VIETNAM JOURNAL OF HYDROMETEOROLOGY

Research Article

Plastic waste, microplastics in the Saigon – Dong Nai river basin, the risk of impacts on the health of people

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Received: 12 Febsruary 2022; Accepted: 19 April 2022; Published: 25 April 2022

Abstract: With the increasing demand for plastic, the environment is now suffering from more plastic waste than ever before; especially disposable plastic waste and medical waste plastic in the post–Covid–19 period. Plastics cannot be biodegraded but persist over time, they are broken down into smaller pieces. These pieces are called microplastics. By means of an overview research method to make theoretical arguments about the risks related to human health from microplastics and we have conducted a survey to sample water on the Saigon–Dong Nai river, the purpose of This paper presents a method to identify microplastics in the continental surface water environment under Vietnamese conditions. The research method has been applied on the Saigon river basin from Dau Tieng lake and Dong Nai tributary from Tri An lake to Thanh Da, at the confluence of the Saigon–Dong Nai rivers; and analyzed some of the impacts of microplastics on human health.

Keyword: Harm of microplastics; Microplastics; Plastic waste; Saigon–Dong Nai River; Surface water.

1. Introduction

Since the 1950s, plastic has been produced about 1.5 million tons/year [1]. Every year, 8 million tons of plastic waste is dumped directly into the environment without any waste management agency [2–3]. Land–based plastic waste flows into the ocean and accumulates in large patches of trash, which can be found in the Pacific Ocean [4]. If current plastic production and waste management policies are prolonged, about 12 billion tons of plastic will be generated by 2050. [2]. While the benefits of plastics are undeniable, their ubiquity and convenience in various forms of use and disposal, such as plastic packaging, has rapidly led to their accumulation in the environment [5]. Floating plastic debris that is continuously affected by wind and waves is rapidly distributed across the water over a large area. Plastic is not lost but decomposed into debris. Microplastics are affected by environmental factors for a suitable time. One of the urgent problems caused by plastic waste recently is microplastics [6].

Vietnam is currently one of the countries with the highest amount of plastic consumption in daily life in the world. According to a report by the Vietnam Plastics Association, Vietnam produced and consumed up to 5 million tons of plastic in 2015. According to statistics of the Ministry of Natural Resources and Environment, 1.8 million tons of plastic waste are discharged into the environment each year in Vietnam; of which, 0.28–0.73 million tons are discharged into the sea, that is, about 6% of the total plastic waste in the sea of the world [7–8]. Specifically, in Hanoi and Ho Chi Minh City (HCMC hereafter), there are 80 tons of plastic is released into the environment every day. Of which, from 7 percent to 8 percent is plastic waste for every 4,000–5,000 tons of waste per day. With the current state of plastic waste, Vietnam will quickly be engulfed in a sea of plastic waste and face the risk of serious "white pollution". Demand for plastic products from urbanizing cities, especially disposable plastic products and medical plastics during the 4th Covid–19 outbreak in HCMC has made the environment and water resources of the Saigon–Dong Nai river basin seriously polluted with plastic waste. This large volume of plastic waste is generating a large amount of microplastics, which is a potential risk to human health when using water contaminated with microplastics. From such a reality, the problem of plastic waste and microplastics needs to be promptly taken care of by responsible individuals and organizations.

One of the important tasks for the monitoring, control and management of microplastic generation in water sources in the future is to have an effective and accurate method of analyzing and detecting microplastics. In this article, we reviewed the relevant data, argued and discussed the topic to initially come up with a synthesis of theoretical arguments about microplastics and human health risks. Further, the purpose of the paper is to introduce the research team's method to determine the appropriate microplastics in Vietnam's conditions and the initial results obtained when applying this method to the water of the Saigon–Dong Nai river basin. The research results are real evidence that river water has been contaminated with microplastics in many forms and shapes, which are harmful to human health. Therefore, this water resource needs to be taken care of and managed in a timely manner.

2. Materials and methods

2.1. Study area

The study and application of the method to determine and evaluate the level of microplastic contamination in continental surface water was carried out in the Saigon–Dong Nai river basin, the Saigon river tributary from Dau Tieng lake and Dong Nai tributary from Tri An lake to Saigon–Dong Nai confluence (Figure 1).

