RGC Ref. No.:
UGC/FDS16/M07/19
(please insert ref. above)

RESEARCH GRANTS COUNCIL
COMPETITIVE RESEARCH FUNDING SCHEMES FOR
THE LOCAL SELF-FINANCING DEGREE SECTOR

FACULTY DEVELOPMENT SCHEME (FDS)

Completion Report
(for completed projects only)

Submission Deadlines: *1. Auditor's report with unspent balance, if any: within **six** months of the approved project completion date.*
*2. Completion report: within **12** months of the approved project completion date.*

Part A: The Project and Investigator(s)

1. Project Title

Study on Microplastics Pollution and Its Interactions with Polycyclic Aromatic Hydrocarbons (PAHs) in Mangrove Wetland

2. Investigator(s) and Academic Department(s) / Unit(s) Involved

Research Team	**Name / Post**	**Unit / Department / Institution**
Principal Investigator	Dr CHAN Sidney Man-ngai Assistant Professor (08/2022-12/2023)	School of Science and Technology Hong Kong Metropolitan University
Principal Investigator	Dr HAN Jie Assistant Professor (01/2020-07/2022)	School of Science and Technology Hong Kong Metropolitan University
Co-Investigator	Dr CHEUNG Siu-gin Associate Professor	Department of Chemistry City University of Hong Kong
Co-Investigator	Dr ZHOU Haichao Associate Professor	College of Life Science and Oceanography Shenzhen University

3. Project Duration

	Original	**Revised**	**Date of RGC / Institution Approval** *(must be quoted)*
Project Start Date	01/01/2020	N/A	
Project Completion Date	31/12/2022	30/06/2023	04/07/2022
Duration *(in month)*	36	42	04/07/2022
Deadline for Submission of Completion Report	31/12/2023	30/06/2024	04/07/2022

4.4 Please attach photo(s) of acknowledgement of RGC-funded facilities / equipment.

Part B: The Final Report

5. Project Objectives

5.1 Objectives as per original application

1. *To analyze the abundance of microplastics in water and sediments at the Futian mangrove wetland;*
2. *To measure concentrations of PAHs, pH, salinity and dissolved organic matter of water and sediment samples at the Futian mangrove wetland;*
3. *To study competitive interaction models between mixtures of three PAHs contaminants and three types of microplastics;*
4. *To examine the sorption-desorption processes under different pH, salinity and PAH concentrations in water and sediment at the Futian mangrove wetland.*

5.2 Revised objectives

Date of approval from the RGC: N/A

Reasons for the change:

5.3 Realisation of the objectives

(Maximum 1 page; please state how and to what extent the project objectives have been achieved; give reasons for under-achievements and outline attempts to overcome problems, if any)

Objective 1:

To analyze the abundance of microplastics in water and sediments at the Futian mangrove wetland

- Objective 1 was fully achieved.
- A scientific methodology for quantifying microplastics (MPs) in both water and sediments was developed. Water and sediment samples from Futian mangroves were collected and analysed using the developed method. The results showed that the presence of mangrove plants has a significant effect on the distribution of MPs in the sediments of coastal wetland environments. The findings from this research have been published in the journal *Science of The Total Environment*.

Objective 2

To measure concentrations of PAHs, pH, salinity and dissolved organic matter of water and sediment samples at the Futian mangrove wetland

- Objective 2 was fully achieved.
- The concentrations of polycyclic aromatic hydrocarbons (PAHs), pH values, salinity and dissolved organic matter level in the water and sediment samples collected from Futian mangrove were analysed. Different types of polycyclic aromatic hydrocarbons (PAHs) were detected and the concentration of pyrene was particularly high. The levels of dissolved organic matter (DOM) significantly varied across the sampling points in the site of this study. The relevant data and conclusions from this study have been published in the journal *Environmental Technology & Innovation*.

Objective 3

To study competitive interaction models between mixtures of three PAHs contaminants and three types of microplastics

- Objective 3 was fully achieved.
- Six different sorption models were applied to study the competitive interaction among PAHs contaminants and different types of MPs. It was found that MPs of polyethylene (PE) showed significant interactions with PAHs. Sorption-desorption models of binary (water-MPs) and ternary (water-MPs-sediment) systems were successfully built for PE MPs at environmentally relevant concentrations. The result was published in the journal of *Environmental Technology & Innovation*.

