香港教育大學
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A Project entitled

Microplastics and heavy metals in domestic dusts in Hong Kong

Submitted by

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Declaration

I, *Leung Hok Tung* declare that this research report represents my own work under the supervision of *Assistant Professor Dr. Man Yu Bon*, and that it has not been submitted previously for examination to any tertiary institution.

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Abstract

21st century is a period that human society carrying out industrialization. One of the most popular materials, plastics, is a kind of artificial materials that satisfying humans' needs in improving living standards. Unfortunately, there are some matters derived from the plastic products, which are microplastics, and they would be derived from the daily usage in Therefore, the microplastics can be possibly contaminate the household environment once the household owners use plastic products. Through the analysis of the indoor dust, the Indoor environmental pollutants would then be investigated, and further deduce how the pollutants released from the indoor materials and activities (Mercier et al., 2011). In indoor dusts, one of the major sources of microplastics is textile washing (Liu et al., 2019). In nowadays, some of the clothes are made of artificial plastic-blending cotton or simply plastics, therefore microplastics would be possibly derived during process of laundry. Polycarbonate (PC) and Polyethylene terephthalate (PET) are the popular microplastics in indoor dusts (Liu et al., 2019). Apart from microplastics, heavy metals are also one of the major contaminants to household, which also could be investigated by analyzing the household dust. Heavy metals from outdoor would be potentially contaminate household indoor environment through airborne dust. Also, heavy metals may cause health risks to humans if humans expose to those heavy metal in their lifetime. In this project, the investigation of indoor household pollution of heavy metals and microplastics in Hong Kong families would be done. Also, the investigation that has been mentioned before would be compared to the relations of habit of using plastic products in Hong Kong families, the location

of the household. For this project, it includes experimental design and literature research, so as to figure out the indoor microplastics & heavy metals pollution with the relation of the usage of plastics in Hong Kong families and the location of household.

1. Introduction

In modern human society, there are many constituents inside the household dust, and one of them is microplastics. Under industrialization, plastics become the popular artificial materials among humans' life. The major source of microplastics is emerged by the consumption of plastics products and its derived plastic wastes. For example, the indoor concentration of microfiber, as microplastics is higher than outdoor concentration (Dris et al., 2017). The release of indoor microplastic could be done by the destruction of larger items that made of plastics, like car tires, clothes and urban plastic waste (Vianello et al., 2019). For indoor environment, there are many sources that have potential in releasing plastics fragments during tearing, wearing or scratching, such as interior furniture, synthetic goods. Microplastics with size < 5 mm appeared from the physical degradation of plastics, and further tuned into smaller fragments, finally changed into smaller sized microplastics (Bergmann et al. 2015). The small sized microplastics have become a popular constituent of household dust. The investigation of microplastics in indoor household dust is crucial to time.

Another common constituent that inside the outdoor and indoor dusts is heavy metals. The heavy metals inside the outdoor street dusts are likely emerged from different origins, such as industrial emission, automobile exhaust and outdoor painting (Rashed, 2008). The heavy metals may enter the indoor household with the airborne dusts, and finally becomes an airborne indoor contaminant. Besides the street outdoor dusts, the products that being used inside the indoor environment may be also the sources of indoor contaminants, for instance, Zinc (Zn) and

Chromium (Cr) could be emerged from smoking, metal plated products and paint work (Madany et al., 1994).

Under the industrialization of human society, plastics have become a kind of popular material in producing different goods to satisfy humans' daily needs. According to Hale (2017), the increasing usage of plastic products in indoor leads to the human' exposure to plastics additives via inhalation and ingestion of indoor dusts. After the microplastics released from the plastics products, it may become airborne such as synthetic fiber. Next, the fibrous microplastics would go through photo-oxidative degradation, the size of microplastics would be getting as small as fine particles (Gasperi et al., 2018).

Microplastics pollution in indoor environment may contaminate humans in sustained exposure. Different views about indoor pollution of microplastics and heavy metals have been stated in different studies. It would be discussed with 3 different aspects:

1.1 The contamination path for microplastics invading indoor environment

According to Vianello et al. (2019), plastics made products and indoor materials are the potential sources to release fragmentated plastics once the products being scratched or damaged while in usage. Then, the small sized fragment plastics would enter the indoor atmosphere, and further changed into atmospheric microplastics, sustain in the indoor environment. Part of the airborne microplastics may be inhaled and reach to the humans' lungs. Polyethylene terephthalate, PET, one of the most common found microplastics, is being widely used in indoor environment and household. According to Li et al.,2016, it has stated that drink bottles, plastic films, food packaging and insulation moldings are the popular usage of plastic materials in household. The PET would become one of the derivatives from the plastic products, and further change into airborne form of micro-PET. Apart from PET, polycarbonate (PS) is also a popular plastic material which is being modified into common products, for instance, building materials, packaging, plates and foam cup (Wang et al., 2016). Micro-PS would be released from the scratched or torn PS made products while being used. The microplastics derivatives in indoor environment is caused by the habit in plastic usage of the indoor users. As has been reported by Kuczenski & Geyer (2010), textile fibers are potentially derived from daily clothing, which is the essential source that emerging PET which is being found inside the indoor dust. In addition to the indoor users' habit, airborne microplastics from outdoor environment is also one of the factors which may contaminate indoor environment. The potential sources such as road waste particles, landfilling, construction materials and industrial wastes may enter indoor environment from outdoor environment by the air current (Dris et al., 2016). would be originated Different kinds of plastic products that being used by indoor users would lead to the occur of microplastics in indoor dusts. Thus, indoor microplastic contamination would also be contributed by the outdoor contaminant in outdoor environment.

1.2 For effects of microplastics on human health

The particles that have size > 5μm may less efficient to be deposited in the respiratory tract (Donaldson & Tran, 2002). The World Health Organization has stated that microplastics is one of the potential substances that being inhaled through respiratory system. Apart from the respiratory exposure, gastro-intestinal exposure may also happens even some of the microplastics being trapped out in human upper airway. Besides the exposure issue, another concern of microplastic to human health is its durability. Plastics is durable that allowing them able to persist in human lungs (Law et al., 1990). The ability of microplastics in biopersistency allowing them to stay in human body once they have entered into the body. The people who have sustained exposure to microplastics for long period may potentially have health risks, like workers who keep expose to plastics. According to Warheit et al. (2001), it has stated that occupational exposure to microplastics may be the potential pathway that causing workers suffered from respiratory irritation although it may not directly raise the risks of suffering from cancer. Allergic alveolitis is one of the symptoms that commonly expressed by some of the workers who occupationally exposed to microplastics (Pimentel et al., 1975). The uncertainty of microplastics in toxicity also causes uncertain health risks to humans. According to Wang et al. (2016), it has reported that micro-PVC and micro-PS are the potential source that causing abnormalities in human reproductive system. PET in common product packaging, is also being considered to be a kind of potential carcinogen (Li et al., 2016). Microplastics towards human health risk remains uncertain. Different kinds of toxicity to human bodies can be done by different types of microplastics. In most of studies, microplastics may lead to adverse effects to human health (Vethaak & Leslie, 2016).

