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RESEARCH ARTICLE
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Exposure of Microplastics by Ingestions through Fish among People Residing Along the Mun River in a Two Setting Area of Ubon Ratchathani Province, Thailand

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ABSTRACT

Thai fish contain microplastics (MPs), but data on fish microplastic exposure is insufficient. This study examined MP in fish from the Mun River and the level of MP exposure from fish consumption in rural and urban areas of Ubon Ratchathani Province, Thailand. Thirty-six fish samples, including the species Paralaubuca typus, Phalacronotus bleekeri, and Morulius chrysophekaion, from both rural and urban stations along the Mun River were collected. The questionnaire assessed microplastic exposure among 310 rural and urban residents along the Mun River in Ubon Ratchathani Province. The fish samples were analyzed in the College of Medicine and Public Health Laboratory at Ubon Ratchathani University. Microplastics in the samples were counted using a stereomicroscope. The analysis revealed that 73.61% of the fish from the urban station were contaminated with microplastics, with an average abundance of 26.50±4.217 particles per fish .In comparison, 26.39% of the fish from the rural station were found to have microplastics, with an average abundance of 9.50±3.51 particles per fish. The exposure to microplastics from fish consumption does not differ significantly between people living in rural and urban area. Conversely, urban residents experienced a higher level of microplastic exposure compared to their rural counterparts. Therefore, government agencies such as the municipality, the Ministry of Public Health, and the Department of Natural Resources and Environment must work cooperatively to prevent and resolve these issues. We suggest comprehensively investigating the categorization, dimensions, and hazards associated with microplastics in each category within this area.

Keywords: Microplastics, Exposure, Assessment, Fish, Consumption.

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INTRODUCTION

Microplastics (MPs) have the ability to emit both organic and inorganic chemical substances that are either inherent in their structure or have been absorbed from the surrounding environment. Additionally, they can serve as carriers for microorganisms (Alberghini et al., 2023). Due to their high abundance, exposure to MPs in the environment can occur through food consumption, inhalation, and skin contact. Exposure to MPs can lead to several negative effects in humans, including oxidative stress, cytotoxicity, neurotoxicity, disturbance of the immune system, and the transfer of MPs to other tissues (Bhuyan, 2022; Gaspar et al., 2023; Li et al., 2023). Microplastics can infiltrate the food chain (Cverenkárová et al., 2021), either directly or indirectly, by contaminating it through the release of their potentially hazardous compounds. According to the study by Rahmatin et al. (2024), the majority of microplastics (100–1500µm) are found in sediment (73–90%) and cockles (77–79%) (Rahmatin et al., 2024). Humans consume a significant amount of microplastic and even nanoplastic particles through food, particularly when consuming fish (Wagner & Lambert 2018; Barboza et al., 2020).

In the upper Gulf of Thailand, a study found microplastics in the gastrointestinal tracts of 46.9% of marine food fish. The average concentration was 1.6±0.5 pieces per fish, or 0.04±0.01 pieces per gram of fish tissue (Srisiri et al., 2024). The study conducted by Klangnurak

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and Chunniyom (2020) found that microplastic fibers were the most common type of plastic found in both demersal (82.76%) and pelagic fish (57.14%) in Thailand. These microplastic fibers were prevalent in all size classes of marine fish in the region (Klangnurak and Chunniyom, 2020). Additionally, many studies indicated the contaminant of MPs in freshwater fish (Kasamesiri and Thaimuangphol, 2020; Yasaka et al., 2022; Seetapan and Prommi, 2023).

The Mun River is a substantial tributary of the Mekong River, annually contributing approximately 20 billion cubic meters of water. Human activities, such as agriculture and urbanization, have a significant impact on the Mun River basin, which is a crucial agricultural sector in Thailand (Tian et al., 2019). MPs were detected in water and sediment samples collected from the Chi River, which is part of the Mekong River network. The average concentration of MPs in the water samples was 141 items per cubic meter, while in the sediment samples it was 9.5 items per kilogram (Thamsenanupap et al., 2022). Numerous studies conducted in Thailand have reported the presence of microplastics in fish in various locations, including the Nam Pong River in Khon Kaen (Yasaka et al., 2022), Songkhla Lagoon in southern Thailand (Pradit et al., 2023; Jitkaew et al., 2024), the reservoir in Phayao Province in Northern Thailand (Seetapan and Prommi, 2023), and the eastern coast of Thailand (Phaksopa et al., 2021). However, there is a lack of data on microplastic pollution the Mun River, and there are no reports on the potential risk of microplastic exposure among people living in nearby river areas through fish consumption. Therefore, the objective of this study was to explore the presence of MPs in fish from the Mun River and assess the level of exposure to MPs through fish consumption among rural and urban populations living near the Mun River in Thailand.

