Microplastics Monitoring in Two Main Rivers of Central Taiwan

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11 March 2022

ABSTRACT

In this study, we used the developing GLOBE Microplastics Monitoring Protocol and GLOBE data to quantitatively analyze plastic debris in Dajia River and Wu River located in central Taiwan. We collected water samples along the river from November, 2021 to January, 2022. In the 16 samples we examined, there was 100% plastic debris, including water from the upper level. Fibers were the most common item in our sample. We also found lots of plastic pellets (2~5mm) on the central west beach of Taiwan, most of them were weathered, which could come from the ocean.

We found that the quantity of microplastics in the lower level of the river (75 items/L) was more than that of the upper level (30 items/L). But the distribution of microplastics was uneven in estuarine areas. The results showed that the abundance of microplastics in estuarine areas ranged from 190 to 310 items/L. We believe that mangroves and mud around them might be like a trap for microplastics because of the plants and roots. The density of microplastic also might be influenced by wind, flow velocity of the river, and proximity to urban centers.

Keywords：Microplastics, Mangrove, Dajia River, Wu River

1. Research Question and Hypothesis

1.1 To explore the difference of microplastic content in the upper, middle and lower reaches of Wu River and Dajia River.

1.2 Exploring the difference in microplastic content between Wu River and Dajia River estuaries.

1.3 To know the probable cause to influence microplastic content in Wu River estuary.

1.4 To explore the impact of population density on the microplastic content of rivers.

2. Introduction and review of literature

Microplastic (<5 mm) pollution has become a topic of our daily life. Microplastics pollution affects all environments, e.g., the ocean, rivers, even the Arctic (Peeken et al., 2018). Microplastics are susceptible to the leaching of potentially toxic plastic additives known as ‘‘plasticizers’’ (Free et al., 2014). And they easily absorb heavy metals in water, because of the large specific surface area of microplastics (Frias et al., 2016). The distribution of microplastics in the environment will impact ecosystems and organisms (Liu et al, 2022).

Studies have shown that 60~80% of the microplastics in the ocean come from rivers (Schmidt et al., 2017). Only a few studies survey the amount and distribution of microplastic in rivers (Alexander K., 2021).

Some studies indicate that microplastic density is influenced by prevailing surface circulation, wind, flow velocity of the river, and proximity to urban centers (Free et al., 2014). High-density microplastics will be deposited at the bottom of the river, when the river flow is slow. The abundance of microplastics in mangrove was significantly higher than that in the non-mangrove area, and microplastics can be found in each layer of the sediments (Liu et al., 2018).

Research shows that fragments and films were the most abundant microplastic types; they might come from plastic bottles, bags, and fishing gear (Free et al., 2014).

3. Research Methods and research equipment

3.1 Sampling

First, investigate the sampling sites conditions , just like the weather, route, and convenience of Wu River and Dajia River.

When we arrived at the sites ,we used containers to collect the surface water of the river and measure water temperature with infrared thermometers. We also measured turbidity of the sample water for about 60 seconds, and then took the average value. We used GLOBE Integrated hydrology data to reference.

Fig 1.Location of study area

3.2 Filter

We used the flask and the filter membrane, whose pore size is 0.45 micrometer, to filter 200ml of water. After that, connect the suction valve device, put a filter membrane on the glass sand core, put a wide-mouth bottle on the filter membrane to hold the water body to be filtered, and then use a syringe to pump air until the water sample is exhausted. Then, use a petri dish to install the filter membrane of the filtered water sample to protect the sample from contamination and facilitate the extraction of the sample, and then place it on the stage of a polarizing microscope for observation.

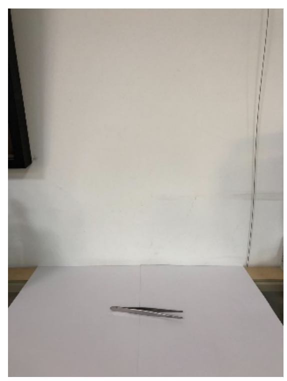
3.3 Recognition

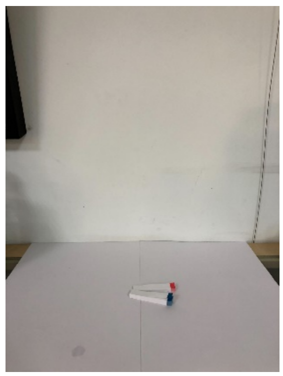
Through the polarizing microscope and through the microplastic database and judgment process under the development of the globe, identify whether the observed microplastic fiber is cellulose or man-made fiber, record it through Excel software, and analyze the data we get. If you see transparent, colorless, and indistinguishable fibers, you can shine with a UVA flashlight, because some fibers will emit light under ultraviolet radiation Fluorescent, which means that those fibers are coated with fluorescent agent, which can also be used as a carrier of micro plastic.

