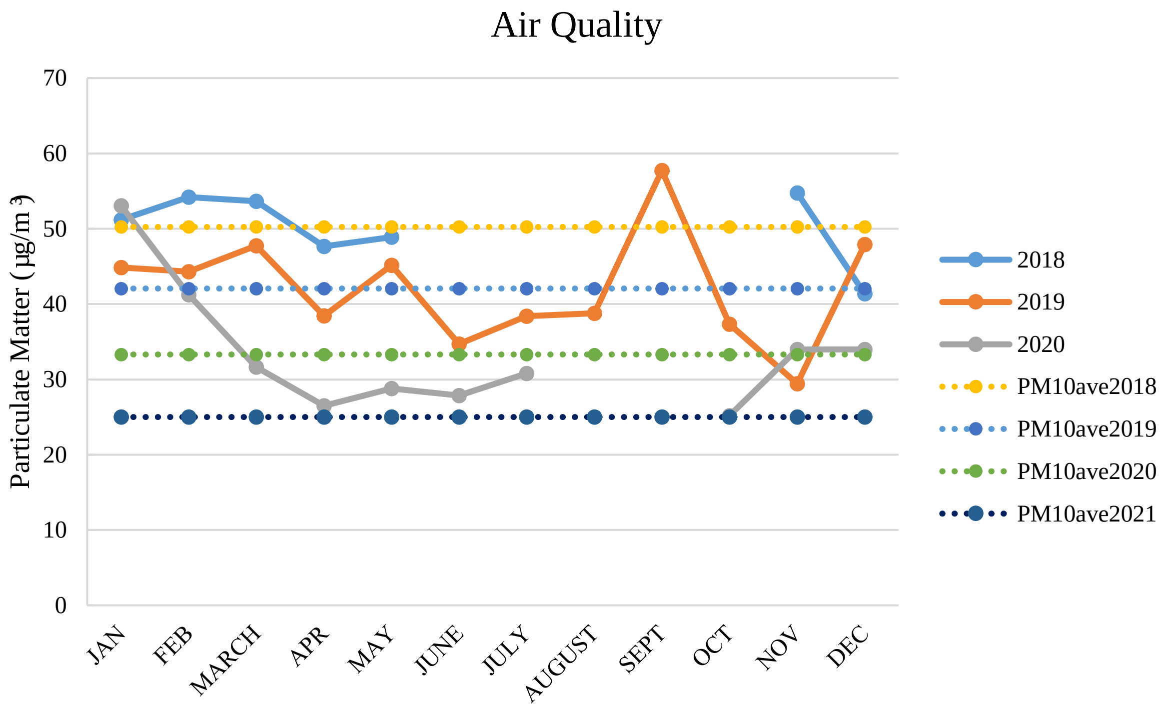

Figure 3. Graph of Air Quality in Cebu from PM10 data from 2018–2021. PM stands for Particulate Matter and it detects particle sizes ≤ 10μm.

Table 1. Air Quality Indices. (Particulate Matter and it detects particle sizes ≤ 10μm.)

INDICATOR	Particulate Matter ($\frac{\mu g}{m^3}$)	
	Total Suspended Particulates (24-hr)	Particulate Matter 10 (24-hr)
Good	0–80	0–54
Fair	81–230	55–154
Unhealthy for sensitive groups	231–349	155–254
Very unhealthy	350–599	255–354
Acutely unhealthy	600–899	355–424
Emergency	900 and above	425–504

The data in Central Visayas is congruent to the findings of the researchers and scientists in NASA that the environment is quickly changing since the onset of the pandemic; the air is way better than the pre-pandemic. Xu et al., (2020) [20] also reported that air quality (e.g., PM_{10}) during the year 2020 is lower than during the years 2017–2019 in the three cities in Hubei Province, China. Thus, the strict compliance of the appropriate and safe gas emissions should be continued in the region.

3.2. Water quality and eater pollution

Another key indicator is water quality and water pollution. This data is important because our bodies of water can become possible sources of certain types of viruses, bacteria, and fungi. Water quality can be determined using Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO) as the main water quality monitoring parameters [21].

The bodies of water in Region 7 are classified according to their beneficial use which is shown in Table 2. Fresh surface waters, which include lakes, rivers, and reservoirs, are classified as AA, A, B, C, and D. Coastal and marine waters, on the other hand, are classified as SA, SB, SC, and SD. The classification is a very important component of water quality management since the application of effluent standardize dependent on this classification (DENR Administrative Order 34 s.1990).