MATERIALS & METHODS

This cross-sectional analytic study aimed to investigate the presence of MPs in fish and assess the level of exposure to MPs through the consumption of fish among rural and urban populations living near the Mun River, Thailand.

We considered several factors, including geographic information, sources of pollutants entering the Mun River, ecological conditions, population density, and characteristics of water usage near the Mun River, to select fish sampling sites for purposive sampling in two locations (Fig. 1):

Sampling station 1: Confluence point between water sources (rural area).
Sampling station 2: Community and commercial area (urban area).

Population and Sample

1) A total of 36 fish samples were gathered from two sampling stations, comprising 18 samples from the rural area station and 18 samples from the urban area station. The obtained fish samples included three species: Paralaubuca typus, Phalacronotus bleekeri, and Morulius chrysophekadion, which were commonly found in the area and consumed by local people.

(2An analysis of sample groups was conducted to assess the degree of microplastic exposure among individuals living near the Mun River in Ubon Ratchathani Province, northeastern Thailand, focusing on their consumption of fish. To compute a sample formula for estimating population proportions, the following calculation was used:

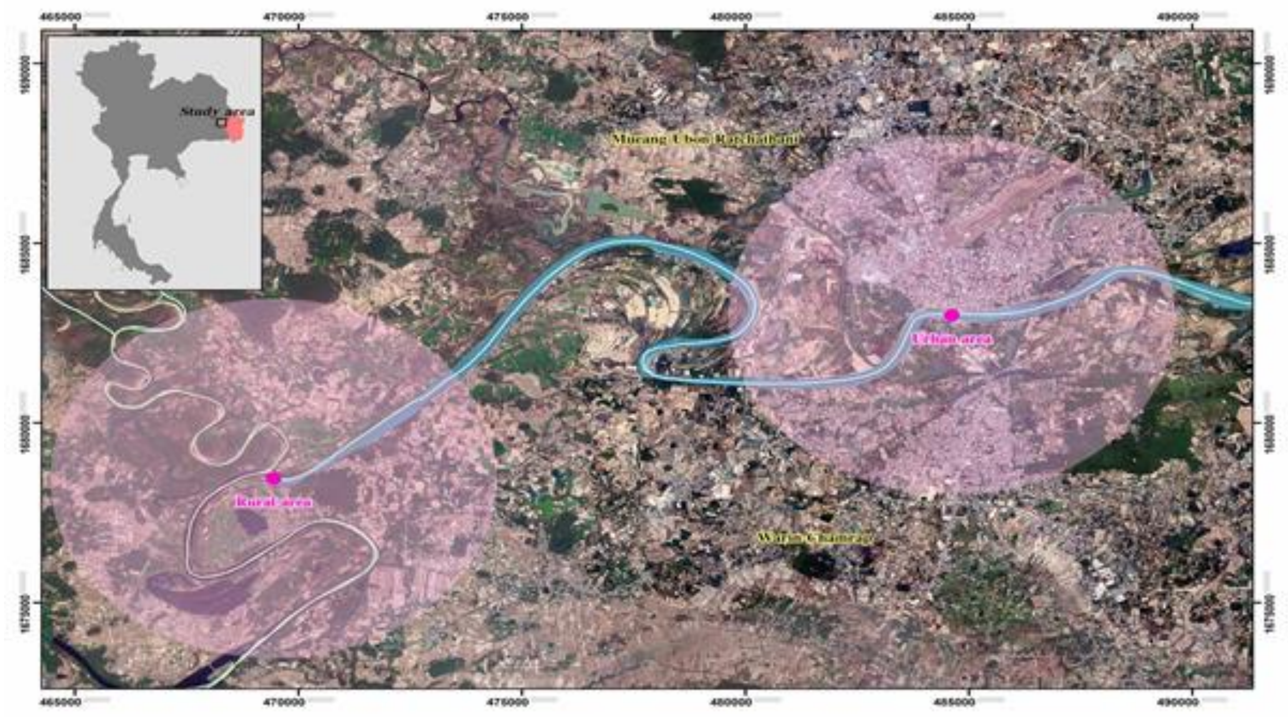

Fig. 1: Study area locations and sampling sites on the Mun River, Ubon Ratchathani Province, Thailand.

$$n = \frac{NZ_{\alpha/2}^2[p(1-p)]}{[e^2(N-1)] + [Z_{\alpha/2}^2[p(1-p)]]}$$

Where:
n = sample size
N = Population (5,369 households)
= the coefficient under the standard normal curve at 95 confidence level
P = proportion estimates (0.77 obtained from reviews in the literature (Kiatsayomphu and Chaiklieng, 2012))
e = precision of estimate (0.045)

$$n = \frac{(5{,}369 \times 1.96^2)[0.77(1-0.77)]}{0.045^2(5{,}369 - 1)] + [1.96^2[0.77(1-0.77)]]}$$

n =303

An accidental sampling for a representative sample size of 310 households was utilized, as indicated in Table 1.