1.3 Potential pathway for heavy metals migrating into the indoor environment and effects of heavy metal to human body:

Under urbanization of city, heavy metals are the popular pollutants to outdoor/ street. As has been reported by Opher & Friedler (2010), one of the common factors is the consumption for the fossil fuels in combustion engine of vehicles, which is also a kind of human activity. The heavy metals particulate may float in the air and turns into airborne contaminants with other substances, for example, organic matters and microplastics, and then transformed into outdoor dusts. Unfortunately, the airborne outdoor dusts may enter into indoor environment, and become a kind of contaminants that contaminating indoor environment, i.e. household. There are several types of potential heavy metals that inside the dusts: Pb, Cd, Cr, Zn, and Cu, etc. Abbasi et al. (2017) has reported that the heavy metals may be the potential agents that lead to health risks to human body, especially for children since their Hazard Quotient and Hazard Index towards heavy metals are higher comparing to adults. Jaishankar et al. (2014) has stated that different kinds of heavy metals may conduct different health risks to human body during sustained exposure. For the heavy metal Pb, it may substitute the original ions which processing in inter cellular signal transmission and then bother the normal cell functioning, mental retardation may happen in children who exposed to Pb. For heavy metal Cr, it would potentially damage the DNA and cell proteins by initiating the production of superoxide ions in body cells. Nomiyama (1980) has mentioned that Cd poisoning to human body may lead to renal impairment, intestinal tract impairment, Itai-Itai disease, proteinuria and bone metabolism. Cadmium is also a potential carcinogenic agent to human respiratory parts, some of the humans died due to the exposure to Cd causing cancer in respiratory part (Nomiyama, 1980). Human body sustainably expose to Cu would lead to Gastrointestinal Symptoms (GIT) and liver failure (Stern, 2010). Exposure to zinc may cause severe Gastrointestinal Symptoms even Zinc is one of the essential elements to human bodies.

1.4 Usage of plastics for domestic purpose in Hong Kong families:

As has been reported by Environmental Protection Department in Hong Kong, the third major portion of municipal solid waste in 2018 is plastics, which means there are nearly 2343 tonnes of plastics disposed per day. There are nearly around 60% are domestic waste among the municipal solid waste. Inside the domestic waste, nearly 20% of it are plastics wastes,which 8.2% are plastics bags and 1.2 % are PET plastic bottles. The overall data in municipal solid waste for plastic waste in 2018 has increased by 10.3% while comparing to the data in 2017. Hong Kong Environmental Protection Department has reported that in 2018, the trend in disposing plastics as domestic wastes are growing upward. It indicates that the rely on plastic products in daily life has increased among Hong Kong families. It also means that Hong Kong household owners has more sustained to be exposed to microplastics. The indoor environment would be contaminated by microplastics in a larger extent, in form of indoor household dust (as an indicator).

There are a lot of reports that investigating about the indoor microplastics and heavy metals contamination in other countries and regions. For this report, it would investigate the indoor dusts from local families, the families' habits in using plastics and household location in Hong Kong with relation to microplastics and heavy metals.

2. Materials and methods

2.1 Sample collection

In this project, active sampling was the sampling method used in collecting sample indoor household dust by using hand-held type of vacuum cleaner suggested by USEPA. The dusts would be packed into sealable bags. The dusts were assembled in the settled floor dust of indoor household. In the aspect of sampling area, the indoor household dusts were taken from total 15 families in 3 different districts. For the Kowloon district, the sample dusts were assembled from Kowloon Bay, Kai Ching, San Po Kong and Yau Tong. In the New territories, the sample dusts were assembled from Ma On Shan, Tai Po, Tiu Keng Leng, Tsuen Kwan O, Hang Hau and Long Ping. In Hong Kong Islands, the samples were assembled from Sai Wan Ho, Aberdeen and Ap Lei Chau.

As has been reported by Census and Statistics Department, the corresponding population density in three districts are in ascending order: 1. The New Territories (4150 persons per sq. km), 2. Hong Kong Island (15590 persons per sq. km), 3. Kowloon district (48930 persons per sq. km). Inside these three districts, they vary from each other about the situation in human activity.

In the Hong Kong Islands, business activities may lead to a busier traffic. Hong Kong Islands have narrower traffic roads which are also near to the households by the limitation in geography. The outdoor airborne contaminants may have higher possibility to migrate into residential buildings.

In the Kowloon district, the crowded traffic occurs since there has the highest residential building density among all districts. Also, the human activities in this district lead to the crowded traffic. The high density of households and population causes the airborne contaminants enter into the indoor household from outdoor environment even the traffic road in Kowloon district is not as narrow as those in the Hong Kong Islands. Furthermore, the high household density leads to the reduction in air flow and the current of airborne pollutants. The airborne contaminants that inside the street dusts may be easier to migrate into the households that besides the traffic road. Also, some of the residential area in Kowloon district is quite near to the industrial area, nearby industrial emission may become a potential origin of contamination.

In the New Territories, it has the lowest density in population and with the largest land area at the same time. The traffic roads in this district are the widest in average compared to other two districts. Thus, the advantageous geographical situation allows the households inside the district are not as close to the traffic road as other districts. Furthermore, the household density is lower than other districts in average, so that The New Territories has a more fluent air flow compared to other districts. The airborne outdoor contaminants may be less possible to migrate into households. Although some of the household area in The New Territories are near the industrial area, the air flow would still be better than other districts since the advantageous low household and population density. The airborne dusts contamination to the nearby households might be relieved.

2.2 Sample preparation for analysis

For the investigation of microplastics, microscopic screening and attenuated total reflection (ATR) analysis was carried out. In order to separate the desired microplastics from the dirty indoor household dust samples, several methods had been tested, including simple alkaline digestion and heated alkaline digestion under different sample mass and volume of alkaline solution. The heated alkaline digestion was the best method to separate the microplastics from the organic matters inside the dusts. 0.025g of sample dusts was treated with 25mL of 10M NaOH solution inside a 100 mL beaker. The solution mixture was then placed on a heat plate and heat it for around 4-5 days within 70 ºC to 80 ºC, until the solution mixture becomes clean and transparent. Addition of extra ultrapure water was required to prevent the formation of insoluble coagulate made of impurities and NaOH crystals. Then, density separation for the solution mixture would then be carried out. The saturated NaCl solution would be used as medium to carry out the density separation, and the required volumes of the saturated salt solution is 1:1 to the volume of solution mixture. The density separation required for around 4 hours. Next, the bottom layer of the solution mixture was released away, and use suction filtration to filter the middle upper layer of the solution mixture. Glass fiber filter paper was used in the suction filtration to tolerate the alkaline solution mixture. The filtered substances on the surface of filter paper would then be ready for microscope screening and ATR analysis. The number of microplastics inside the household dust of each household were screened manually under microscope. The identification of type of microplastics was done by ATR analysis.