Tables 3–6 and Tables S1–S4 show the summary of average water quality monitoring results of the rivers in Region 7 from 2017–2020. The waters must have low Biochemical Oxygen Demand (BOD) and high Dissolved Oxygen (DO) concentration for it to be determined as good water quality.

Table 2. Classified waterbodies in central Visayas, Philippines.

Class	Province	Usage
1 Class AA	1 Cebu	Intended primarily for waters having watersheds that are uninhabited and otherwise protected and which require only approved disinfection to meet the National Standards for Drinking Water.
28 Class A	6 Bohol 12 Cebu 9 Negros Oriental 1 Siguijor	Intended as a source of drinking water that requires standard treatment such as coagulation, sedimentation, filtration, and disinfection.
29 Class B	3 Bohol 18 Cebu 7 Negros Oriental 1 Siquijor	Recreational water is intended for primary contact recreation such as bathing and swimming.
15 Class C	3 Bohol 9 Cebu 3 Negros Oriental	Fishery water is used to propagate and produce fish and other aquatic resources.
6 Class D	6 Cebu	For agriculture, industrial water supply class 2, and inland waters.
2 Class SA	2 Cebu	Suitable for propagation survival, tourist zones, national marine parks, coral reef parks, and reserves.
8 Class SB	4 Cebu 3 Negros Oriental 1 Siquijor	Fishery water is used for commercial shellfish propagation and as spawning grounds for milkfish and other similar species.
4 Class SC	4 Cebu	For industrial water supply class 2 and other coastal and marine waters.

Average BOD and Average DO data tell us that out of the monitored rivers, only Guadalupe River (upstream and downstream) and Bulacao River downstream are found to have extremely high pollution levels, having high BOD and low DO (colored red in Tables 3–6). Guadalupe River, which is Class C, is located in a highly urbanized city where the increasing population, small food centers (carinderia), and boarding houses where wastewater discharging directly to the river are the great contributors of the contamination [21]. Bulacao River downstream has a high BOD concentration since the water traverses from two highly populated cities; water pollution comes from different sources namely wastewater from drainage (non-point sources) and mostly from household and small business discharges that cause very high BOD [17]. Although Butuanon River passed the criteria for Class D in terms of DO, its BOD value is increasing, thus the contamination level is increasing and it is worsening. There is an improvement seen in the water quality of Class A and B Rivers. The improvement can be associated with the relocation of the informal settlers and the closures and rehabilitation of industries and businesses operating near these rivers.

Table 3. Summary of BOD[1] and DO[2] results for the monitored Class A Rivers in Region 7, 2017–2020.

Class A	Average BOD[1] (mg/L)				Average DO[2] (mg/L)			
	2017 ≤ 3* mg/L	2018 ≤ 3 mg/L	2019 ≤ 3 mg/L	2020 ≤ 3 mg/L	2017 ≥ 5* mg/L	2018 ≥ 5 mg/L	2019 ≥ 5 mg/L	2020 ≥ 5 mg/L
Argao River upstream	1.45	2.00	2.00	2.50	7.44	8.09	8.06	7.32
Bagatayam River	-	-	2.50	1.75	-	-	7.78	5.50
Cotcot River	4.44	8.06	14.0	4.75	6.69	5.09	7.10	7.25
Danao River upstream	4.75	3.63	2.50	3.00	7.63	8.30	9.22	6.00
Luyang River	1.40	2.00	5.67	2.67	8.29	8.44	9.03	6.33
Mananga River	6.10	20.4	34.5	9.56	6.65	6.53	6.98	5.20

Notes: [1]*Biochemical Oxygen Demand;* [2]Dissolved Oxygen; *Normal values; Source: EMB-DENR [17].

Table 4. Summary of BOD[1] and DO[2] results for the monitored Class B Rivers in Region 7, 2017–2020.

Class B	Average BOD[1] (mg/L)				Average DO[2] (mg/L)			
	2017 ≤ 5* mg/L	2018 ≤ 5 mg/L	2019 ≤ 5 mg/L	2020 ≤ 5 mg/L	2017 ≥ 5*mg/L	2018 ≥ 5 mg/L	2019 ≥ 5 mg/L	2020 ≥ 5 mg/L
Argao River downstream	1.80	2.17	2.00	2.00	7.43	7.90	7.78	7.32
Guadalupe River upstream	12.6	43.5	11.0	6.00	5.20	3.05	3.10	5.00
Danao River downstream	3.63	2.25	4.00	3.00	7.75	7.25	6.89	5.00

Table 5. Summary of BOD[1] and DO[2] results for the monitored Class C Rivers in Region 7, 2017–2020.