Objective 4

To examine the sorption-desorption processes under different pH, salinity and PAH concentrations in water and sediment at the Futian mangrove wetland

- Objective 4 was fully achieved.
- The effects of various parameters on the sorption-desorption processes of PAHs to MPs were investigated. It was found that the sorption and desorption of the PAHs to MPs were strongly related to the PAHs concentrations. Additionally, the presence of sediment phase strongly affects the sorption behavior. PAHs migrated from sediment phase to MPs.

5.4 Summary of objectives addressed to date

Objectives *(as per 5.1/5.2 above)*	**Addressed** *(please tick)*	**Percentage Achieved** *(please estimate)*
1. To analyze the abundance of microplastics in water and sediments at the Futian mangrove wetland	✓	100%
2. To measure concentrations of PAHs, pH, salinity and dissolved organic matter of water and sediment samples at the Futian mangrove wetland;	✓	100%
3. To study competitive interaction models between mixtures of three PAHs contaminants and three types of microplastics;	✓	100%
4. To examine the sorption-desorption processes under different pH, salinity and PAH concentrations in water and sediment at the Futian mangrove wetland.	✓	100%

6. Research Outcome

6.1 Major findings and research outcome
(Maximum 1 page; please make reference to Part C where necessary)

A total of seven journal manuscripts and four conference papers were published to disseminate the research findings of this study.

It was found that microplastic pollution in a subtropical mangrove forest in South China is serve, with approximately 4000 items/kg sediment d.w. Discrete distribution of MPs in different areas of the site of study. The abundance at the mangrove forest fringe are higher than that of the interior and mudflat area. Positive dependence ($p < 0.05$) between the density of *Sonneratia* pneumatophores and the abundance of fiber type MPs were found suggesting that pneumatophores is important for protecting mangrove forest from MPs pollution. These findings were published in a journal, Science of The Total Environment in 2022 titled "*How mangrove plants affect microplastic distribution in sediments of coastal wetlands: Case study in Shenzhen Bay, South China*".

This study also explored the differences in the sorption behaviours of pyrene, a type of PAHs, at environmentally realistic concentrations between binary (water-MPs) and ternary (water-MPs-sediment) systems, elucidating the role of sediment in the sorption process and the impact of the coexistence of sediment and MPs. The sediment phase acted as a "sponge" to adsorb the vast majority of pyrene at the beginning of the sorption experiment in the ternary system, which behaved differently than in the binary system. The sediment-sorbed pyrene was then gradually released but re-adsorbed by polyethylene MPs (PE-MPs), while the concentration of pyrene in water remained at a steady low level. It took longer to achieve the sorption equilibrium of pyrene onto MPs in the ternary system than in the binary system, from 15 min to 480 min, indicating that competitive sorption occurred between MPs and sediment and hence decrease in equilibrium constants. These findings indicated that PE-MPs exhibited a higher pyrene affinity than sediment and were potential pyrene carriers in aqueous systems. It was also discovered that the effects of pH value and salinity are limited to the sorption behaviours of pyrene, the model PAH in this study. Through sorption kinetics and isotherm models study, it was found that pseudo-secondorder (PSO) kinetics (0.9773), Elovich (0.9314) and Henry's (0.9850) models has the highest r^2 value, indicating that chemisorption and hydrophobic interactions were attributed to the sorption process. These findings support that MPs pollution may enhance the mobility and availability of pollutants in marine environments, resulting in wider spread of pollutants. This study also provides a pilot protocol for investigating the interaction of multiple absorbents in the sorption process, including the separation of three phases, instrumental extraction and analysis procedures. This model protocol can be applied to further research on sorption behaviours and interactions among different types of sediment, water and MPs to discover their individual and synergic roles in the sorption process. These contributes to an accurate prediction of the transportation and fate of pollutants in aquatic environments. The above findings were delineated in a paper titled "*Different sorption behaviours of pyrene onto polyethylene microplastics in a binary system with water and a ternary system with water and sediment*" of Environmental Technology & Innovation in 2023.