For the investigation of heavy metal, atomic absorption spectroscopy was chosen to analyze the heavy metal concentration inside the household dust. Acidic digestion and microwave digestion were chosen to digest the sample dusts. The acidic digestion was done by adding 1.1g of household into 10mL of aqua regia inside the Teflon tube, and ready for the microwave digestion. The microwave digestion required around 1 hour. Next, use 1% nitric acid solution to recover the digested sample, filter the sample into pp tube and add extra 1% nitric acid solution to 25mL. The solid impurities/ wastes would be filtered away so as to prevent the blockage of suction tube inside the AAS machine. Standard solution with Pb, Cd, Cr, Zn & Cu were prepared into different concentration (in unit of ppm): 0.1, 0.5, 1, 2, 5, 10, 20. The concentration of dust in mg/kg were then calculated to illustrate the heavy metal contents in each household dust sample.

In both microplastics analysis and heavy metal analysis, the exposure assessment (in average daily dose) had been done. For the heavy metal analysis, the health risk assessment had been done also. It was difficult to carry out microplastics analysis because the exact health risk of microplastics to human bodies still uncertain, objective health risk assessment was difficult to be made.

3. Results and discussion

3.1 Result of microplastics analysis

There was a total of 15 household samples being analyzed for the microplastics screening under microscope. The number of microplastics were manually calculated through screening. Although the heated alkaline digestion had eliminated a lot of impurities, there still had other minor impurities such as sand, rocks remained inside reaction mixture. Therefore, some of the specific screening techniques should be made during screening (*Coalition Clean Baltic*). According to *Coalition Clean Baltic*, the identification of microplastics could be done by using tweezer, observation and temperature. During the identification of microplastics, hot tweezer test had been used which able to turn microplastics curled since microplastics would react to high temperature. Tweezer proding also used to test whether the suspected substance is flexible or not since microplastics is flexible. Most of the microplastics had colorful appearance although some of the dye would be digested by 10M NaOH. Furthermore, most of the microplastics have regular shape, especially for the filament.

The amount of microplastics and average daily dose had been counted, the data was shown in Fig.1 and Fig.2 respectively. The average number of microplastics in each household is 1440 pcs. For 15 households, there were 6 of them had a much higher content of microplastics inside the household dust than the average: Kowloon Bay (1860 pcs), Kai Ching (2081 pcs), Tsuen Kwan O (1994 pcs), Ap Lei Chau (1586 pcs), Tai Po (1626 pcs), Yuen Long (1548 pcs). For Kowloon Bay, Kai Ching, Tsuen Kwan O and Tai Po, these households were near the main traffic road (distance < 1km).