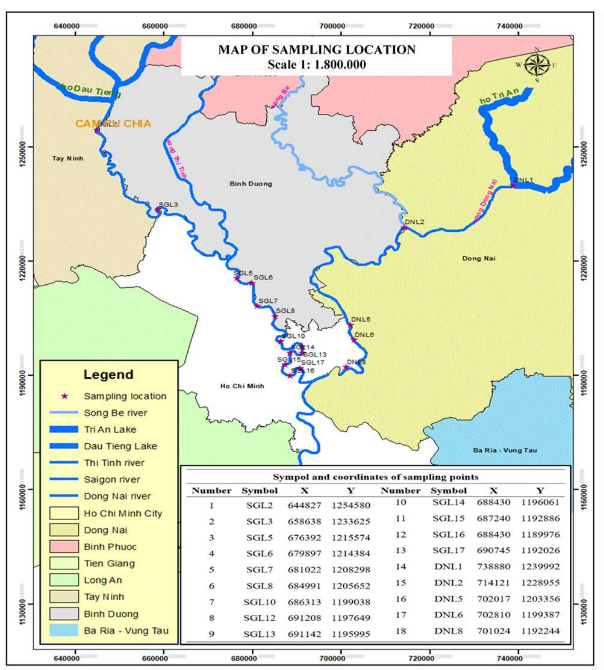

Figure 1. Research area on microplastics Saigon – Dong Nai river basin.

2.2. Methods of data collection and document analysis

The method performed a review of the literature used. The data information that is used has been published in the journals, monographs, thematic reports, topics to analyze and evaluate the presence of plastic waste and microplastics in the country. From the results of determining the level of microplastic contamination in the Saigon–Dong Nai river basin and the results obtained from the research works on microplastics, theoretical perspectives in article was made to outline the aware of the existence and risks related to human health of microplastics in continental surface water and devised an appropriate method of determination in the conditions of Vietnam. The authors performed material selection and extracted data from unambiguous, reliable sources. The arguments for agreement and disagreement were thoroughly discussed and resolved by all members of the research team. After the information and research data was collected, the content was classified and checked for accuracy.

2.3. Sampling method

2.3.1. Method of collecting microplastic samples in surface water

Currently, because of the lack of a standard method, the sampling device has been designed by the research team to sample microplastics, and the sampling method is implemented as follows: Surface water and sediment samples in the Saigon–Dong Nai river basin were taken at 18 locations (13 locations on the Saigon river and 5 locations on the Dong Nai river), which are densely populated areas, or main river confluence areas, where canals empty into rivers. All samples were taken in November 2021 and March 2022, this work being done at high tide and low tide.

Surface water samples were collected using a Neuston grid, which is 1×1 m^2, 500 µm meshed meshes with a length of 3 meters. Nets were installed on the port side of the research vessel, which were kept 2.5m from the vessel to prevent small waves from interfering with sample collection. The net was dropped into the water to a depth of 0.5 meters; half below and half above the water to reduce the possibility of waves washing past the top of the net. The tugboat was run at a speed of nearly 4 km/h for 10 minutes. The average trawl distance was 0.7 km (range = 0.6–0.8 km).

Water samples were taken at low tide and at high tide. Samples were collected in the area from low tide (lower shoreline) to high tide (upper shoreline), which could represent microplastics dispersed in the river. At each sampling site, two different depths were selected: in the surface layer (2–30 cm top) and in the 50–100 cm layer, 70–100 m from the upper shoreline to the river at high tide and 20–30 m from the lower shoreline at low tide. The purpose of this manipulation is for us to study the relationship between microplastics and water depth. A total of 18 locations were sampled with 4 samples each, according to the wet and dry seasons, that means a total of 144 water samples were collected in this study. All samples were stored at room temperature and transported to the laboratory for analysis.

2.3.2. Method of collecting microplastic samples in the sediment

Sediment sampling was carried out according to the random sampling method. Samples were taken at the featured locations, along with the water sampling sites. Before sampling, it is necessary to remove large impurities first; Samples were taken with a stainless steel spoon with a depth of 2–3cm and the weight of each sample was about 2–4 kg. In order to avoid plastic contamination from other sources, the samples after collection were transferred to 1 liter glass jars with lids and stored at 4ºC.

2.4. Method to determine microplastics in continental surface water which is suitable for Vietnam conditions

2.4.1. Analysis of microplastics in surface water

The samples were processed in the laboratory, the process of separating the microplastics from the organic debris and other debris in the sample helped us to count and separate the microplastics visually.

(i) Prepared catalysts

The Iron (II) catalyst used in the wet peroxide oxidation was prepared: 500 mL distilled water +3 mL concentrated H_2SO_4 combined with 7.5 g $FeSO_4.7H_2O$. The catalyst was stored in a glass vial.

Wet sieve: The sample was poured into a set of two stainless steel sieves stacked on top of each other (0.355–0.999 mm and 4.7 mm), which allowed the removal of large organic debris and plastic from the largest sieve (≥ 4.75 mm) before starting wet peroxide oxidation and accelerating decomposition. The sample bottles were rinsed three times with distilled water to ensure no plastic particles remained in the vials. The material in the two sieves was then washed thoroughly with distilled water. Any large plastic that was found in the top sieve was removed with forceps, washed, and placed separately in a labeled petri dish. Large organics were separated, which were then carefully rinsed with distilled water to collect any microplastics that might still be trapped. After all the microplastics were washed and collected, the largest pieces of organic matter were completely removed. The material remaining in both sieves was rinsed into a labeled 600 mL beaker, using as little deionized water as possible.