3.4 Measure the conduction

Since the direct measurement of the conductivity of seawater and rivers at the sampling point will exceed the range that the instrument can measure, it is necessary to dilute it by 4 times before measuring the conductivity.

3.5 Research equipment

			
measuring bottle	dropper	tweezers	infrared thermometer
			
bottle	LabQuest 2	petri dish	the flask and the filter membrane

			
conductivity meter	pH-meter	turbidimeter	filter membrane (0.45 μm)
			
optical microscope	memo	UVA flashlight	

4. Results

4.1 Dajia River Results

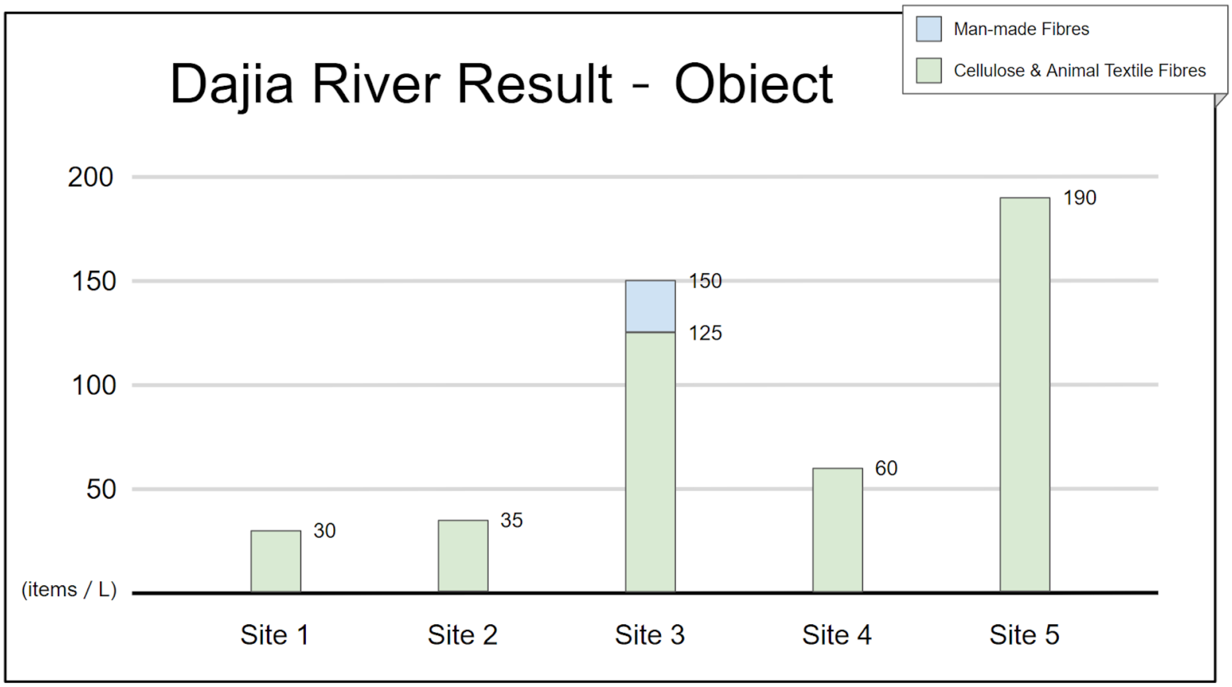


Fig 2. Content and types of Dajia River

The microplastic content of Dajia River Site 1 is 30 items/L, which is the most upstream of the five sampling Sites. Most of the microplastic types are cellulose. The microplastic content of Dajia River Site 2 is 35 items/L . It is also located upstream of the Dajia River. Most of the microplastics are cellulose.