Class C	Average BOD[1] (mg/L)				Average DO[2] (mg/L)			
	2017 ≤ 7* mg/L	2018 ≤ 7 mg/L	2019 ≤ 7 mg/L	2020 ≤ 7 mg/L	2017 ≥ 5* mg/L	2018 ≥ 5 mg/L	2019 ≥ 5 mg/L	2020 ≥ 5 mg/L
Bulacao River	-	-	6.00	3.00	-	-	7.48	7.15
Guadalupe River downstream	61.0	51.2	65.3	74.3	0	2.17	0	3.00
Luyang River downstream	2.19	3.67	9.00	9.00	7.96	7.37	7.53	5.00
Sapangdaku River downstream	1.56	1.50	2.78	2.38	7.81	7.81	7.78	6.23

The estimation of pollution load being received by the bodies of water is shown in Figures 4 and 5. In the figures, the majority of the Biochemical Oxygen Demand (BOD) and Total Suspended Solids

(TSS) concentrations are attributed to household or domestic wastes in Central Visayas, Philippines as of 2020. There is still no centralized treatment facility that could treat domestic wastewater with higher efficiency [21]. The significant increase in the consumption of soap cleaning products during the surge of the pandemic [22] is also a contributing factor. Surface runoff also accounts for 41% of the Total Suspended Solids (TSS) concentration, especially during the rainy season. In the year 2020, there are a total of 3 occurrences of tropical cyclones in Region 7: a.) Typhoon Ofel (Oct. 13–15, 2020); b.) Typhoon Quinta (Oct. 23–27, 2020); and Typhoon Vicky (Dec. 18–20, 2020) (PAG-ASA, 2020). Some of its effects are flooding and landslide or soil collapse [23].

Table 6. Summary of BOD[1] and DO[2] results for the monitored Class D Rivers in Region 7, 2017–2020.

Class D	Average BOD[1] (mg/L)				Average DO[2] (mg/L)			
	2017	2018	2019	2020	2017	2018	2019	2020
	≤ 15* mg/L	≤ 15 mg/L	≤ 15 mg/L	≤ 15 mg/L	≥ 2* mg/L	≥ 2 mg/L	≥ 2 mg/L	≥ 2 mg/L
Bulacao River downstream	-	-	30.8	36.00	-	-	1.64	2.93
Butuanon River	45.6	95.2	70.1	102.6	3.50	2.77	2.64	3.65

Notes: [1]Biochemical Oxygen Demand; [2]Dissolved Oxygen; *Normal values; Source: EMB-DENR.

The data in Central Visayas reveals the importance of the formulation of water policies and the strict implementation of them. Although according to Goddard Space Flight Center-NASA, the water pollution in the world is way better than the pre-pandemic, it still does not suggest that everyone is safe from water contamination especially that people and some establishments are continuously secreting wastewater without proper treatment. Thus, this calls for innovative procedures and facilities that can address this water problem so that it will somehow prevent possible virus transmission coming from the different water sources. Suggested innovations may include household filters and harvested rainwater/ rainwater harvesting and water impounding systems.

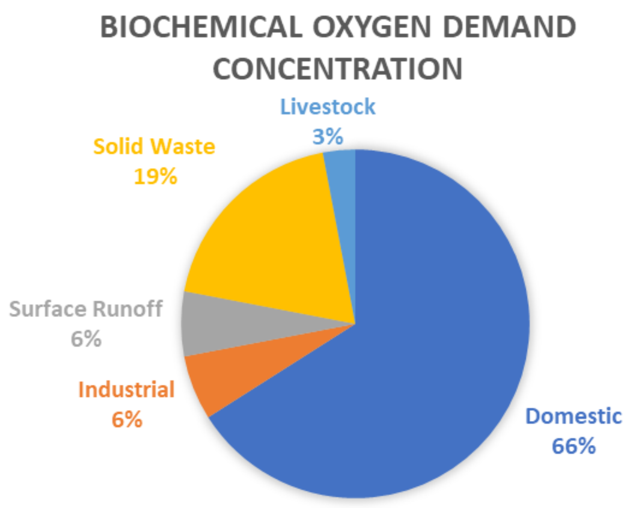

Figure 4. Pollution load source distribution in terms of BOD concentration in Region 7, Philippines as of 2020.