(ii) Wet Peroxide Oxidation

When the organic matter was coated into the 600 mL beaker, 20 mL of 30% hydrogen peroxide (H_2O_2) and 20 mL of the Iron(II) catalyst were added afterwards. Depending on the amount of water required to coat the organic material in the beaker, the total volume of the initial liquid ranged between 60 and 100 mL and was dark amber in color. The beaker was placed on the electric stove and stirred at 75ºC. The speed of the stirrer was dependent on the amount of organic material present in the sample and was set high enough to evenly mix the sample without allowing the contents of the beaker to be thrown to the sides; The electric stoves were located inside the fume hood. During treatment, 20 mL of H_2O_2 was added as the reaction progressed (indicated by the color change from amber to pale yellow). If H_2O_2 had been added but the color of the solution was still dark amber or rusty, we continued to add 20 mL of 6M H_2SO_4. The amber or rust color then continued to darken, indicating that the iron in the catalyst was removed from the solution. During the process, do not add H_2O_2 or H_2SO_4. If we had added H_2O_2 or H_2SO_4 but the reaction no longer continued (no change in color was observed), the beaker was again rinsed through the smallest sieve (0.355 mm) and was repeated from the beginning. No color change indicated that the solution had become too dilute for the reaction to continue.

The sample was carefully monitored and heated above 75°C. If the solution boils vigorously and boils excessively, reduce the heat and add distilled water to slow the reaction. The reaction was complete when the color of the solution changes from yellow–orange to pale yellow and the organic matter had completely decomposed.

In some cases, we needed to process the sample multiple times so that the organic materials were completely decomposed and microplastics could be classified. If a large amount of organic matter remained after the wet peroxide oxidation, the sample was rinsed through the stacking sieves again. The process was repeated. In some cases, we had to repeat the whole process up to four times to completely decompose the organic material in the cup due to the large amount of organic matter. After the wet peroxide oxidation was completed, the sample was ready for us to continue the optical analysis.

(iii) Microscopic analysis

After wet peroxide oxidation, the sample was again sieved by us through stainless steel stacked sieves, during this stage, we used three sieves to separate the particles by fractional size (0.355–0.999 mm, 1.00–4.749 mm and ≥ 4.75 mm). The largest sieve (≥ 4.75 mm) was still used. Although the large visible resins were removed by us and set aside before the wet peroxide oxidation was complete. Large plastic components may have become entrapped in the organic material and were unable to separate until the wet peroxide oxidation was complete. Therefore, we needed to use all three sieve sizes. After being carefully coated, the contents of each individual sieve were carefully coated into individual petri dishes labeled with sample number and size composition. Then, each petri dish was placed under an analytical microscope at 40X magnification and all the microplastics present were counted and identified by us as: flakes, pellets, sugars/fibres, films or foams. There have been many guidelines for determining microplastic morphology, but there are no universal standards at this time. The morphological categories used in our study, which are consistent with those used in a number of other surface water studies [9–11]. This information for all size types is recorded on a single data sheet for each model. Microplastics were identified, counted, and placed in a 4 mL screw–cap glass vial and labeled using thin clamps. For each sample, size fractions were separated into individually labeled vials such that each sample was divided into two or three vials (depending on whether microplastics were identified in each size category). The vials were then sealed and stored.

(iv) FTIR analysis

To prepare for FTIR analysis, sample vials were washed and poured into a clean, dry, labeled petri dish (separated by size fraction) and placed in an oven at 50°C for until the petri dish and contents are dry. Then, the individual plastic beads were removed from the petri dish using a microscope (Leica EZ4HD, 8–40x zoom, built–in 3Mpixel camera) and were placed on the FTIR (PerkinElmer Spectrum Two ATR; 450/cm to 4000/cm, 64 scans, resolution 4/cm) for analysis. The spectra that we obtained, which are compared with internal spectral libraries to find the closest match and determine the chemical composition. A match of 70% or more is considered sufficient for confirmation.

Not all particles from all samples can be analyzed because of the time–limited nature of the FTIR analysis and the number of particles counted and classified. In an attempt to analyze a representative number of particles, about 10% of the total particles counted were selected for analysis. To achieve a total analysis of 10%, samples with a high microplastic count were selected from all over and from these samples not less than 10 and not more than 30 particles (divided into size and morphological fractions). The remainder was returned to the corresponding 4mL labeled glass vial.

2.4.2. Methods for the analysis of microplastics in sadiment samples

The execution procedure was as follows: Weigh 100g of dry sample into a 600 mL beaker, dry at 90ºC for 20 to 24 hours. Then the samples were left to dry naturally overnight.