The microplastic content of Dajia River Site3 is 150 items/L, which is in the middle reaches of Dajia River. The microplastic type cellulose accounts for about 83%, and man-made fiber is about 17%. The microplastic content of Dajia River Site4 is 60 items/L, which is lower than Site3. Most of the microplastics are cellulose. The microplastic content of Site 5 is 190 items/L, which is the most downstream of Dajia River. Most of the microplastic types are cellulose.

In these samples, we measured the conductivity data to increase from the most upstream (Dajia River Site1), until the value of the sea outlet (Dajia River Site5) suddenly surged. Because Dajia River Site5 is the junction of river and sea, and seawater contains sodium ions, chloride ions and other Positive and negative ions, the dissociation of these ions causes the electrolyte to become high.

4.2 Wu River Results

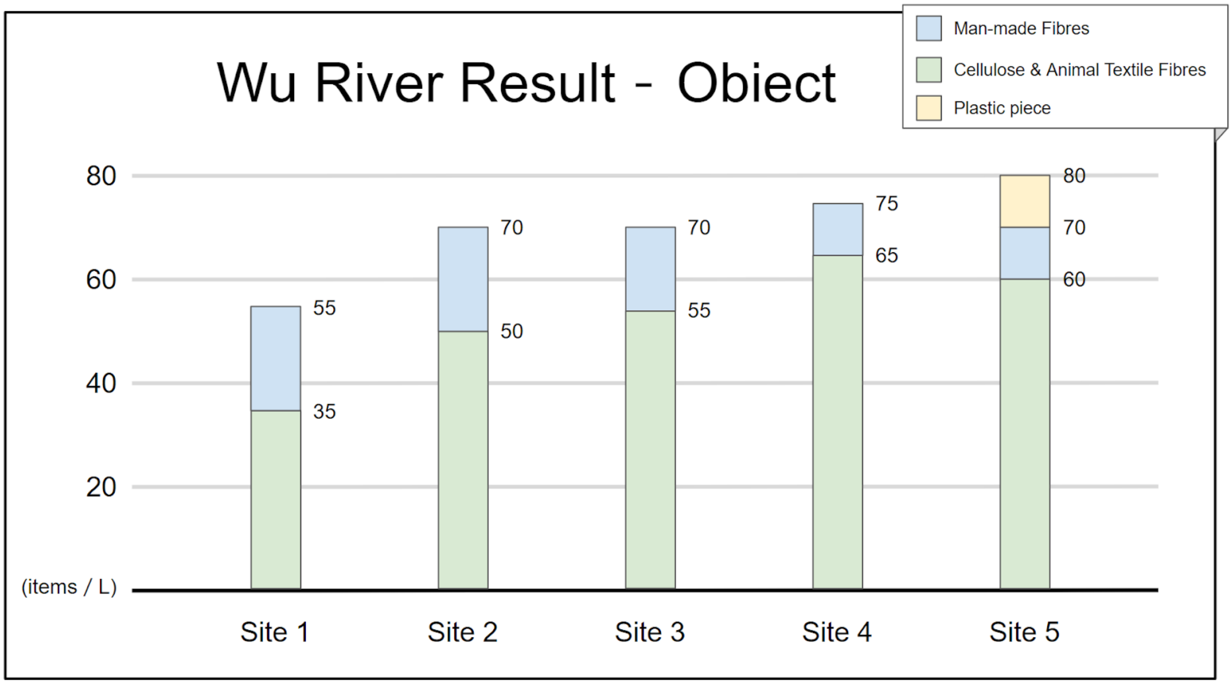


Fig 3.Content and types of Wu River

In the data analysis of Wu River, the proportion of fibers was the highest, with a total of 363 collected, accounting for 60.17% of all microplastics, of which cellulose textile fibers and animal-derived textile fibers contained the most. Man-made textile fibers have the second highest content, with 212 collected, accounting for 35.27% of all microplastics. The third most numerous were plastic fragments, which accumulated a total of 25 and accounted for 4.15% of all microplastics.

The data shows that the Wu River has a gradually increasing trend from upstream to downstream, but the number of Wu River Site 5 that is only far away from Wu River Site 4 has not increased significantly because Wu River Site 5 is close to the estuary.