6.2 Potential for further development of the research and the proposed course of action *(Maximum half a page)*

This study has developed an experimental procedure that allow monitoring of pyrene in different fractions of a system consisting of PE-MPs, water and sediment. Furthermore, sorption kinetics and isotherm models were established in a simulated environment. In real situation, different types of pollutants co-exist in the environment. Therefore, the present study can be extended to investigate the interactions among multiple types of pollutants and MPs. The established sorption kinetics and isotherm models in this study can also be modified to explain sorption behaviours in a real environment instead of a laboratory environment with well-controlled conditions. The research approach of this study can also be applied to soil instead of sediment. These further studies will contribute knowledge for establishing models to estimate the impacts of MPs pollution to MPs associated organic pollutants in concern such as PAHs and bisphenols.

7. Layman's Summary

(Describe in layman's language the nature, significance and value of the research project, in no more than 200 words)

Microplastic pollution is a growing environmental concern, as these tiny plastic particles can accumulate and widespread harmful contaminants such polycyclic aromatic hydrocarbons (PAHs). This research project aims to deepen our understanding of how microplastics interact with and retain these pollutants, particularly in mangrove reserves, one of the important but sensitive coastal ecosystems. The team has investigated the complex sorption and desorption dynamics between microplastics and PAHs in different environmental conditions - in water alone and in water-sediment mixtures. We found that while microplastics can quickly adsorb PAHs in water, the pollutants are not held tightly. However, microplastics show a much stronger affinity for PAHs when interacting in a water-sediment mixture. This appears to be driven by chemisorption and hydrophobic interactions. By modeling these interactions, the team can evaluate the combined risks posed by microplastics and PAHs in coastal environments. This knowledge can inform more effective strategies to monitor, control and manage microplastic pollution, especially in vulnerable habitats like mangrove reserves. Ultimately, this research contributes to preserving the health of these vital ecosystems through a deeper understanding of microplastics and their capacity to accumulate and transport harmful contaminants.

Part C: Research Output

8. Peer-Reviewed Journal Publication(s) Arising Directly From This Research Project

(Please attach a copy of the publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.)

The Latest Status of Publications				**Author(s)** *(denote the correspond-ing author with an asterisk*)*	**Title and Journal / Book** *(with the volume, pages and other necessary publishing details specified)*	**Submitted to RGC** *(indicate the year ending of the relevant progress report)*	**Attached to this Report** *(Yes or No)*	**Acknowledged the Support of RGC** *(Yes or No)*	**Accessible from the Institutional Repository** *(Yes or No)*
Year of Publication	**Year of Acceptance** *(For paper accepted but not yet published)*	**Under Review**	**Under Preparation** *(optional)*						
2021				Duan, J. H.#; **Han J.**#; Cheung, S.G.; Chong, R K-Y; Lo, C. M.; Lee, F. W.-F.; Xu, S. J.-L.; Yang, Y.; Tam, N. F.-Y.*; Zhou, H. C*. (#Co-first author)	How mangrove plants affect microplastic distribution in sediments of coastal wetlands: Case study in Shenzhen Bay, South China. Science of The Total Environment 2021, 767, 144695	**2021**	**Yes [Attachment 1]**	**Yes**	**Yes**
2021				Wang, Q; Guan C.; **Han J**., Chai, M.; Li, R*.	Microplastics in China Sea: Analysis, status, source, and fate. Science of The Total Environment 2021, 803, 119887	**No**	**Yes [Attachment 2]**	**Yes**	**Yes**
2021				Shen, X.; Li, R.*; Chai, M.; Cheng, S.; Tam, N. F.-Y., **Han, J.**	Does combined heavy metal stress enhance iron plaque formation and heavy metal bioaccumulation in *Kandelia obovata*? Environmental and Experimental Botany 2021, 186, 104463	**No**	**Yes [Attachment 3]**	**Yes**	**Yes**
2021				Shi, YF; Lu, YH; Zhang, FB; Su, X; Wu, QH*, Lei, HF, Fang LC, Zhang, F; Liu, ZB; **Han, J**; Mai, BX	Investigation into Polycyclic Aromatic Hydrocarbons in Sediments of Wei River Basin. Water, Air, & Soil Pollution 2021, 232	**No**	**Yes [Attachment 4]**	**Yes**	**Yes**