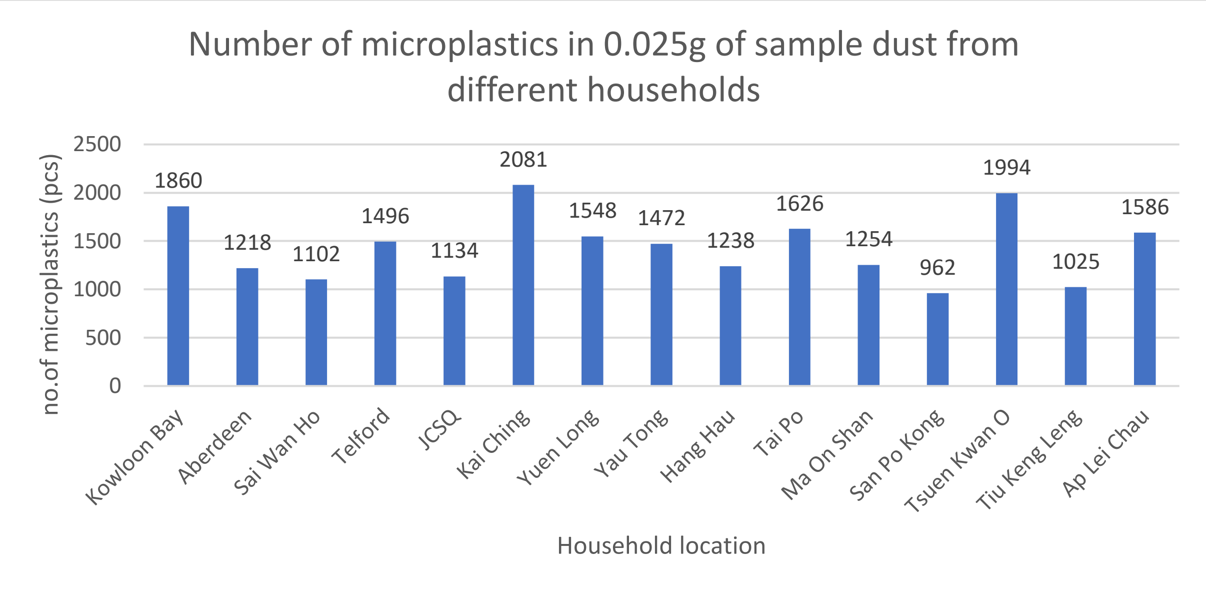


Fig.1 Amount of microplastics in different household dust

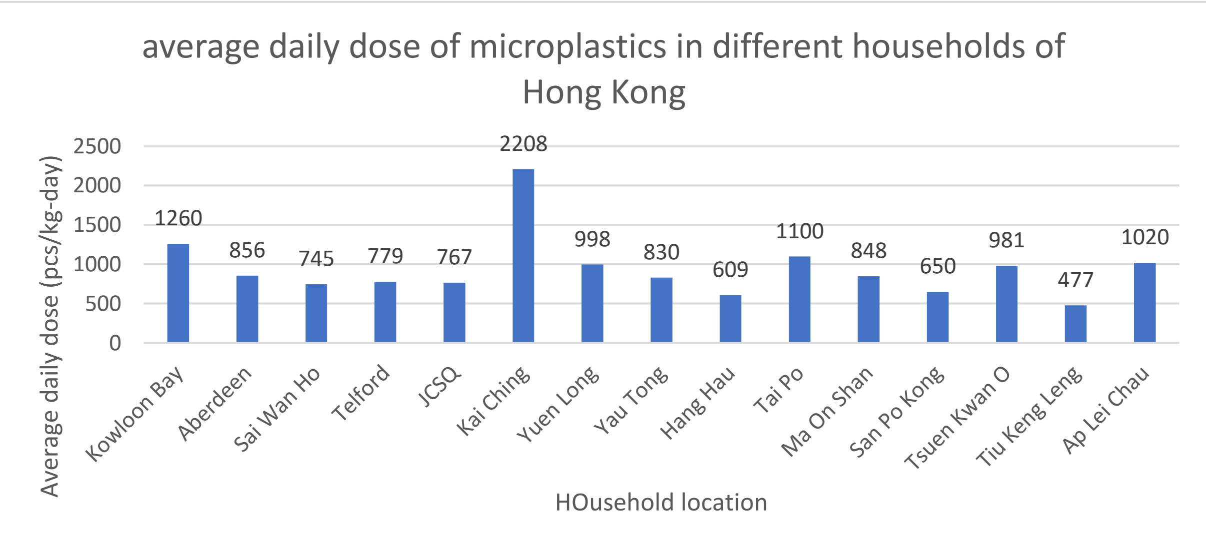
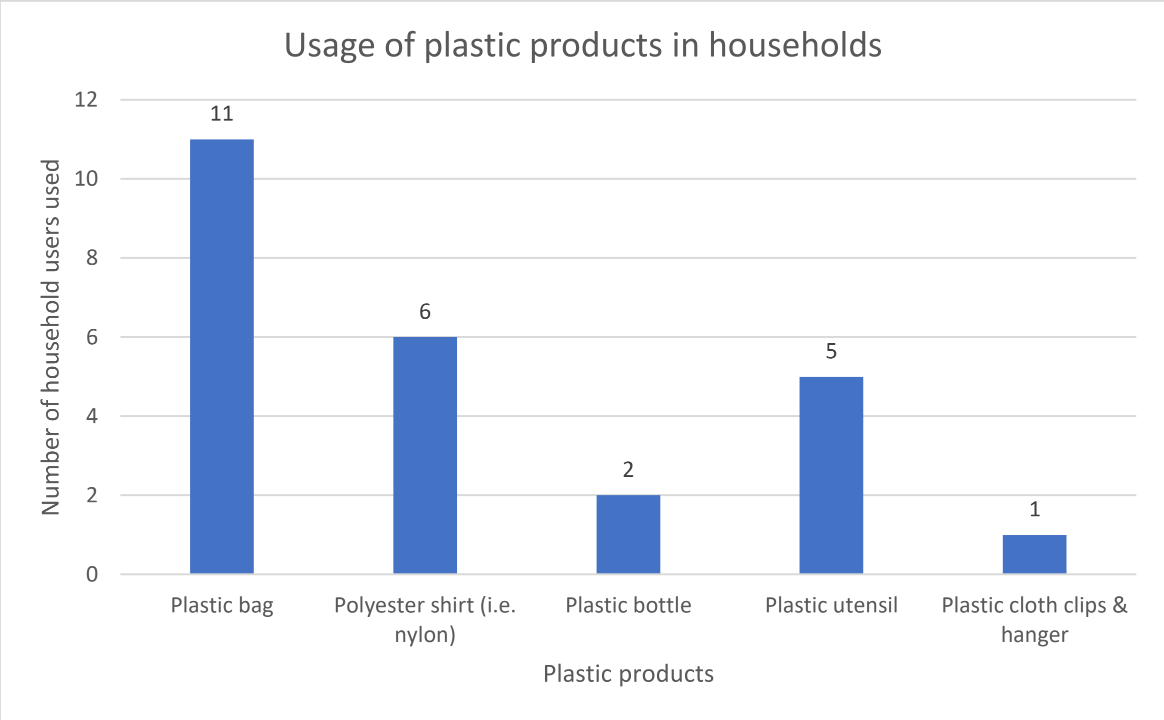


Fig 2. average daily dose of microplastics in different household

For the above 6 households, the household users respectively stated that they had high or moderate dependence on the plastics products, which meant that they had been habituated to use plastic products. The most common plastic products are plastic bags and plastic utensils as shown in Fig.3.



In order to find out the type of microplastics that remains inside the household dusts, ATR analysis was then carried out. After comparing the absorbance graph on the ATR machine, polyethylene (PE), Polystyrene (PS), Polycarbonate (PC) and polyester-cotton blend had been found.

The households that were near traffic road and had high or moderate dependence on plastic products had more microplastics remained in their dusts. Christian (2019) had stated that airborne microplastics able to travel around 20km to 95 km via the air flow. Therefore, main traffic road may be one of the factors that lead to the high accumulation of microplastics to the households that nearby since the main traffic road had higher car flow, thus leading higher air flow to nearby households. The chance of invasion of outdoor airborne microplastics would be increased due to this situation, and the outdoor airborne microplastics become the indoor microplastics contaminants. While calculating the number of microplastics inside the household dusts, it was quite interesting that under similar frequency in usage of plastic products, the high-floored household had less microplastics inside their dusts than low-floored household. For example, both household in Yau Tong (6^{th} floor) and Tiu Keng Leng (42^{th} floor) had low frequency in using plastic products, but Tiu Keng Leng (42^{th} floor) had less microplastics found inside its dust compared to Yau Tong (6^{th} floor). Both household in Aberdeen (27^{th} floor) and Ap Lei Chau (16^{th} floor) had moderate frequency in using plastic products, but Aberdeen (27^{th} floor) had less microplastics found inside its dust compared to Ap Lei Chau (16^{th} floor). Therefore, the floor height of the household might have attenuated the effect of invasion of outdoor airborne microplastics. From a macro of view, the household in Kowloon districts averagely had the highest number of microplastics found in the dust, The second was Hong Kong Islands and the third was the New Territories. It might be related to the different human activity, population density and the building density in different districts, so as to have different amount of microplastics content accumulated inside the household dust.

As has been reported by Zhang (2020), economic activity and human activity are the factors that contribute to the distribution of microplastics like PC and PET in indoor dust. The polyethylene that had been found inside 15 household dusts would be potentially derived from the household users' used plastic products. As mentioned before, the popular plastic products within the households were plastic bags, polyester shirts and plastic utensils. The potential PE source might be the plastic bags. The micro-PE might be derived from the plastic bags fragments, or torn plastic bags inside the households. In most of the case, the plastic bags might be food packaging & container, which were the common and convenient products in daily life. For the potential PS source, it might be derived from the plastic tableware, especially for the disposable take-out food container. Micro-PS could be easily released from the food container by scratching, accumulated into indoor dust and become one of the microplastic contaminants. The potential PC source might be the plastic bottle. Some of the PC products that without scratch-resisting coating were sensitive to scratching (Hwang et al., 2003). The small-sized PC fragments that emerged from the product might be accumulated into indoor dusts. For the polyester-cotton blend, the potential source might be the polyester shirts. The polyester shirt was one of the common plastic products that being used in household, and its microplastics-cotton blend would be derived during wearing and moving, or even during laundry.