4.3 Tides

Table 1. Comparison of environmental data and microplastic content table in Wu River estuary

Type of object \Site		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
State	Tidal Range	moderate tide			spring tide		
	Tides	Low	Low	Low	Low	High	High
	Water Domain	open water	closed water	open water	open water	open water	open water
pH		7.85	8.39	7.91	8.25	8.59	8.30
Cellulose Textile Fiber and Animal-origin Textile Fiber (items)		145	140	65	97.5	55	60
Man-made Textile Fiber (items)		157.5	80	37.5	10	7.5	0
Plastic piece (items)		7.5	100	7.5	7.5	2.5	0
Unknows (items)		0	0	2.5	0	0	0
Items / L		310	320	112.5	115	65	60

Site 1, 2, 3, 4, and 5 were collected at various points on January 26. That day belonged to the moderate tide, Site 1, 2, 3, and 4 were low tide, and Site 5 was high tide. Site 6 was collected on March 6, which was a spring tide and a high tide.

Site 1, 3, 5, and 6 are the water collection from the river bank, site 4 is the collection near the river outlet, and site 2 is the puddle formed at low tide.

5. Discussion

5.1 Dajia River

Dajia River Site1 and Dajia River Site2 are located in the upper reaches of Dajia River(Guguan), so the microplastic content is relatively small compared with the middle and lower reaches of Dajia River Site3, Dajia River Site4, Dajia River Site5, and the type of microplastics seen is mostly cellulose. We speculate that the reason why there are fewer microplastics at these two sites is that Guguan is located in the mountainous area,where the population is small, the environment is relatively clean, and the turbidity is relatively low, and thus there is less pollution.

Dajia River Site3 is located in the middle reaches of Dajia River, a place with high population density in Dongshi. There, the microplastic content is 150 items/L. Dajia River Site 4 is located in the middle and lower reaches of Dajia River in Shengang, with a low population density near the water intake location, and the microplastic content is 60 items/L there. The reference that the density of microplastics is affected by the velocity of flow, or the degree of proximity to the city center (Tien, 2018; Free et al., 2014).

Dajia River Site 3 is closer to the city center than Dajia River Site 4, and we can also see that the degree of dense population near the watershed affects the microplastic content. In Dajia River Site3 we found that man-made fibers contained is 25 items/L. According to previous research, man-made fibers can flow into rivers and oceans through man-made and non-man-made pipes, and in areas close to urban centers(high density of human activities),the amount of fibers pollution is 3 times higher than that of other types of microplastics. So we infer the amount of man-made fibers is associated with human activities.

Dajia River Site5 is located in Gaomei Wetlands, whose content of microplastics is the highest in these five sites, I think this is related to the tides and formation of Gaomei Wetlands, Gaomei Wetlands is formed by the siltation of rivers, and the date of our visit is just about 14:45 on January 28 of the lunar calendar, when the tide is low and the time is close to the dry tide. Therefore, we infer that

Dajia River Site5 is located in Gaomei Wetlands. The content of microplastics is the highest among the five points. I think this is related to the formation and tides of the Gaomei Wetlands. The formation of Gaomei Wetlands was formed by river siltation. The water was taken at around 14:45 on January 28 of the lunar calendar. At this time, the tide was low and the time was close to the dry tide. Therefore, we infer that the microplastics will flow from the upstream to the downstream of the Dajia River along the water flow. The microplastics washed out to the sea were buried in the bottom mud, resulting in the highest microplastic content measured in the Gaomei Wetlands.

5.2 Wu River

The number of samples one to five increases gradually, but the value didn't increase in Wu River Site 5. We suspect that it may be related to oyster farming, tides, and water sampling location and depths.

We found lots of pellets (2~5mm) in Wu River Site 5 (Lishui fishing port). Those pellets are very likely from the ocean. Because we didn't find any pellets in other river samples, most of the pellets were weathered (Fig. 4), and the port is so close to the sea. It could be evidence for a marine origin of the pellets.

Fig 4. weather pellets

5.3 Tides

We took samples at two locations near Lishui Fishing Port (Site 1 and Site 3). It was found that the pH, salinity and microplastic content of the water bodies in the two places were very different. Site 1 is between mangroves and fishing ports. The salinity and microplastic content of the river here are relatively high. The microplastic content is 310 items/L. The content of microplastics is less, the content of microplastics is 112 items/L.