2022				Chai, M.; Li, R.*; Shen, X.; Yu, L.; **Han, J**.	Multiple heavy metals affect root response, iron plaque formation, and metal bioaccumulation of *Kandelia obovate*. Scientific Reports 2022, 12(1), 14389	**No**	**Yes [Attachment 5]**	**Yes**	**Yes**
2023				Fung, Y. H., **Han, J.***, Tam, N. F. Y., Chen, J., **Chan, S. M. N.***, Cheung, S. G., Zhou, H. C., Lo, C. M., & Ma, Y.	Different sorption behaviours of pyrene onto polyethylene microplastics in a binary system with water and a ternary system with water and sediment. Environmental Technology & Innovation, 30, 103086.	**No**	**Yes [Attachment 6]**	**Yes**	**Yes**
2023				Tse, Y.T., Lo, H.S., Tsang, C.W., **Han, J.**, Fang, J.K.H., **Chan, S.M.N.** & Sze, E.T.P.*	Quantitative analysis and risk assessment to full-size microplastics pollution in the coastal marine waters of Hong Kong. Science of the Total Environment, 879, 163006.	**No**	**Yes [Attachment 7]**	**Yes**	**Yes**

9. Recognized International Conference(s) In Which Paper(s) Related To This Research Project Was / Were Delivered

(Please attach a copy of each conference abstract)

Month / Year / Place	**Title**	**Conference Name**	**Submitted to RGC** *(indicate the year ending of the relevant progress report)*	**Attached to this Report** *(Yes or No)*	**Acknowledged the Support of RGC** *(Yes or No)*	**Accessible from the Institutional Repository** *(Yes or No)*
08/2022, Hong Kong, China	Determination of whole spectrum microplastics in bottled water samples by flow cytometry complimented with microscopic identification	International Conference on Environment and Human Health: Challenges and Opportunities in the 21st Century	**No**	**Yes [Attachment 8]**	**Yes**	**Yes**

04/2023, Hong Kong, China	Full Size Microplastics Pollution Survey to the Costal Marine Waters of Hong Kong	International Conference on Conservation and Sustainable Development of Coastal Wetland	**No**	**Yes** [Attachment 9]	**Yes**	**Yes**
08/2023, Hong Kong, China	The Effect of Microplastics on Different Microalgae Focusing on their Growth and Bio-adsorption Responses	International Conference on Algal Research, Application and Management	**No**	**Yes** [Attachment 10]	**Yes**	**Yes**
11/2023, Hiroshima, Japan	Different effects on growth of *Scenedesmus quadricauda*, *Scenedesmus dimorphus*, and *Scenedesmus obliquus* under microplastics stress	The 20th International Conference on Harmful Algae (ICHA2023)	**No**	**Yes** [Attachment 11]	**Yes**	**Yes**

10. Whether Research Experience And New Knowledge Has Been Transferred / Has Contributed To Teaching And Learning

(Please elaborate)

Through this project, the PIs gained lot of experiences of visiting mangrove forests, environmental sampling and analysing organic pollutants in different types of samples. These experiences and techniques furnishing the PIs' teaching in undergraduate science and testing courses. Sharing of research ideas, approaches and findings of this project in different occasions is inspiring to undergraduate students and enhancing their interest in science and research. The project is also a good reference for the students to construct their own research idea in their final year project.

11. Student(s) Trained

(Please attach a copy of the title page of the thesis)

Name	**Degree Registered for**	**Date of Registration**	**Date of Thesis Submission / Graduation**
N/A			

12. Other Impact

(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, teaching enhancement, etc.)

N/A

13. Statistics on Research Outputs

	Peer-reviewed Journal Publications	Conference Papers	Scholarly Books, Monographs and Chapters	Patents Awarded	Other Research Outputs (please specify)	
No. of outputs arising directly from this research project	7	4	0	0	Type	No.

14. Public Access Of Completion Report

(Please specify the information, if any, that cannot be provided for public access and give the reasons.)

Information that Cannot Be Provided for Public Access	Reasons
N/A	