Density separation: Add 73g of 2.5 M NaCl (d = 0.073 g/mL) to 500 mL of distilled water. The mixture was stirred for several minutes with the stirring rod. After the mixture of distilled water and NaCl solution had been dissolved, continued to add 100g of sample to mix well. Let the mixture settle for 15 to 20 minutes, the solids began to float on the surface and the sample was left to settle overnight for 8 to 12 hours. Then, using a 0.3 mm sieve to filter and transfer the solids to another beaker, we obtained particles with a size less than 0.3mm, having removed particles with a size larger than 0.3mm.

Remove organic matter: The sample was subjected to density separation. Next, they were placed in a 600 mL beaker with 20 mL of 0.5 M Fe(II) and 20 mL of 30% H_2O_2. We let the mixture rest for 5 minutes at room temperature before heating. After 5 min, the mixture was stirred with a magnetic stirrer, placed on the electric stove and covered with a glass lid. To avoid spillage, we used a thermometer to control the temperature and let the temperature reach 75ºC. Once the mixture had started to boil, the mixture was removed from the heat and allowed to cool. Once we had observed that organic matter remains in the sample cup, continued to add 20 mL of 30% H_2O_2 to the beaker. The same process was repeated. After 20mL of 30% H_2O_2 was added a second time, the reaction was faster. This process was repeated until the organic matter in the sample cup was absent or very little. After this step, we added 6g NaCl to 20 mL of the mixture to increase the density of the solution. We further heated to 75ºC to dissolve the salt in solution. Then, the mixture was wrapped in aluminum foil and left in a fume hood overnight. Finally, after the mixture was left overnight in a fume hood, the particles were removed from the bottom.

Vacuum filter: After the filter was completely assembled, slowly poured the solution from the de–organic sample flask until the entire sample had passed through the filter. Distilled water was used to clean the cup and filter wall, which helped to limit the loss of microplastics during the filtration process. The sample after being filtered and liberated by removing the vacuum tube, we carefully removed the filter paper with forceps and placed it in a pre–labeled petri dish. The operation was repeated with all remaining samples.

Fluorescent staining – Nile Red dye: Samples after density separation and organic matter removal, a total of 44 filters were further processed by fluorescence microscopy. Nile Red solution of 5 µg/mL was prepared with 1 mg of Nile Red dye in 1 mL of 99.5% acetone and diluted with 100 mL of distilled water [12]. Filters were stained with diluted Nile Red solution and allowed to dry for 30 min at room temperature.

Identification of microplastics in sediment s amples: The FTIR method was randomly performed on microplastic samples after density separation, organic matter removal and vacuum filtration. Infrared radiation of 1/600–1/4000cm was used with a resolution of 1/4cm. We performed 4 scans to generate the specific spectrum.

Before microplastic analysis, we cleaned the analysis system with alcohol and a lint–free cloth. The sample was then placed on the auto–scanner filter and the joystick was used to determine the sample's position. Optical images were recorded and marked an area, which microplastics were characteristic. Finally, we recorded the background spectrum and placed the sample on the sample holder and then collected the spectrum at a predefined location.

3. Plastic waste and the existence of microplastics in the Saigon – Dong Nai river

In urban areas of Vietnam, the total volume of plastic bags is 10.48–52.4 tons/day; only about 17% of these bags are reused [13]. Between 2000 and 13000 tons of floating plastic debris is collected annually in the municipality's main canals [14]. the main types of plastic waste are plastic bags, plastic bottles, disposable plastic products, hard–to–recover and difficult to recycle plastic products, ect, arising from (i) Daily activities and consumption; (ii) Socio–economic activities. Similar to the world, nearly 50% of plastic products are designed and manufactured for single use and then discarded in Vietnam. Of the total amount of plastic waste discarded, only a portion is recovered or recycled, and a portion is treated by incineration or landfilling. In 2015, the plastic industry produced and consumed nearly 5 million tons of products; the majority is imported (about 80%), which includes imported plastic scrap [15]. In 2017, Vietnam plastic industry consumed about 5.9 million tons of virgin plastic materials [16]. Currently there are about 2,000 plastic enterprises, of which 450 are manufacturing packaging, generating a large amount of daily plastic waste including hard–to–decompose plastic bags. In 2018, the production output of the plastic industry increased by 7%, reaching 8.3 million tons, of which the production of packaging plastic accounted for the largest proportion in the industry's value structure, reaching about 36%; plastic construction materials, household appliances and other industries such as electronics, electricity, and transportation account for about 16%, 36% and 12% respectively [17].

HCMC has to process about 9000 tons of domestic waste every day; Infrastructure, solid waste management and waste treatment system are mainly landfill. The decomposition time of organic substances in water is from 7–15 days, but plastic products such as plastic water bottles, plastic bags, masks, toothbrushes, and so on have a decomposition time of 50–500 years. The decomposition process does not make the plastic disappear but decomposes into microplastics. When microplastics enter wastewater, rivers, canals, groundwater, ect, srimp, fish and aquatic animals eat or drink water contaminated with microplastics, they all have microplastics in their bodies. Therefore, humans can also ingest microplastics through food sources such as salt, vegetables, shrimp and fish, drinking water contaminated with microplastics.