According to our research data, the content of microplastics in seawater is relatively low. Comparing the data of Lishui Fishing Port at high tide and dry tide, the content of microplastics in dry tide is relatively high, about 310~112 items/L, but if it is high tide, the content of microplastics is about 60~65 items/L, so we infer It is related to the entrainment of river water.

Site 1 and Site5 are similar locations but at different tide levels, Site1 is dry tide and Site5 is high tide. It can be seen from the data that the number is the largest during dry tide, even five times that of high tide. Therefore, we infer that the samples were collected from the surface of the water body, and according to the literature, because there are algae and other objects attached to the microplastics, the overall density increases and sinks, resulting in a situation where there are more microplastics at the bottom of the water body. And the overall water depth changes under different tide levels. Therefore, if the water depth is high when taking water, the surface is relatively clean. Site2 is a puddle near Site1. After on-site observation, it is found that the depth of Site2 is shallower than that of Site1. After further water quality analysis, the value of plastic content per liter is even higher. Therefore, we infer that the depth of the collection site will affect the Microplastic content in water.

Site2 is a puddle near Site1, and it is found that the water depth of Site2 is shallower than Site1 through on-site observation. After further water analysis, the value of plastic per liter was higher. Therefore, we infer that the depth of the collection point affects the microplastic content in the water.

6. Conclusion

We used the surface water of the stream for analysis, but in the Gaomei wetlands at the Dajia River estuary and Li Shuei at the Wu River estuary, we all found that when the sampling water was closer to the sediment, the higher content of microplastics in the water. Based on the survey results and literature, we speculate that the deeper the overall water intake and the farther away from the bottom, the less micro-mud in the water body. This allows us to know where the water is taken in the river can significantly affect the amount of microplastics in the water.

6.1 Future work

Research shows that all rivers have a positive correlation between precipitation and the amount of microplastic particles (Alexander K., 2021). Our sampling time is only in the winter, it’s a dry season in central Taiwan. We will collect more samples in the rainy season or after heavy rain to understand the distribution of microplastics in the river.

When observing the sample, the length of the target can be calculated, so that the overall microplastic distribution can be observed and relevant information can be obtained. In addition, the relationship between microplastic content and organisms can be studied by dissecting organisms near the coast. According to the relevant literature, microplastics may be contaminated with algae or other components of the sediment, increasing and decreasing density. To test this hypothesis, more precise studies can be performed using high-powered microscopes.

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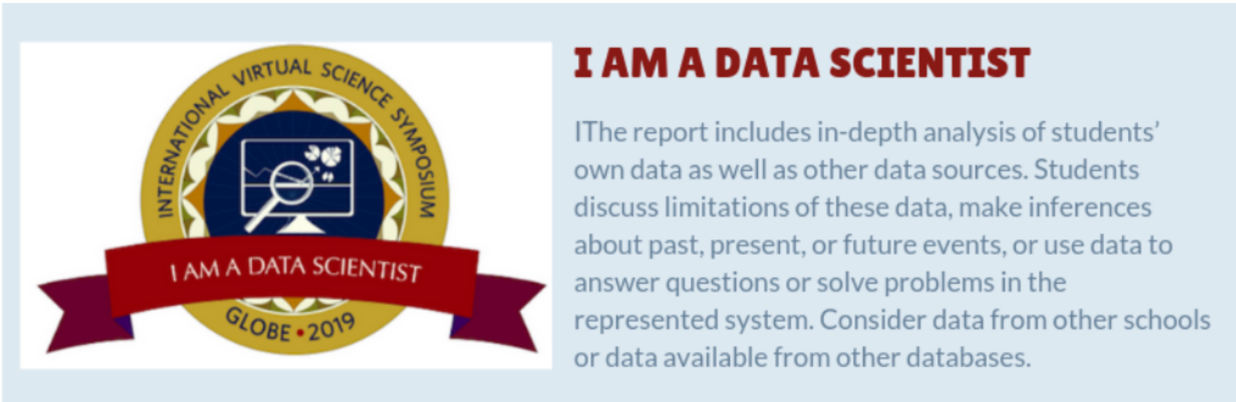
8. Badge Descriptions/Justifications



Through the analysis of sample data and a large number of literatures, to explore the relationship between the proportion of microplastics and the local environment, and make a logical explanation.