Table 1: Sample size

Area	Number of communities	Number of households	Sample size
Rural area	3 communities (Bung Wai, Nong Kin Phen, Kham Nam Saap)	2,650	153
Urban area	3 communities (Mueang, Chaeramae, Warin Chamrap)	2,719	157
Total		5,369	310

Inclusion Criteria

The participants must be permanent residents of the target community where the Mun River is used for fish consumption, aged at least eighteen, proficient in speaking and understanding, with a high level of awareness, and willing to participate in the study project.

Fish Sample Collections and Preparations

There are three different species of fish :*Paralaubuca typus, Phacronotus bleekeri*, and *Morulius chrysophekadion* . We collected a total of 36 samples, with 18 samples from each sampling station.

Local fishermen used gill nets and trawling techniques to catch fish. Then the weight of each fish was documented in grams and its length in centimeters was measured. Subsequently, each fish was wrapped in foil, transported in insulated containers at 4°C, and stored at -20°C until further analysis (Goswami et al., 2020).

The fish samples were analyzed in the laboratory of the College of Medicine and Public Health, Ubon Ratchathani University. Initially, the frozen fish were thawed and thoroughly cleaned with purified water. Subsequently, the intestines and segments of the digestive system (gastrointestinal tract, or GIT) were dissected, and the gills were separated. Afterward, the GIT and the gills were weighed in grams and transferred to 100mL Erlenmeyer flasks. 30% H_2O_2 was used to break down the organic matter (Jabeen et al., 2017). The volume of H_2O_2 used was calculated based on the weight of the GIT samples (approximately 30mL/sample). The extracted samples were kept in a shackled incubator at 80°C for a full day and approximately 300 g/L of saturated sodium chloride (NaCl) was added to the filter.

Microplastics Calculation

The density of microplastics was calculated using the extracted samples. The samples were shaken for two minutes using a shaker until layers of solution and precipitate were separated. Subsequently, the supernatant was filtered through a glass microfiber filter (Whatman GF/C, 0.45µm pore size) using a pipette. The filter paper was then dried for four hours at 50°C. Microplastics in the samples were examined by placing the filter paper on Petri plates and counting the particles under a stereomicroscope.

Research Questionnaire and the Quality Assessment

The questionnaire consists of two components.

Part 1 includes 10 items related to general and participant characteristics, such as gender, age, education level, occupation, marital status, and others.

Part 2 gathers data on fish consumption, including the type of fish consumed, frequency of consumption, and quantity consumed.

Three subject experts validated the questionnaire responses, and the Index of Item Objective Congruence evaluated the questionnaire itself. Each item received a score ranging from 0.67 to 1.

Questionnaire Collections

Upon obtaining human ethics approval and acquiring experimental animals, the researchers provided training to two assistants for the purpose of data collection. These assistants were Bachelor of Science students specializing in environmental health, as well as village volunteers. The training aimed to ensure all individuals involved had a uniform understanding and could effectively collaborate. We gathered questionnaire data through interviews conducted only with individuals from homes in the target group who consume aquatic animals in the Mun River area.

Data Analysis

1) Analysis of microplastic exposure

The estimation of microplastic exposure among individuals residing in the vicinity of the Mun River in two distinct areas was conducted using a deterministic approach, employing the equation (Exposito et al., 2022):

DIt = (Cm x Fc) / Bw
DIt = Exposure to microplastics from fish consumption (particles/person/day)
Cm = Concentration of microplastics in fish (particles/gram)
Fc = Fish consumption rate (grams/person/day)
Bw = Body weight (kilograms)

Measures such as average, standard deviation, minimum, and maximum were utilized to assess the daily and annual intake of microplastics in fish by individuals residing in rural and urban areas.

The T-test statistical method was used to assess the differences in microplastic exposure in fish between people living in rural and urban areas.

2) Analysis of demographic variables

Demographic variables were analyzed using descriptive statistics: frequency, percentage, mean, standard deviation, median, minimum, and maximum.