There have been many research works that have given a lot of evidence to recognize the existence of microplastics in the environment. The definition or classification of microplastics is based on their size as Macroplastics (5 mm–10 cm), Microplastics (1 µm–5 mm) and Nanoplastics (1 nm–1 µm) [18]. As defined by NOAA (National Oceanic and Atmospheric Administration), microplastics are very small plastic samples less than 5 mm in size [19]. The world's rivers and seas and oceans have been shown to be heavily contaminated with microplastics, especially in estuaries. The distribution and abundance of microplastics depends on environmental factors, including wind, tides, currents, tributary inputs, and human factors including water treatment, factories discharge of wastewater containing microplastics. The causes related to high concentrations of microplastics in surface water are urbanization and high population density in areas such as Thu Dau Mot City and Ho Chi Minh City in Vietnam.

Due to their small size, microplastic particles are easily washed down the drains and ditches by the water flow and passed through the wastewater treatment plant. Wastewater treatment plants are almost "collection points" of microplastic pollution that are released into the receiving water's water environment. Current wastewater treatment systems are not designed to remove or treat these microplastics. Therefore, they are washed into the source water, drifting into the sea every day, where they are also accumulating countless other pieces of microplastic. In particular, in the aquatic environment, microplastic particles over time are surrounded by microorganisms, isolated from destructive factors. At the same time, the temperature in the water and low oxygen concentration prolong the decomposition time of these microplastics.

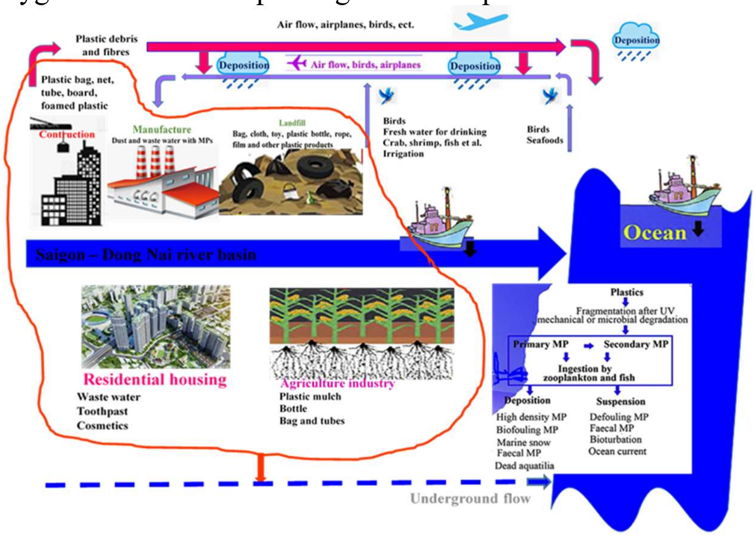

Figure 2. Simulation of microplastic formation in the Saigon – Dong Nai river basin from large plastic waste.

Microplastics are derived from plastic wastes released into the environment by humans. They are classified into 3 groups: primary microplastics (primary), secondary microplastics (secondary), microplastics from other sources. Once microplastics are introduced into the environment, they are very difficult to remove. Plastic undergoes decomposition into microscopic sizes due to physical influences (wind, rain, heat), chemical influences (ultraviolet radiation from sunlight or corrosion) and through mechanical biodegradation (microorganism).

Microplastics are persistent, non–biodegradable and cannot be recovered for recycling like large pieces of plastic, which leads to accumulation in the environment. The half–life of microplastics is almost impossible to determine, their accumulation causing even longer–lasting environmental effects than persistent organic pollutants (POPs).

Vietnam does not have many specific statistics on microplastics in continental surface water sources, especially microplastics in the Saigon–Dong Nai rivers. However, recently there have been a number of studies to determine the distribution and content of microplastics in sediment samples and water environment of the river basin. The latest research has shown that the water source is not only contaminated with organic and physico–chemical parameters but also contaminated by microplastic emissions after performing microplastic analysis in surface water, sediment samples at 18 locations (13 locations on the Saigon river and 5 locations on the Dong Nai river) [20].

The results showed the appearance of microplastics in the form of thin, fibrous and microplastic particles from 0.1–5 mm in size. The results of research on microplastics in water and sediments of the Saigon–Dong Nai river at 18 locations are a clear proof that the Saigon–Dong Nai river basin has been contaminated with microplastics at a high level.

▪ Microplastics have been found in various colors, shapes and very small sizes. They are unevenly distributed in number and volume at sampling points.

▪ There were 228.120 microfibers/m^3 of water, at most 715.124 microfibers/m^3 of water and 11–222 microplastic flakes/m^3 of water.