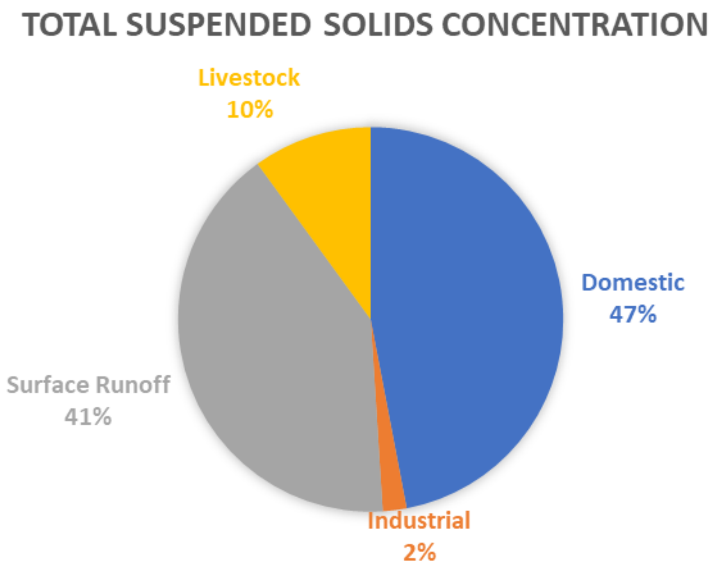

Figure 5. Pollution load source distribution in terms of TSS concentration in Region 7, Philippines as of 2020.

3.3. Solid waste management

Solid waste management is also another key indicator that is important to be looked into because environmental sanitation can pose a threat to our healthcare system. Tables 7 and 8 are the summary of the waste management facilities in Region 7. It tells us that some LGUs have more access to waste management facilities while others do not. All of the open dumpsites in Central Visayas are already closed and mostly are undergoing rehabilitation. There is also an increase in the total number of waste management facilities. The closure of open dumpsites and an increasing number of waste management facilities in the region can help improve our air pollution, water pollution, and decrease the presence of disease vectors and causative agents (Figure 2).

Table 7. Summary of the waste management facilities in region 7 from 2019–2021.

Waste Management Facilities	Year 2019	Year 2021
Materials Recovery Facility	40	96
Sanitary Landfills	14	17
Open Dumpsites	40	0
Dumpsite (Closed and Ongoing Rehabilitation)	-	88
Dumpsite (Closed and Rehabilitated)	-	31

Source: EMB-DENR 7 [10]

Solid wastes can come from different sources: a.) Residential or household wastes; b.) Commercial or wastes from marketplaces; c.) Institutional (e.g., Academic Institutions and Hospitals); and d.) Industrial or wastes from businesses and establishments. Figure 6 shows the graph of the total waste generated in the provinces and chartered cities in Central Visayas. Cebu province has the biggest volume of wastes collected (908,008.40 kgs/day) and Siquijor province has the least (5,696.87 kgs/day) as of 2021. There is a total of 2,893,067.86 kgs/day waste generated in Region 7 as of 2021 which is a 0.67% increase from the total waste generated in the year 2019. However, Figure 7 reveals that Mandaue City is the highest in terms of comparing the total waste generated to its total population.

Table 8. Summary of the waste management facilities in region 7 as of 2021.

	CEBU	BOHOL	NEGROS OR.	SIQUIJOR	CEBU CITY	LAPU-LAPU CITY	MANDAUE CITY
Sanitary Landfill	9	1	4	1	2	0	0
Residual Containment Area	17	21	1	2	0	0	0
Material Recovery Facility	49	25	13	3	0	4	2
Dumpsite (Closed and Ongoing Rehabilitation)	34	25	21	5	1	1	1
Dumpsite (Closed and Rehabilitated)	16	12	2	0	0	1	0

Source: EMB-DENR 7 [10].