In the aspect of average daily dose of the microplastics, it was quite interesting that some of the households had significant drop in average daily dose comparing to the number of microplastics in dust. It was because the calculation method in Fig.4 includes the area of the household in C_{air}. For the average daily dose calculation, there were several assumption being made: Hong Kong household has 2.8m height (HK legal household height), normal inhalation rate = 26.2m^3 /day (1.09m^3 /hr), exposure year = 1 (dust would be cleaned every year) and body weight = 67.8 kg

(HK people average weight). Therefore, the average daily dose would be affected by the size of household, thus the average daily dose would be attenuated due to the size of the household. In overall trend, the participants had exposed to around 477 pieces ~ 2208 pieces of microplastics per day.

$$ADD = C_{air} \times InhR \times ET \times EF \times ED/BW \times AT$$

Where:
ADD = Average daily dose (mg/kg-day)
C_{air} = Concentration of contaminant in air (mg/m^3)
InhR = Inhalation rate (m^3/hour)
ET = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

Fig.4 Average daily dose calculation

3.2 Result of heavy metal analysis

There was a total of 15 household samples being analyzed for heavy metal atomic absorption spectroscopy analysis. There were 5 types of heavy metals were being analyzed, which were lead (Pb), cadmium (Cd), chromium (Cr), zinc (Zn) and copper (Cu). The concentration of heavy metals and average daily dose had been counted, the data was shown in Fig.5 and Fig.6 respectively. (Clear version of data shown in **Appendix I**)