▪ The volume of microplastics in the sediments at the sampling points ranged from 6.47 ± 1.45 to 52.32 ± 4.92 mg/kg with an average value of 21.77 ± 6.9 mg/kg.

▪ Microplastics are unevenly distributed in number and volume at sampling points. Of which PE 51.2%, PP 27.1%, PVC 13.4% and 8.3% are other plastics.

4. Results of applying research methods and discussion

4.1. The results of the application of research methods

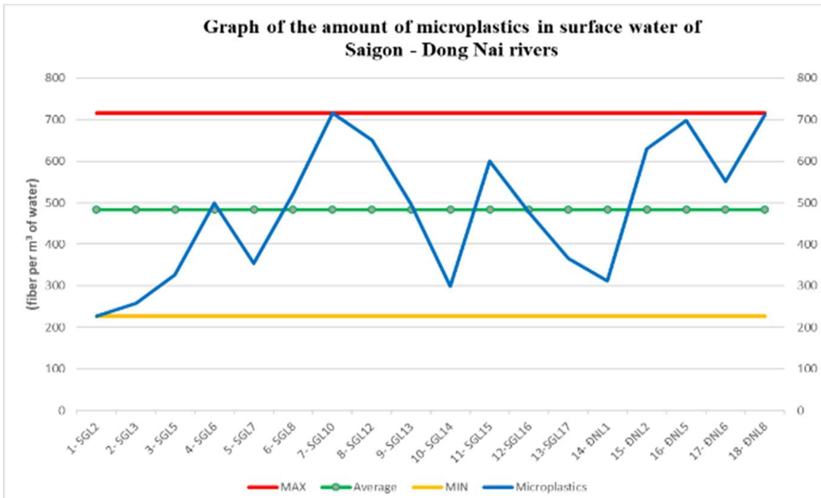

Figure 3. Filamentous microplastics at sampling points.

The results of applying the analytical method in Vietnamese conditions have shown that microplastics are found with many different colors, shapes and very small sizes; microplastics in the form of flakes, fibers and microplastics from 0.1–5 mm in size. The results of research on microplastics in water and sediments of the Saigon–Dong Nai river for water and sediment samples at 18 locations are a clear proof that the Saigon–Dong Nai river has been contaminated with microplastics at a high level.

Figure 4. Determination of microplastics in sediments under fluorescence microscopy.

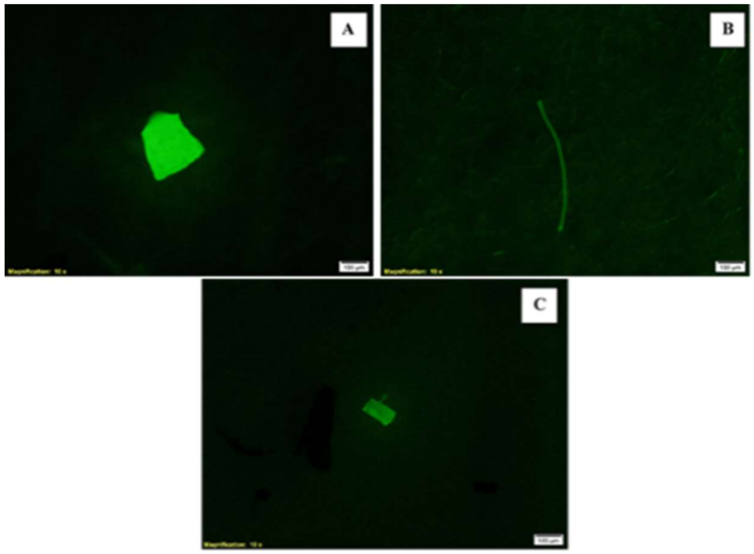

Figure 5. At 100x magnification, the microplastic (A) has a length of 229.49 μm; fibrous (B) with a length of 524.68 μm and granular (C) with a length of 113.81 μm.

4.2. Discuss the method of analyzing microplastics in water samples and sediments of continental surface water

The National Oceanic and Atmospheric Administration (NOAA) method of analyzing microplastics in water and ocean sediment samples is used to analyze plastic debris as suspended solids in water. They are collected by a surface sampling grid, consisting of layers of 5.6 mm and 0.3 mm sizes. This method only stops at the task of detecting and determining the mass and content of microplastics in water samples, sediment samples through density separation and mass analysis. Although the NOAA method uses a 40× magnification microscope for confirmation and relies on the density of the resins to determine the composition, it has not yet provided an accurate demonstration for the method. The results of the method should depend on the analyst's intuition. Nanoscale microplastics are almost unidentified by this method.