To control the spread of the virus and reduce mortality rates brought by the COVID-19 pandemic, authorities and experts suggest wearing personal protective equipment (PPE) like a face mask and face shield, frequent handwashing with soap, or using of antiseptic solution, maintaining social distance, and even enforcing lockdown. One of the environmentally destructive effects is medical wastes resulting from increased medical activity [24]. For example, Vicente Sotto Memorial Medical Center (VSMMC), which is one of the hospitals in Cebu, has produced a 0.37% increase in its infectious wastes since the onset of the pandemic. However, the Environmental Management Bureau-DENR released EMB Memorandum Circular No. 2020-20 last April 27, 2020, regarding the provisional guidelines on hazardous wastes management during the quarantine period. This covers the monitoring of the transport, treatment, storage, and disposal of hazardous wastes and provides temporary protocols for waste generators, transporters, treaters, local government units, law enforcement authorities, and other stakeholders. The pandemic has also increased household wastes due to reliance on online shopping and home delivery during the COVID-19 pandemic [19].

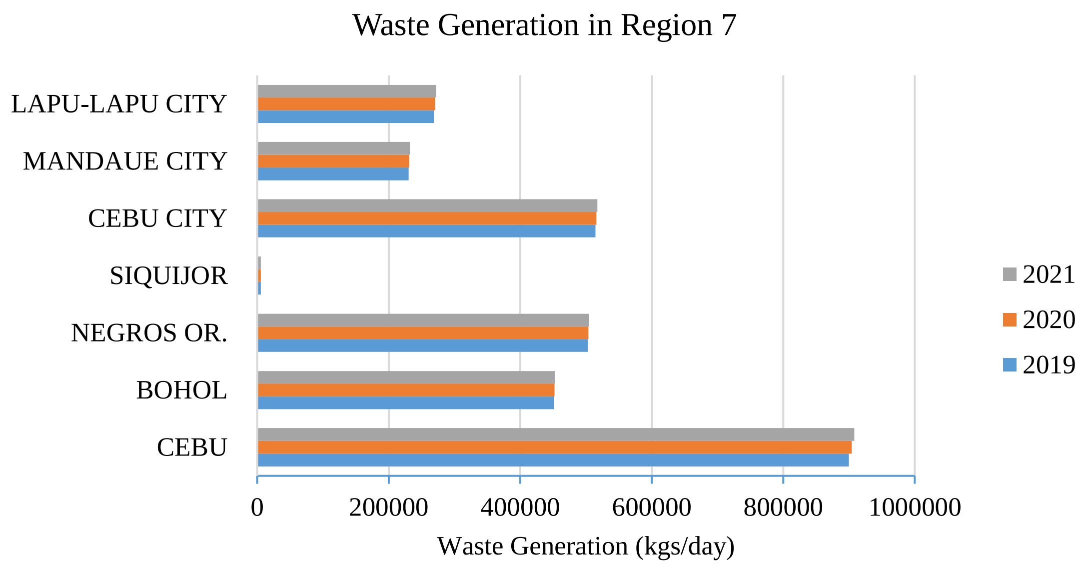

Figure 6. Total waste generated in Region 7 from 2019–2021. (Source: EMB-DENR 7[17])

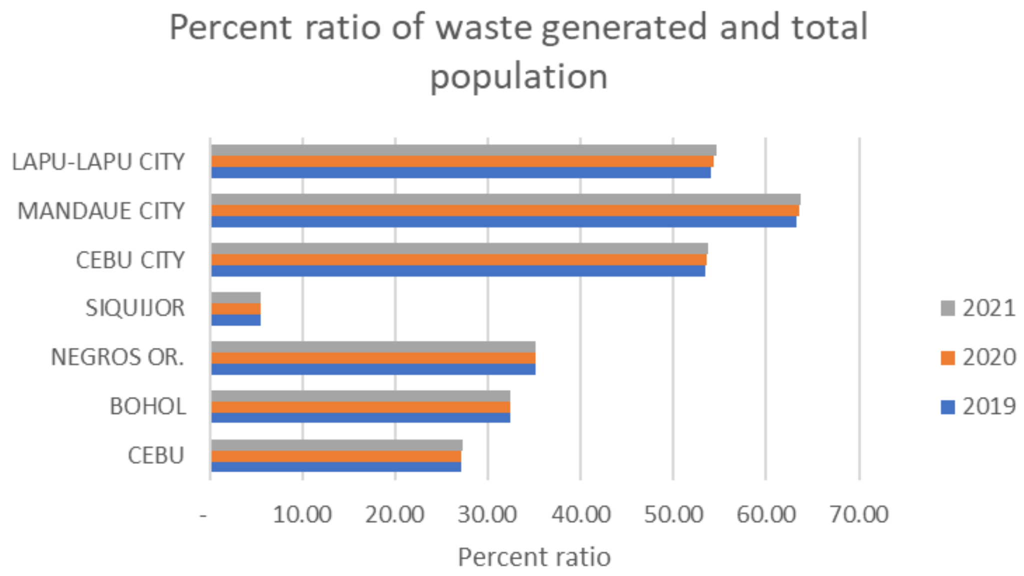

Figure 7. Percent ratio of total waste generated and total population in each province and chartered cities in Region 7 from 2019–2021.

