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A Study on The Abundance of Microplastic Pollutant in Residential Tap Water

Nur Afifah Nasuha Mohd Nor[1], *Izzat Muqri* Shamsul Azahar[1], *Nurain* Saipolbahri[1,2], and *Noor Syuhadah* Subki[1,3*]

[1]Faculty of Earth Science, Universiti Malaysia Kelantan Jeli Campus, 17600 Jeli, Kelantan
[2]International Ceramic Manufacturing Hub (ICMH), Batu 4, Jalan Batu Pahat, Kawasan Perindustrian Mengkibol, 86000 Kluang, Johor
[3]Centre of Management for Environment, Occupational Safety and Health, Universiti Malaysia Kelantan, 16310 Bachok, Kelantan

Abstract. Plastic pollution is one of the most pervasive and sinister ecological threats worldwide. Microplastics (MP), is a small piece of plastic and its size is less than 5 millimetres. They were existed from various sources, including personal care products, synthetic clothing, and plastic litter. Microplastics have been found in a wide range of environmental matrices, including soil, sediment, and surface water. The presence of microplastics in tap water has received considerable attention in recent years. This study focuses on the presence of microplastics (count) and the types of microplastics pollutants (chemical properties) in tap water as the drinking water sources in the residential area. Approximately, 120 L of water samples was collected from tap water in houses/shops using random sampling method in four sampling sites. The presence of microplastic in the tap water might come from many sources. In this study, a light microscope and Micro-Fourier Transform Infrared Spectroscopy instrument have been used to identify the presence of microplastics precisely. From the analysis, three types of microplastics were found in the tap water samples which are cellulose, cellophane, and poly (2, 2, 2-trifluoroethyl vinyl ether). In conclusion, there are presence of microplastic in tap water at the residential area which is used as the drinking water sources. Since microplastics found in drinking water is one of the potential health risks to human by exposing direct plastic ingestion, microplastic contamination in water supply systems should be controlled.

1 Introduction

Microplastics (MPs) are synthetic polymeric particles with a diameter of less than 5mm [1] and commonly include nano plastics with a diameter of less than 100 nm [2]. The two types of microplastics are primary which are intermediate raw materials, pellets and by-products and secondary products produced by breaking and degradation [3].

* Corresponding author: syuhadah@umk.edu.my

The ubiquitous problems of microplastic in waters is receiving global attention as microplastic can harm aquatic organisms, and finally can accumulate in the human body through biological chain amplification. In addition, microplastic act as a carrier capable of carrying heavy metals, organics, which form complex pollutants. These new combinations of pollutants, once ingested by aquatic organisms, are amplified through the food chain and can have unpredictable ramifications for aquatic organisms and human beings. Therefore, human beings are not only the source of plastic pollution, but also the sink of microplastic pollution [4].

Plastics have become widely used due to their exceptional adaptability and durability. Although plastics have improved our lives in terms of affordability and convenience, the indiscriminate disposal of end-of-life plastics causes major environmental issues, as plastics fragment into smaller pieces once they reach and collect in the aquatic environment due to their low biodegradability [5]. Plastic contamination is widespread globally and is considered one of the main problems of environmental protection and management of aquatic resources [6]. Recently, the presence of microplastics in drinking water sources is very prevalent which can cause human health to be affected [7].

Microplastics have become increasingly prevalent in water supply sources in recent years and have become a public concern leading to increased potential risks to their environmental health [8]. Lately, there have been several issues of microplastic. This is due to improper management, lack of information on the negative effects of pollutant microplastics and irresponsible use as well as dumping of plastic products that adversely affect human and animal health [9].

1 Methodology

1.1 Sample Collection

In this study, random sampling methods were used to collect water samples from residential areas in 4 different sampling sites. There are 10 sampling points for each sampling site. About 1 L of water samples with 3 replicates were taken from each sampling point. Clean glass bottles were used for water sampling. To prevent contamination, the bottles were rinsed with distilled water and then filled with tap water until flow out. After that, the bottle's mouth was covered with aluminium foil and capped tightly with the lid and labelled. After the tap water samples were collected, the glass bottles were put into an ice container to maintain the temperature before transfer to the laboratory. The collection of water samples was then stored in a chiller at 4˚C until filtration.