Vietnam is a country located at the southeastern tip of the Indochinese peninsula. Vietnam's river network has a distinct spatial division. The hydrology of Vietnam's rivers closely follows the rhythms of the wet and dry seasons of the humid monsoon intratropical climate. Most of Vietnam's rivers are the main source of water for communities near the area, in which the typical Saigon–Dong Nai river basin is. When conducting microplastic analysis in this river basin, our authors carefully studied factors such as current water quality, seasonal variation, existence of microplastics, different types of microplastics, types of population and related types of plastic waste, ect, to apply NOAA method appropriately and effectively. The content of the analysis has been more developed, that is, we have applied a combination of modern microplastic identification methods to be able to determine more accurately about microplastic components, more effectively for different types of microplastics. Colorless, transparent, detectable plastics include micro and microplastics. The more developed analysis content is that we have applied a combination of modern microplastic identification methods to be able to more accurately determine the microplastic components. The method is more effective for colorless, transparent and detectable microplastics including macroplastics and microplastics.

4.3. Discuss the risks related to human health through the water of Saigon – Dong Nai river of microplastics

Currently, 8 out of 10 (80%) items that are discarded floating in the Saigon River are single–use plastic [21]. Research results have proved that the water of the Saigon River is seriously contaminated with microplastics. In one liter of water from the Saigon–Dong Nai river flowing into the sea, it can contain up to 715.124 microplastics/m^3 of water, which is 1000 times higher than the microplastics in the Seine river. [22]. With the increasing demand for plastic, the environment is currently suffering from more waste plastic than ever before, especially disposable waste plastic, post–Covid–19 medical waste plastic. Plastics are not biodegradable but persist over time, they break down and break down into smaller pieces, these pieces are called microplastics.

The presence of microplastics in the water environment of the Saigon–Dong Nai river has negative impacts on the health of aquatic organisms, zooplankton or animals at low trophic levels. They may mistake microplastics as food and inadvertently ingest them. The accumulation of microplastics in the body of animals can cause health risks such as suffocation of the trachea, or adverse effects on the digestive system, which is a cause of death for many aquatic species. When aquatic organisms ingest microplastics, which are mediators of the accumulation of dangerous chemicals. This can lead to the spread, accumulation of microplastics and other pollutants from lower to higher organisms; even in the human body through the food chain. Thus, when people consume these species in their daily meals, it also means that they will directly eat microplastics into the body. This reception leads to health risks due to microplastics and other pollutants attached to plastic surfaces. Research results of [23] have found microplastics in familiar seafood such as shrimp, oysters, crabs, fish, ect. In addition, microplastics have also found in drinking water, beer, honey, sugar, and salt [24–26]. All of these are related to water sources (which are habitats for aquatic organisms and are a source of water for production and human activities). When infected with microplastics, the Saigon–Dong Nai river basin is also inevitable as the agent leading microplastics to enter aquatic animals and human food.

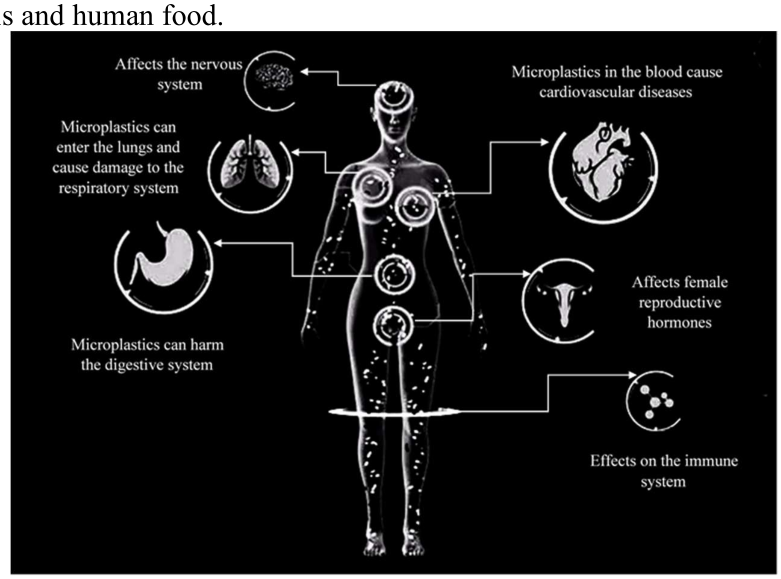

Figure 6. The effects of microplastics when appearing in the human body [27–31].

The existence of microplastics in the environment raises concerns about the impact on human health. The most recent research results of the Dutch National Organization for Health Research and Development and the Common Seas organization specializing in actions to reduce plastic pollution have found the existence of microplastics in human blood. The results were published in the journal Environment International in March 2022. [32]. This finding further supports the hypothesis that exposure to microplastics can cause them to enter the bloodstream and other internal organs of humans. Knowledge about the harmful effects on human health from microplastics is very limited, difficult to clearly assess and still controversial. As a result, human risk assessments are challenging and necessary, especially with regard to the perceptions of exposure pathways and human health risks.