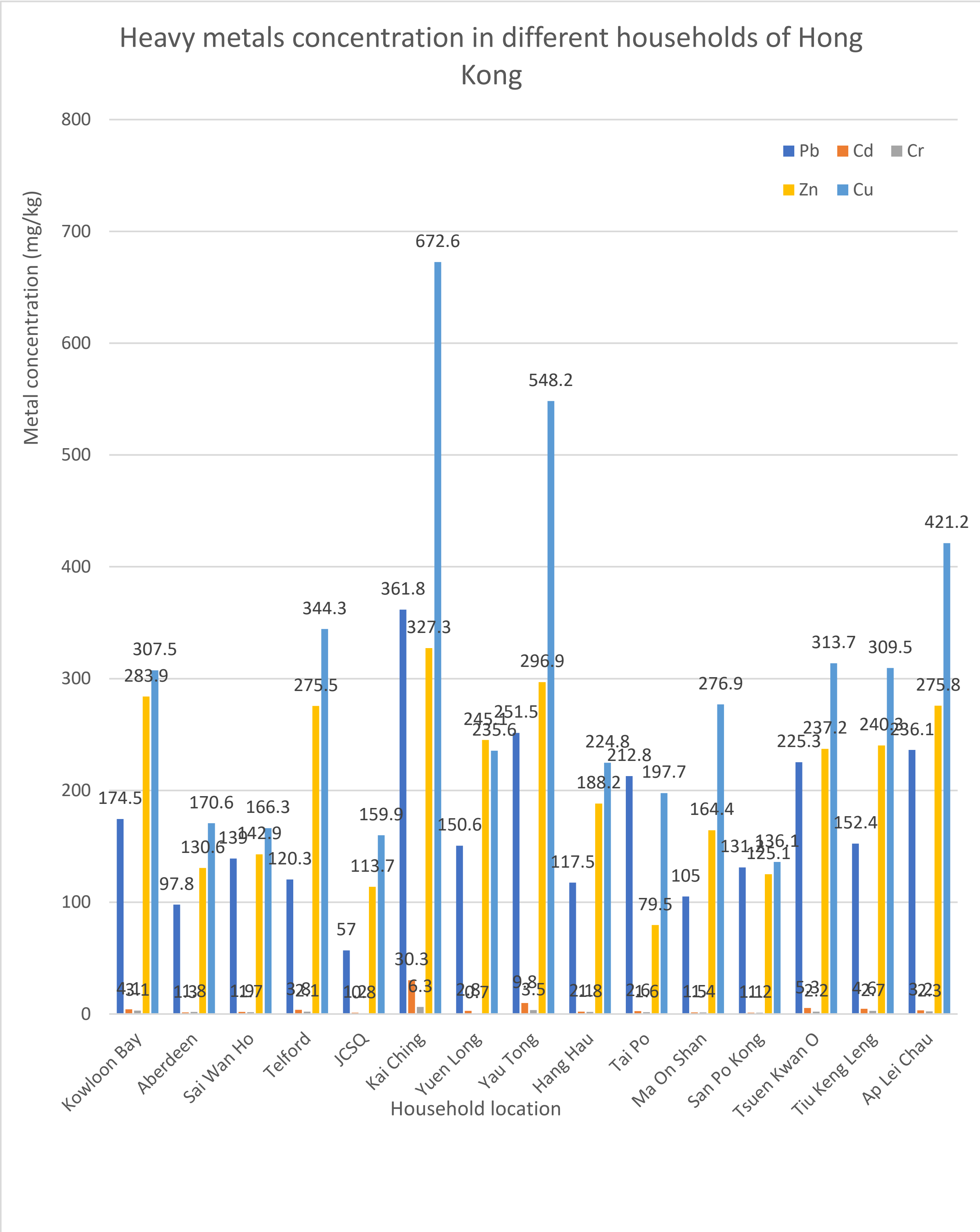


Fig.5 Heavy metals concentration in different households of Hong Kong

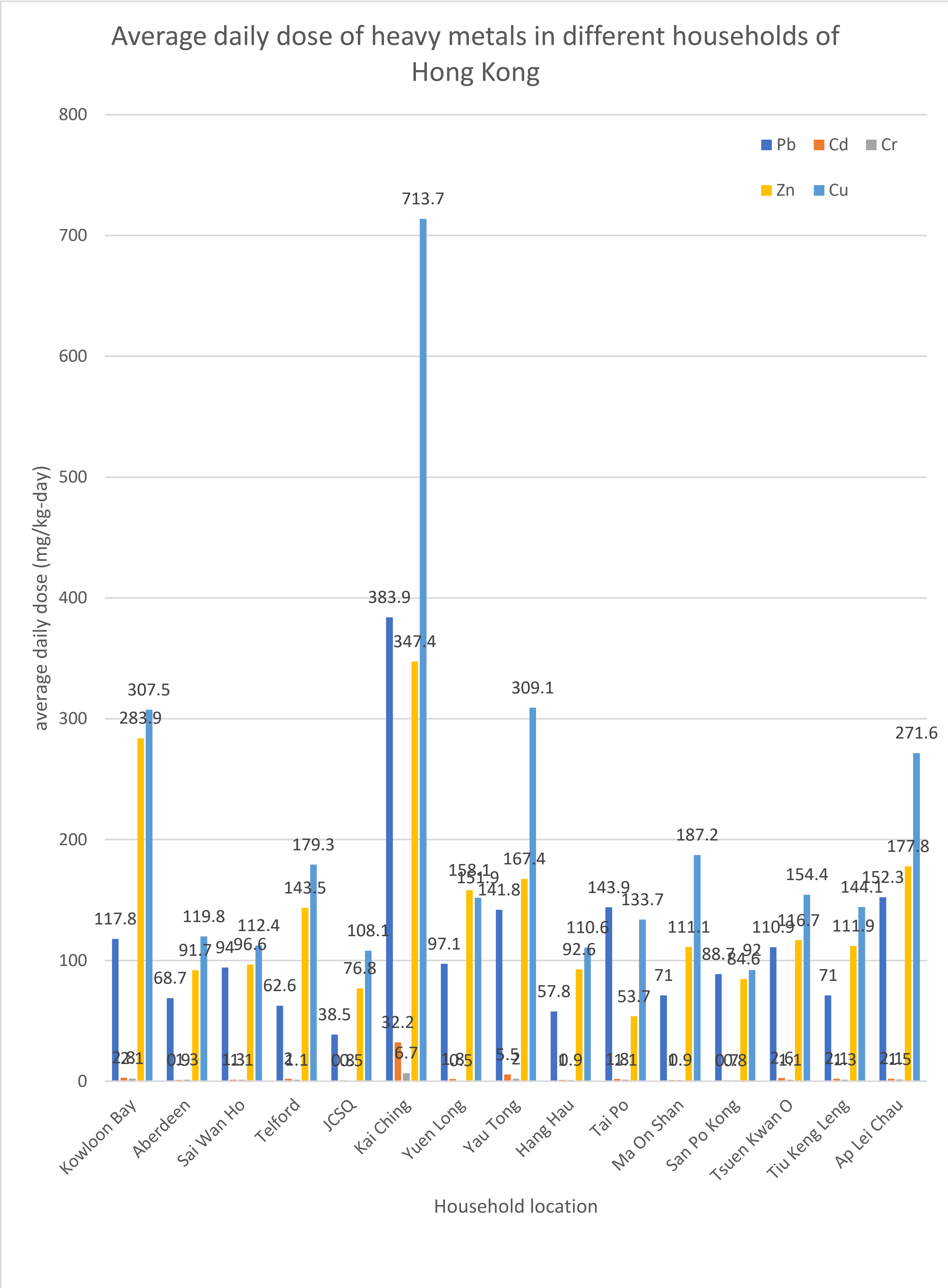


Fig.6 Average daily dose of heavy metals in different households of Hong Kong

Among the five heavy metals, the most abundant was copper, zinc and lead. In Fig.5, Kai Ching (7^{th} floor), Yau Tong (6^{th} floor) and Ap Lei Chau (16^{th} floor) had the highest concentration of heavy metal inside the household dust. Among these 3 households, they were all near the main traffic road. It showed that the household that near main traffic road might have higher chance to accumulate heavy metals inside the household dust. According to Hjortenkrans et al. (2006), combustion of fossil fuels, which was commonly used in automobile, would produce residue like Pb and Cd. Some of the other traffic-emitted metals such as Cu and Zn would be produced by brake-induced metals. This might be the reason for the high concentration of heavy metal found in those household that near main traffic road.

However, some of the high-floored households that near main traffic road had comparatively lower concentration of heavy metal in their dust, such as San Po Kong (26^{th} floor). The floor height of the household might affect the invasion of airborne heavy metal particulate into household, that was high floor might attenuate the invasion of airborne heavy metal particulate. The low floored households commonly had higher concentration of heavy metals found in their dust compared to high floored households, for instance, Kai Ching (7^{th} floor), Yau Tong (6^{th} floor), Ap Lei Chau (16^{th} floor). Some of the low floored households which was away from main traffic road, such as Kowloon Bay (6^{th} floor) and Telford (12^{th} floor), there were still moderate concentration of heavy metals being found inside their dust. Therefore, low floored household might be easier for airborne heavy metals to invade even the household was away from the main traffic road.

Apart from the traffic factor and floor height factor, construction site might be another potential factor that affecting the accumulation of airborne heavy metals particulates inside dust. Construction site would cause heavy metal contamination due to the movement of soil, artificial structures, and cause pollution to urban city (Yang et al., 2020). Yau Tong (6th floor), Tai Po (5th floor), San Po Kong (26th floor), Hang Hau (8th floor) had 1 construction site nearby (distance < 2 km), thus Tiu Keng Leng (42th floor) had 2 construction sites and Kai Ching (7th floor) had more than 3 construction sites. Although the effect of construction site was difficult to compare (size and duty of construction sites might vary), the lower floored household (i.e. Kai Ching at 7th floor) with more construction sites had a much higher concentration of heavy metal found inside its dust comparing to other households. Thus, the household that is low floored and with construction site nearby had higher possibility to be invaded with more heavy metal particulate. Industrial emission might be one of the factors that contribute to the heavy metal accumulation in the household dust. According to Wu et al. (2011), heavy metals such as Cu, Zn might be emitted via industrial emission during industrial process. San Po Kong (26th floor), Tsuen Kwan O (21th floor) and Yau Tong (6th floor) had nearby industrial estates (distance < 3 km). However, the heavy metal concentration in these three households were too deviated, some of them were too high, some of them were too low, it was difficult to clarify that industrial emission was one of the factors that contributing to the invasion of outdoor heavy metals into indoor household environment. It might be caused by the strict industrial emission policy in Hong Kong, so that most of the factories had low concentration of heavy metal emission.

According to USEPA, the regional screening level provided a standard risk-based concentration in analyzing health risk assessment of heavy metals. The corresponding screening level of each heavy metal were shown below: 1. Pb: 400 mg/kg; 2. Cd: 7.1 mg/kg; 3. Cr: 0.3 mg/kg; 4. Zn: 2300 mg/kg; 5. Cu: 310 mg/kg. In 15 household dust samples, there were none of them over the Pb screening level. For cadmium, Yau Tong (9.8 mg/kg) and Kai Ching (30.3 mg/kg) had over the Cd screening level. According to Fowler (2009), overdose of cadmium exposure might cause kidney tubular damage, pneumonitis and itai-itai disease. Chronic exposure to Cd also could be carcinogenic to humans by causing mutation to human genes. For chromium, all of the samples had over the screening level. It might be derived from the household silverware since the silvery coating on the silverware were made of chromium ion containing complex. For example, chrome coating shower, chrome-coating tableware. Furthermore, it might be caused by contamination of chromium while carrying out sample collection and sample preparation. Chromium (III) was a kind essential micronutrient, while Chromium (VI) was a kind of carcinogen since it could react with histone and cause damage to the DNA (Pavesi et al., 2020). For zinc, all of the 15 household dust samples were below the screening level. For copper, Telford (344.3 mg/kg), Kai Ching (672.6 mg/kg), Yau Tong (548.2 mg/kg), Tsuen Kwan O (313.7 mg/kg) and Ap Lei Chau (421.2 mg/kg) had over the screening level. According to Kurlov (2012), copper poisoning might cause liver failure, GI tract bleeding, kidney failure to human body.

3.3 Relation of microplastics and heavy metals in dust

In the overall performance of different household dusts in number of microplastics and heavy metal concentration, it was interesting that the household dust that having more microplastics, would also had higher concentration of heavy metal. For example, Ap Lei Chau, Kai Ching, Kowloon Bay, Telford, Yau Tong. These household had dust with both having large amount of microplastics and high concentration of heavy metal. The possible reason might be the outdoor airborne microplastics and heavy metals invade indoor household environment together. It was because the microplastics provided spaces for heavy metals to adsorb on the surface, and the microplastics act as vector for the heavy metals invade the household environment (Lang et al., 2020). The other reason might be the habit of usage of microplastics of the household users. Since the household users had high dependence on using plastic products, it would increase the chance for derivation of microplastics from these plastic products, thus more microplastics accumulated inside the dust. Therefore, it would provide more surface for outdoor or indoor airborne heavy metals to adsorb on to it. The result was that both number of microplastics and concentration of heavy metals increases simultaneously. The microplastics act as an indicator to show approximate amount of heavy metal inside the dust since microplastics act as vector for heavy metal particulate to travel around via air flow.