1.2 Water Filtration and Drying Process

A glass vacuum suction filter was used for the filtration process. Filter paper (cellulose nitrate membrane) was inserted into the glass vacuum suction filter. Then the water samples from each sampling points was poured into the graduated glass funnel. Finally, the vacuum pump was turned on to absorb the tap water sample, and the water samples flowed into the conical flask. After the filtration process, each filter paper that represent the sampling points were put in a petri dish (with cover). The labelled petri dish was placed in desiccator within 24 hours for the drying process.

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1.3 Physical Characterization (sorting)

After the drying process, the petri dish containing dried filter paper was placed under a glass box to control contaminants before viewed using a light microscope. Next, both hands are inserted inside the hole of a glass box as shown in Figure 1 and microplastics were taken one by one using forceps and placed on the new filter paper. The physical characterization of the microplastics such as color and shapes were recorded during the sorting process. In case of doubt, the Hot Needle Test was applied to the sample. A hot needle test is a technique to classify microplastic and non-microplastic. The new filter paper was placed in a new petri dish and covered with a lid and was kept again in the desiccator before chemical characterization process.

Fig. 1. Sorting process under microscope

1.4 Chemical Characterization (Fourier Transform Infrared Spectroscopy (FTIR) Analysis)

All the samples were analyzed to determine the presence and type of microplastics by using Nicolet iS20 FTIR Spectrometer Fourier Transform Infrared Spectroscopy (FTIR). A very accurate microplastics detection system was developed using Micro-Fourier Transform Infrared Spectroscopy with Attenuated Total Reflection (-ATR-FTIR). This was crucial for describing the morphology and structure of the particles collected from the samples. To confirm the type of microplastics, the spectra were compared to Hummel's polymer and additive library as a reference.

2 Results and Discussions

2.1 The Abundance of Microplastics Pollutants

Water samples were collected in four different sampling sites (A, B, C and D). Each sampling sites have 10 sampling points. Table 1 shows the number of microplastics (count) pollutants that have been found in each sampling sites.

Table 1. Number of microplastics in each sampling sites.

Sampling sites	Number of microplastics (pieces)
A	118
B	120
C	268
D	255
TOTAL:	761

2.2 Physical Characterisation

Microplastic pollutants that found in each sampling sites were sort according to their shapes such as fiber, fragment, film and pellet. Table 2 shows the physical characterization of each microplastic pollutants found in each sampling sites.

Table 2. Physical characterization of microplastic pollutants

Sampling sites	Shape of Microplastics (pieces)			
	Fiber	Fragment	Film	Pellet
A	48	49	16	5
B	64	34	10	12
C	145	44	43	36
D	103	95	31	26
TOTAL	360	222	100	79

At sampling site A, the most dominant shapes of microplastics are fragments with a total of 49 pieces. While sampling site B is dominant with fibers which are 64. The number of microplastics is influenced by its source as well as by the activities and such car wash sector, restaurants, shops, and housing area. Sampling sites A and B is is located at the city centre of Kelantan which is Kota Bharu. The shape of microplastics found in a city can vary widely, depending on the source of pollution. According to a study by Li et al. (2020), microplastics found in urban areas can come in various shapes such as fibers, pellets, fragments, and films.

Sampling sites C and D is located near the rural area (village). Sampling sites C is a village area that rich in water resources, with natural and geological/geomorphological features such as a lake, river, waterfall, and hot spring. Although, it is rich in water sources with natural characteristics, there are still contamination in the tap water which contains microplastics that might cause by human daily activities. Fiber is the most abundant shape found in sampling site C which is 145 pieces when compared to other shapes of MP.

Fibers are thin, elongated shapes often found in synthetic textiles, such as clothing and carpets, and are a common form of microplastics found in urban environments. Fiber of microplastics comes from synthetic fibre clothes to tyre dust and microbeads, as well as the fragmenting of bigger pieces of plastic, which in the most part is not biodegradable [10]. According to the findings of a previous study, plastic fiber can originate from the washing of human textiles. The water supply network, which runs from distribution tanks to households and is mainly made of PVC, PE, PA, PET, and other polymers, is more likely to pollute raw water.

Pellets, also known as nurdles, are small, cylindrical shapes that are used as raw materials in the manufacturing of plastic products, and they can be found in urban areas because of their transport and handling. Pellets are transported to plastic transformers, which are responsible for the manufacture of plastic goods. Along the whole plastic value chain, pellets could leach into the environment because of accidents of varying sizes that can occur during production, processing, transport, and recycling [11]. Plastic pellets have the potential to absorb contaminants from the surrounding water, such as dioxins, and then pass those contaminants to the food chain, as well as potentially to human diets. This raises the possibility of detrimental impacts on both wildlife and humans. Ingestion of microplastics by humans has been linked to a variety of adverse health effects, including oxidative stress, DNA damage and inflammation. Persistent inflammation for a long period of time can pave the way for very serious health problems [12].