Microplastics can enter the human body through digestion and inhalation, where they can be absorbed in many organs and can affect health. Ingestion is considered the main route of human exposure to microplastics. Microplastics can reach the digestive system through contaminated drinking water or food, which can lead to inflammatory responses, increased permeability, and changes in the composition and metabolism of gut bacteria [33]. Microplastics can penetrate the intestinal mucus, adhere to the intestinal wall causing pus and internal wounds. Skin contact with microplastics is considered a less important route of exposure, although it has been speculated that nanoplastics (< 100 nm) can penetrate the skin barrier [34].

Plastic products also contain many other ingredients that can be harmful to human health, such as colorants often containing heavy metals and many other toxins that disrupt the endocrine system in the human body. Phthalate ester plasticizers are often added during the production of microplastics for the desired purpose. They are used to increase the anti–cracking effect of nail polish (dibutyl phthalate DBP), skin softener, colorant, fragrance (diethyl phthalate DEP) or anti–foam in some cosmetics. Ester phthalate is a substance that disrupts the endocrine process, affects reproductive health and has a risk of causing breast cancer.

In addition, the Bisphenol A (BPA) ingredient in plastic packaging and containers has the potential to "leak" into food and interfere with human reproduction. Bisphenol A (BPA) is used mainly in the production of polycarbonate (PC) and epoxy resins, among many others. Actual plastic products such as water bottles, sports equipment, CDs and DVDs, plumbing pipes, and even poor quality toys for young children… Plastics contain BPA if released into food. Eating has the ability to destroy the body's hormones, causing many dangerous diseases such as cancer, affecting the nervous system, hypothyroidism, etc... and other dangerous diseases. The diseases that BPA can cause such as behavioral changes, early puberty, down syndrome, reduced sperm count, breast cancer, prostate cancer, etc. directly affect people's quality of life. The most commonly affected internal organs are the liver, kidneys, heart, nervous system (including brain), and reproductive system [35].

Microplastics can almost be considered as a substrate that creates a favorable environment for some types of bacteria that cause human diseases. Microplastics on the coast of Belgium were found to contain bacteria that cause diseases in humans such as Escherichia coli, Bacillus cereus, Stenotrophomonas maltophilia. In addition, microplastics also create a habitat for the larvae of the parasites that cause malaria, Zika virus, and liver fluke in freshwater snails, leading to an increased risk of infection with these diseases.

Small microplastics can penetrate the cell wall or the blood–brain barrier, the placenta, causing oxidative stress, cell damage, inflammation and other dysfunctions. Microplastics with a size of 3–9 micrometers can enter the circulatory system, penetrate blood cells, and affect the cardiovascular system. They also cause oxidative stress, necrosis and inflammation of liver cells, leading to cirrhosis. In addition, microplastic particles are adsorbed with organic pollutants, which causes endocrine disorders and affects reproductive functions. Microplastics can almost be considered as a substrate that creates a favorable environment for some types of bacteria that cause human diseases. Microplastics on the coast of Belgium were found to contain bacteria that cause diseases in humans such as Escherichia coli, Bacillus cereus, Stenotrophomonas maltophilia. In addition, microplastics also create a habitat for the larvae of the parasites that cause malaria, Zika virus, and liver fluke in freshwater snails, leading to an increased risk of infection with these diseases.

5. Conclusion

Although the special benefits of plastic for modern life cannot be denied, the negative effects and potential risks to human health are of great concern. Notably, research results have shown the existence of microplastics in the Saigon–Dong Nai river basin, a major source of water for the people of Ho Chi Minh City. It can be seen the fact that the number of studies on microplastics in the continental surface water environment has increased rapidly in recent years, but no standard method of microplastic determination has been given. Most research methods relied on NOAA's method of determining ocean microplastics. The method of analyzing microplastics in water and sediment samples suitable to Vietnamese conditions proposed by the research team has been successfully applied in the identification of microplastics in the Saigon–

Dong Nai river. In addition, the basic data on the risks affecting human health due to the appearance of microplastics have contributed to the confirmation that it is necessary to have solutions to protect river water sources to avoid the harmful effects of microplastics.

Authors contribution: Contructing reseach idea: H.P., H.T.N.H.; Select research methods: H.P., H.T.N.H., N.L.N.T.; Data processing: H.P., H.T.N.H., N.L.N.T.; Sample analysis: H.P., H.T.N.H., N.L.N.T.; Take samples: H.T.N.H., N.L.N.T.; Writing original draft preparation: H.P., H.T.N.H.; N.L.N.T.; Writing review and editing: H.P., H.T.N.H.

Acknowledgments: This study was carried out under the sponsorship of the research project Microplastics in surface water and sediments of Saigon - Dong Nai rivers, of Phu My Institute of Technology Development for Environment and Water Resources.

Conflicts of Interest: The authors declare that this article was the work of the authors, has not been published elsewhere, has not been copied from previous research; there was no conflict of interest within the author group.

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