RESULTS

The participants comprised 50.65% of those residing in urban areas, and 51.94% were female. The mean age is 51.00 years, with a standard deviation of 12.39. The predominant occupation among the participants was agriculture, accounting for 41.94% of the total. The median monthly income was 8,000 baht. The majority of participants, 70.65%, did not have any congenital disease, while 29.35% did. Among the various diseases, diabetes had the highest prevalence, affecting 41.76% of the participants. Among the participants, 60.65% lived in communities for more than 40 years; 56.45% lived within 400 meters of the Mun River; and 35.48% obtained aquatic animals for consumption by purchasing them from the community. The majority of participants, 73.55%, preferred to consume aquatic animals throughout the year (Table 2).

According to the results of microplastic contamination in fish from two sampling stations, the urban area station had 477 pieces of microplastic contamination (26.50±4.21 pieces per fish), accounting for 73.61 %. Meanwhile, the rural area station had 171 pieces of microplastic contamination (9.50±3.51 pieces per fish), representing 26.39% (Table 3).

Microplastic Exposure through Fish Consumption among Residents in Rural and Urban Areas

The parameters used to assess microplastic exposure (Table 4) revealed that the concentration of microplastics in fish was 1 particle per gram in urban areas, whereas it was 0.26 particles per gram in rural areas. Additionally, the rate of fish consumption per person per day was 12.32g in urban areas and 42.86g in rural areas. Furthermore, the average body weight in both areas was around 60kg.

The study examined the effect of microplastic exposure on residents living near the Mun River in both rural and urban areas. The results showed that individuals in urban areas had the highest level of microplastic exposure, with a maximum exposure of 1.30 particles per person per day and 475.11 particles per person per year. The average daily exposure was 0.20+0.21 particles per person, while the yearly exposure was 72.15+76.40 particles per person. In comparison, individuals in rural areas had a maximum exposure of 0.76 particles per person per day and 275.74 per person per year. The average daily exposure in rural areas was 0.18+0.17 particles per person, and the yearly exposure was 64.69+63.75 particles per person (Table 5).

While investigating differences in microplastic exposure through fish consumption between individuals residing in rural and urban areas. The results indicated no significant difference in the level of microplastic exposure between the two groups, with a $P>0.05$ (Table 6).

DISCUSSION

This study found that most participants were engaged in agriculture and fishing and had lived in the community for over 40 years. Furthermore, most participants lived within 400 meters of the Mun River. The study also revealed the presence of microplastic contamination in fish, particularly in urban areas. This poses potential risks for people who are consistently exposed to microplastics. It is evident that people consume fish purchased from the community or caught for personal consumption throughout the year. Several studies suggest that microplastics may enter the food chain when aquatic species consume contaminated food. From there, the

Table 2: Characteristics and general data of participants (n=310)

Characteristics and general data	Number	Percentage
Community type		
Rural community	153	49.35
Urban community	157	50.65
Gender		
Male	149	48.06
Female	161	51.94
Age (years)		
18-29	18	5.81
30-44	64	20.65
45-59	153	49.35
≥60	75	24.19
Mean = 51.00, S.D. = 12.39, minimum = 20, maximum = 84		
Education level		
Primary school	153	51.29
Secondary school	134	43.23
Bachelor's degree	14	4.52
Higher than bachelor's degree	3	0.96
Marital status		
Single	38	12.26
Spouse	244	78.71
Widowed, divorced, separated	28	9.03
Occupation		
Fisherman	101	32.58
Agriculturist	130	41.94
Merchant	26	8.38
Hired laborer	47	15.16
Government officer	6	1.94
Monthly income (baht)		
< 5,000	58	18.71
5001-10,000	169	54.52
10,001-15,000	67	21.61
15,001-20,000	14	4.52
≥20,000	2	0.65
Median = 8,000, minimum = 1,000, maximum = 30,000		
Congenital disease		
No	219	70.65
Yes	91	29.35
- Diabetes	38	41.76
- Blood pressure	29	31.87
- Heart disease	5	5.49
- Kidney disease	1	1.10
- Muscle pain	9	9.89
- Others	9	9.89
Duration of residence (years)		
< 10	5	1.61
11-20	14	4.52
21-30	51	16.45
31-40	52	16.77
> 40	188	60.65
Median= 45, minimum = 4, maximum = 84		
Distance of residence from the Mun River (meters)		
< 100	88	28.39
101-400	87	28.06
401-600	50	16.13
601-1000	31	10.00
> 1000	54	17.42
Median = 300, minimum = 1, maximum = 1500		
Source of aquatic animals used for consumption		
Purchase from the community	110	35.48
Purchase from the market	99	31.94
Catch it for private consumption	101	32.58
Season preferences for consuming aquatic animals		
Dry season	11	4.19
Rainy season	69	22.26
All year round	228	73.55