Fragments are broken pieces of larger plastic items, such as plastic bottles, and they can be found in urban areas as a result of poor waste management and littering. Films are thin, flat shapes often found in plastic bags, food packaging and cigarette filters, and they can be found in urban areas as a result of their widespread use and disposal [13]. Fragments from particles produced by the fragmentation of larger materials, while films are soft fragments of thin polymers derived from plastic bags or wrapping paper [14]. Fragmented microplastics could possibly from the exposure of larger plastic items to strain, fatigue, or UV light.

Microplastics in water sources affect human health, causing symptoms such as nausea, vomiting, headache, skin irritation, and long-term or chronic exposure may lead to anemia, kidney damage, and cancer due to toxic characteristics in the microplastics. Microplastics can enter the human body by inhalation or ingestion, potentially causing health problems. The inhalation of fibres during factory activity has been linked to the development of some diseases. There is apparently a correlation between the exposure to low levels of respirable fibres and an increased risk of developing respiratory diseases and lung cancers. The large bulk of fibres are able to be eliminated from the respiratory system. However, certain fibres will continue to induce inflammatory responses and even lesions in the respiratory system [15].

2.3 Chemical Characterization

The FTIR has been employed for the type of microplastics in each sampling sites. The FTIR spectra revealed complex surface as by presence of several peaks. The range wavenumber of FTIR spectra measurements were carried out between 650 – 4000 cm. Each of the samples showed their major peaks which indicate the type of polymer plastics referred to the reference setup in the library of Thermo-scientific FTIR instrument. The example of microplastics'

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types found in this study is shown in Figure 2. The three types of microplastics found in this study are cellulose, cellophane, and poly (2, 2, 2-trifluoroethyl vinyl ether).

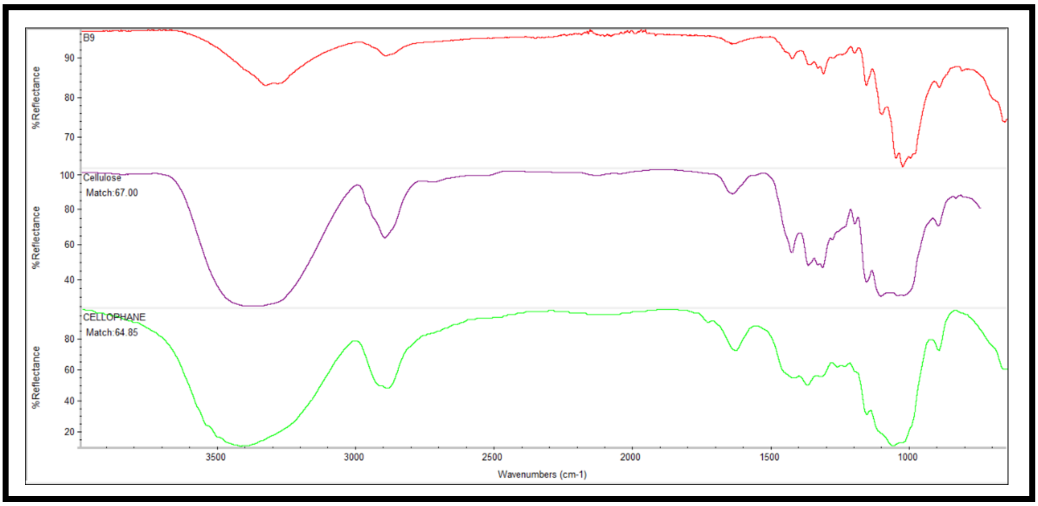

Fig. 2. FTIR Spectrum of Microplastic Pollutants

The findings of this study show the presence of microplastics in a variety of shapes and types. Plastic fibres and fragment are the most common shapes of microplastics found in tap water. The results of the type of microplastics were discussed. Plastic pollution is extremely damaging to living organisms, especially aquatic life, because it can pollute drinking water sources. The water source for tap water comes from fresh water through municipal and public water supplies and industrial processes are the main sources of microplastics in tap water. Homeowners be encouraged to instal filtering systems for their drinking water to significantly reduce their exposure to microplastics.

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