Figures S1–S7 (see Supplementary Information) show the percentage by weight of municipal solid waste fraction in the provinces and chartered cities in Central Visayas. It can be seen that Cebu, Bohol, Negros Oriental, Siquijor, and Cebu City have the most biodegradable wastes; Mandaue City has the most recyclable wastes, and Lapu-Lapu City has the most residual wastes. Figure 8 shows the percentage by weight of municipal solid waste fraction in Region 7. In general, biodegradable wastes are voluminous in Central Visayas as of 2021. The high percentage of biodegradable wastes can improve our environmental condition as these decay easily and fastest among other solid wastes.

The data in Central Visayas reveals that the government policy on the removal of single-use plastic has been implemented well in the region. Ncube et al., (2021) [25] presented how wastes from food packaging plastics, which can harm our environment, can be disposed of and regulated properly. They suggested reducing, reusing, recycling, landfilling, re-extrusion, mechanical recycling, biological recycling, and chemical recycling of these solid wastes. Additionally, to address the worldwide concerns in the increasing medical wastes due to COVID-19, biodegradable PPEs can be innovated and infectious wastes should always be properly managed and regulated.

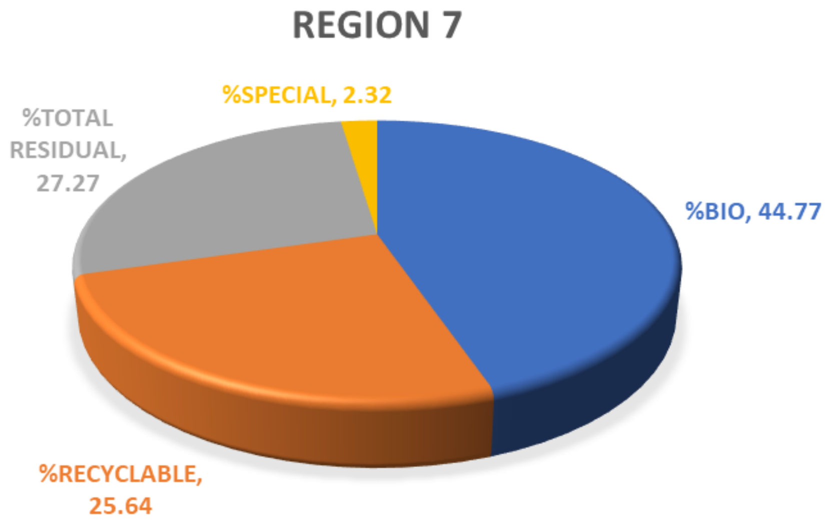

Figure 8. Composition of municipal solid waste in Region 7 as of 2021.

4. Conclusion and recommendation

The Environment Sector can affect the vulnerability of the community to future pandemics and epidemics in Region 7. This plays a crucial role in maintaining the overall well–being of the people. There has been a positive environmental condition, specifically in the air quality, air pollution, and solid waste management since the start of the pandemic. However, Central Visayas fall short on water quality and water pollution. The closures of open dumpsites, continuous rehabilitation of our solid waste management facilities and establishments, few to zero usage of plastics, and creation of environmental programs in Region 7 with strict guidelines have contributed to better changes in the environment as compared to pre-pandemic environmental conditions. However, there are limitations in the study because pandemic and epidemic evolution entails a lot of contributing factors and sources of data in this paper are only for assessing a few of the many environmental factors in Central Visayas that can somehow trigger future pandemics.

It is recommended that proper measures to protect the environment should be followed. There should be a continuous thorough analysis of the proper disposal of wastes especially infectious and hazardous or special wastes and transforming hazardous waste treatment technology. The central and local governments should use innovation to promote green development, the transformation of local economies and the adoption of green environmental policies should be further promoted to protect the environment. Environmental sustainability can also be achieved by using green and clean energy, sustainable industrialization, well-organized waste management facilities, and efficient wastewater treatment.

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Conflict of interest

The authors declare no conflict of interest.

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