Table 3: Concentrations of microplastics in fish classified by area

Area	Microplastics in fish				
	number of microplastics (648 particles)		particles/fish ($\bar{X}$±S.D.)	minimum	maximum
	Particles	Percentage			
Rural area (n=18)	171	26.39	9.50±3.51	5	18
Urban area (n=18)	477	73.61	26.50±4.21	19	36

Table 4: Parameters used to calculate microplastic exposure

Area	Body weight (kg) ($\bar{X}$±S.D.)	Fish consumption rate (g/person/day)	Concentration of microplastics in fish (average) (particles/g)
Rural area (n=153)	62.66±11.53	42.86	0.26
Urban area (n=157)	64.85±11.55	12.32	1.00

Table 5: Microplastic exposure through fish consumption among residents in rural and urban areas along the Mun River

Area	Microplastic exposure by ingestions through fish			
	particles/person/day		particles/person/year	
	minimum-maximum	$\bar{X}$ (S.D.)	minimum-maximum	$\bar{X}$ (S.D.)
Rural area (n=153)	0.01-0.76	0.18(0.17)	4.98-275.74	64.69 (63.75)
Urban area (n=157)	0.05-1.30	0.20(0.21)	17.38-475.11	72.15 (76.40)

Table 6: The differences of microplastic exposure through fish consumption between people living in rural and urban areas

Area	N	$\bar{X}$±S.D.	t-test	p-value
Rural area	153	0.18±0.17	-0.93	0.3520
Urban area	157	0.20±0.21		

particles can continue to transfer to the next predator in the food chain, which includes humans (Mahamud et al., 2022; Ali et al., 2024).

Although the number of microplastics found in fish, as indicated in particles per fish, in rural areas of this study was lower than in the urban area, it was greater than in another rural area as the Chi River in northeastern Thailand (Kasamesiri and Thaimuangphol 2020). Those residing in the vicinity of the Mun River may be more susceptible to microplastic exposure from consuming fish compared to those who consume fish from the Chi River.

The study revealed that people residing in urban areas had a greater degree of exposure to microplastics than those living in rural areas, with a maximum exposure of 1.30 particles per person per day and 475.11 particles per person per year. After studying the concentration of microplastics, it was observed that residents in rural areas had a higher fish consumption rate compared to those living in urban areas. However, the research has shown that fish caught in the urban area stations of the Mun River are nearly four times more contaminated with microplastics compared to fish caught in rural area stations. Furthermore, it is evident that the community provided the aquatic animals for human consumption, with individuals catching them for personal consumption. Therefore, the exposure to microplastics in urban areas is likely higher than in rural areas. This is in line with several studies indicating that as urban areas expand and develop, there is a greater use and disposal of plastic products, leading to increased amounts of plastic pollution. Urbanization is a significant and primary factor that contributes to the release of microplastics into the environment (Jahandari, 2023; Österlund et al., 2023). Studies have shown the rivers in urban areas have higher concentrations of microplastics compared to those in rural areas (Chen et al., 2022; Kunz et al., 2023; Zhang et al., 2024). According to Wardlaw et al., urban areas have higher concentrations of microplastics in fish than rural ones (Wardlaw et al., 2022).

Conclusion

This study found no significant difference in microplastic exposure through fish consumption among people living around the Mun River in Ubon Ratchathani Province, which is a major tributary of the Mekong River in northeast Thailand. However, urban residents experienced higher levels of microplastic exposure than rural residents. Hence, it is crucial for government entities such as the municipality, the Ministry of Public Health, and the Department of Natural Resources and Environment to collaborate in addressing and preventing these problems. We also recommend conducting a study on the classification, size, and risks of microplastics in specific categories within this region.

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Conflicts of Interest

The authors declared that they have no conflict of interest.

Authors' Contributions

Conceptualization, CL, LB, UI, PR, and NC; methodology, CL, UI, and LB software, CL and LB; validation, CL, LB, UI, PR, and NC; formal analysis, CL and LB; investigation, CL, LB, UI, PR, and NC; resources, CL, LB, UI, PR, and NC; data curation, CL, LB, UI, PR, and NC; writing-original draft preparation, CL and LB; writing-review and editing, CL, LB, UI, PR, and NC; visualization, CL, LB, UI, PR, and NC; supervision, PR; project administration, CL; funding acquisition, CL. All authors have read and agreed to the published version of the manuscript.

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Availability of Data and Material: Data from the corresponding author is available on reasonable request.

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