4. Conclusion

The amount of microplastics inside the household dust could be affected by the floor height, traffic flow and the habit of household users in using plastic products. The habit in using plastic products directly affect the indoor microplastic content in the household dust. The floor height would affect the invasion of outdoor airborne microplastic into indoor household environment. The higher floor of the household at, the more attenuation on the invasion of outdoor airborne microplastics; the lower floor of the household at, the less attenuation on the invasion of outdoor airborne microplastics. The location of the main traffic road also important in contributing in the microplastics contents in household dust. The traffic flow would raise the outdoor street dust and causing the dusts easier to flow to nearby household via airborne. In the aspect of heavy metals, both indoor and outdoor environment contribute to the accumulation of heavy metals inside the household dust. Traffic flow, floor height and construction site were the factors that affecting the heavy metal concentration in household dust. Industrial emission was not as expected as to be important in affecting the accumulation of heavy metal in household dust. In most of the case, both number of microplastics and heavy metal concentration would increase simultaneously, vice versa. It is because the microplastics is the potential agent for heavy metal to adsorb on it, and become a vector for heavy metal particulate invade indoor household environment.

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Appendix I

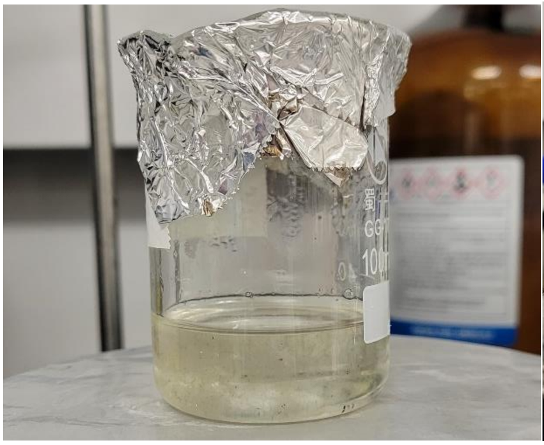
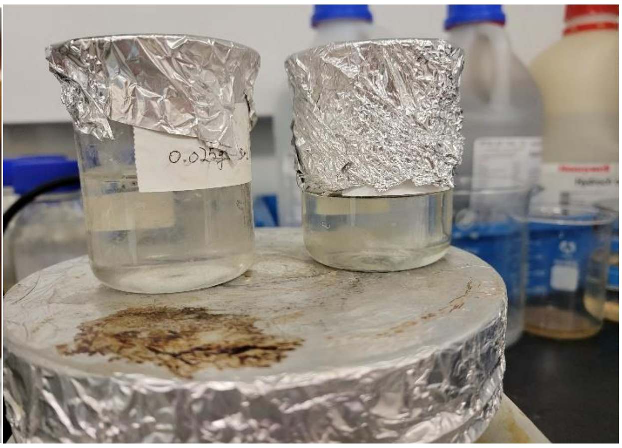
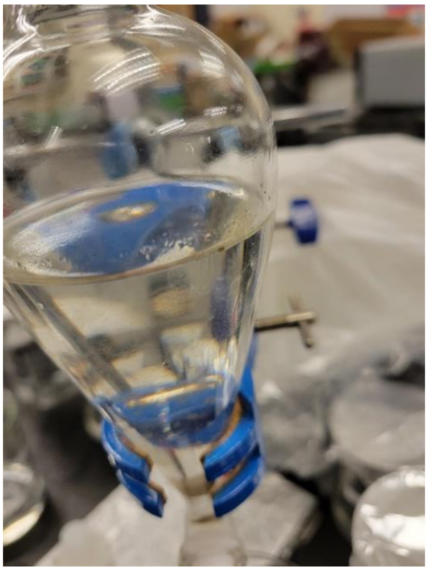
Metal concentration (mg/kg)	Pb	Cd	Cr	Zn	Cu
Kowloon Bay	174.52	4.1	3.1	283.86	307.49
Aberdeen	97.830	1.3	1.8	130.58	170.56
Sai Wan Ho	138.98	1.9	1.7	142.90	166.27
Telford	120.28	3.8	2.1	275.50	344.31
JCSQ	56.996	1.2	0.8	113.67	159.92
Kai Ching	361.77	30.3	6.3	327.35	672.63
Yuen Long	150.64	2.8	0.7	245.13	235.56
Yau Tong	251.48	9.8	3.5	296.92	548.17
Hang Hau	117.54	2.1	1.8	188.21	224.79
Tai Po	212.79	2.6	1.6	79.479	197.70
Ma On Shan	105.02	1.5	1.4	164.39	276.92
San Po Kong	131.17	1.1	1.2	125.17	136.11
Tsuen Kwan O	225.32	5.3	2.2	237.21	313.68
Tiu Keng Leng	152.40	4.6	2.7	240.34	309.47
Ap Lei Chau	236.12	3.2	2.3	275.79	421.22

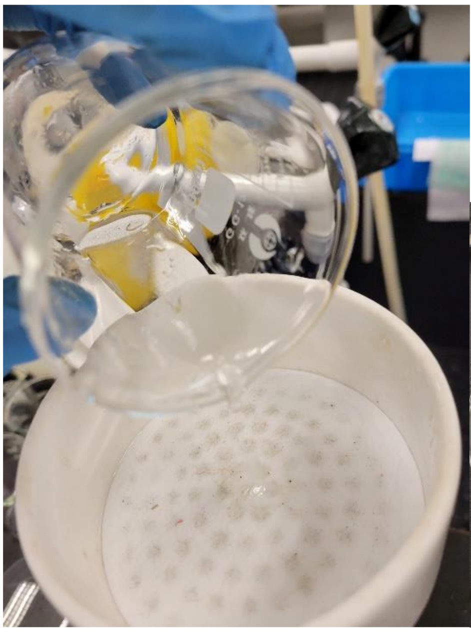
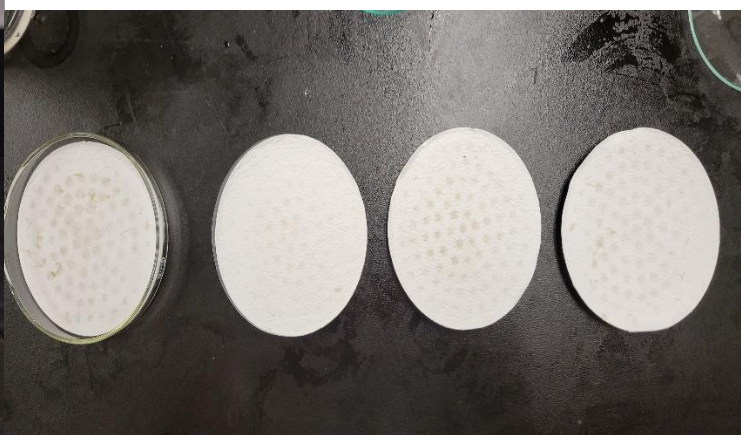
Metal Average daily dose (mg/kg-day)	Pb	Cd	Cr	Zn	Cu
Kowloon Bay	117.8	2.8	2.1	283.9	307.5
Aberdeen	68.7	0.9	1.3	91.7	119.8
Sai Wan Ho	94.0	1.3	1.1	96.6	112.4
Telford	62.6	2.0	1.1	143.5	179.3
JCSQ	38.5	0.8	0.5	76.8	108.1
Kai Ching	383.9	32.2	6.7	347.4	713.7
Yuen Long	97.1	1.8	0.5	158.1	151.9
Yau Tong	141.8	5.5	2.0	167.4	309.1
Hang Hau	57.8	1.0	0.9	92.6	110.6
Tai Po	143.9	1.8	1.1	53.7	133.7
Ma On Shan	71.0	1.0	0.9	111.1	187.2
San Po Kong	88.7	0.7	0.8	84.6	92.0

Tsuen Kwan O	110.9	2.6	1.1	116.7	154.4
Tiu Keng Leng	71.0	2.1	1.3	111.9	144.1
Ap Lei Chau	152.3	2.1	1.5	177.8	271.6

Appendix II

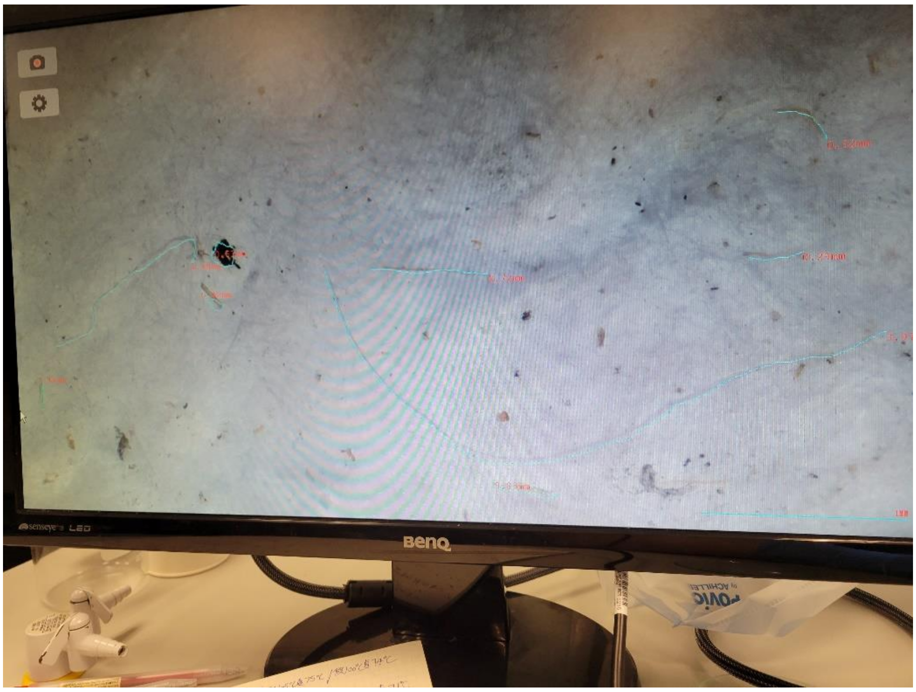
Sample preparation

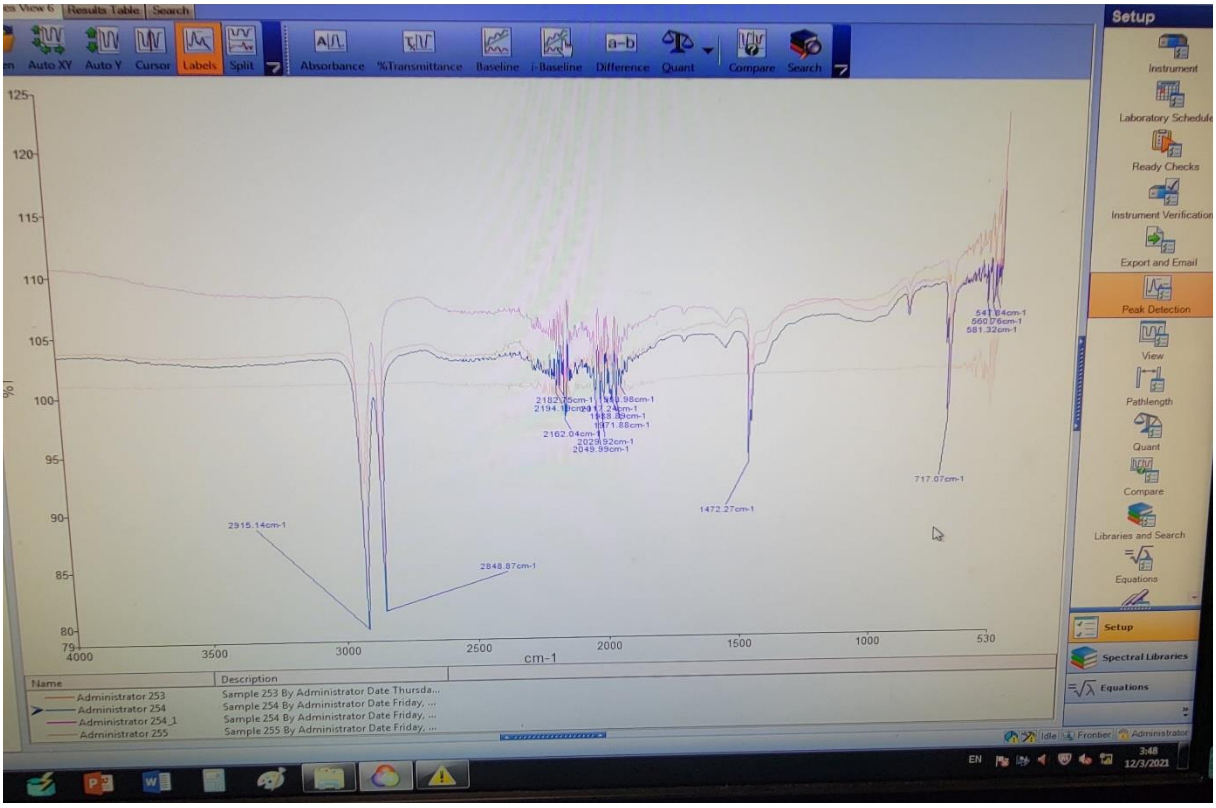




Appendix III

Sample analysis

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717.07cm-1
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Administrator 254
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Sample 253 By Administrator Date Thursda...
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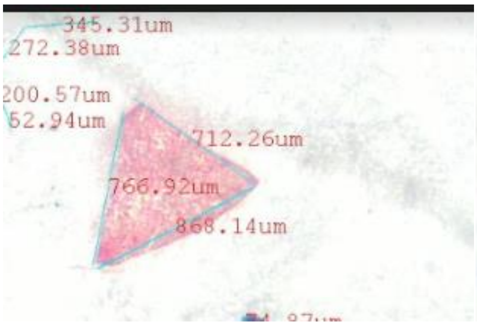
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