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# Characteristic study of microplastics distribution and response to human activities in nine highland lakes in Yunnan province

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***Abstract***---Nine highland lakes in Yunnan Province—Dian Lake, Erhai Lake, Fuxian Lake, Qilu Lake, Yilong Lake, Xingyun Lake, Yangzonghai Lake, Chenghai Lake, and Lugu Lake—were the principal objects of this study. To investigate the microplastic pollution patterns in highland lakes and to identify the most effective microplastic monitoring techniques, the distribution characteristics, abundance, and species of microplastics in the water bodies and sediments of nine highland lakes were scientifically sampled and analyzed in this study. To better understand the relationship between the level of economic development, the intensity of human activity and the level of governmental attention to environmental protection, the strength of the general public's environmental awareness, and the level of microplastic pollution in the Yunnan region, this study also looked into the areas surrounding nine highland lakes. To analyze and study the relationship between the distribution characteristics of microplastics in water bodies and sediments in the nine lakes and external natural conditions, additional external factors, such as geographic location and climatic conditions of the study area of the nine highland lakes, were collected and collated. This work seeks to provide some theoretical support for the successful prevention and control of microplastics in highland lakes by conducting the aforementioned research.

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***Keywords***---Nine highland lakes, microplastics pollution, Yunnan region, human activities, environmental pollution.

## Introduction

Yunnan Province is home to nine highland lakes, each of which plays an incredibly important part in a variety of the province's activities and functions. For instance, every highland lake in the region serves multiple purposes, such as climate management, water storage, flood control, agricultural irrigation, and habitat for the reproduction of aquatic flora and fauna, as well as providing opportunities for tourists to enjoy the environment (Wang etal. (2020)). As a consequence of this, the Nine Lakes Basin is currently one of the most populous, anthropogenically active, and economically developed regions in the province of Yunnan. As depicted in figure 1 the migration will depend on a variety of factors, including hydraulic and weather factors. Some MPs in the air may remain suspended, while others may be carried by the wind to new locations or settle through the dry or wet deposition. Some of them will eventually make their way into the oceans, where they will either settle at the ocean's bottom or be carried to new locations. For instance, wind can also carry larger MPs from inland or offshore environments to the ocean. Surface runoff has the potential to carry the plastic particles in the soil's top layer into freshwater rivers and ultimately the ocean (Yadav et al. (2020)). Additionally, certain MPs may enter groundwater through soil organisms before entering the ocean. On a different note, plastic particles in the marine ecosystem can travel through the food chain, floods, and high tides to the terrestrial environment. Standardizing sampling and analytical methodologies is needed to study the movement and worldwide dispersion of MPs contamination.

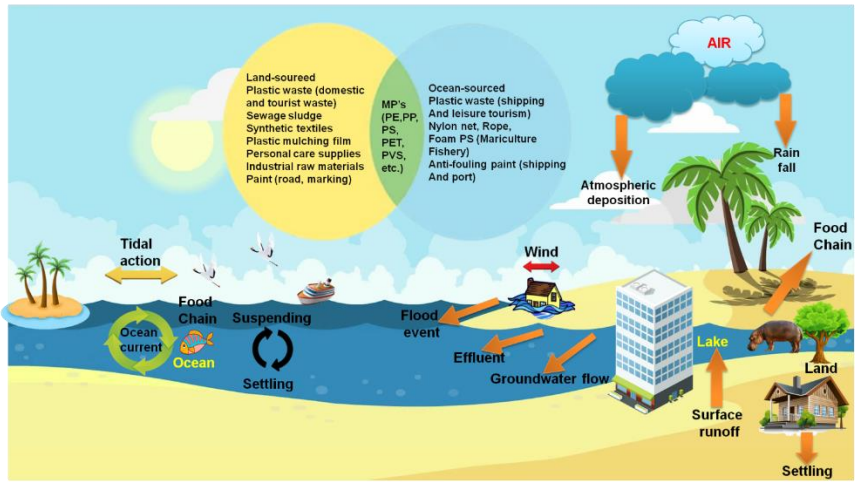


Figure 1. Plastics emigration contamination in the water, land, and air matrices

It is so abundantly obvious that the nine lake basins play a significant role in both the economic development and the social development of Yunnan Province. Therefore, the protection of water resources and the quality of the water

environment in the nine highland lake basins of Yunnan Province are especially important for the economic and social development of Yunnan Province (Ma et al. (2022)). This is because the nine highland lake basins contain a significant amount of water. At the moment, the water quality of all nine of Yunnan Province's highland lakes has remained relatively unchanged and has shown an upward trend from one year to the next. Despite this, the overall protection position is not looking particularly promising (Meaza et al. (2021)).

Especially in the past few years, with the express growth of the local nation and the increasing population, coupled with the fact that the highland lakes are closed semi-closed lakes, small catchment areas, evaporation, and water resources are very short, the lake storage capacity is poor, and the lake itself there is a huge stock of pollution, so the highland lakes in the basin are still facing many objective factors such as pollution sources, each lake around the lake interception (Berger et al. (2021)). The conservation and governance of Yunnan's nine highland lakes are risky. Clarification of the pollution status of the nine plateau lakes and the acquisition of the foundation necessary to offer an effective theoretical framework for the management of the nine plateau lakes in Yunnan are both goals that need to be accomplished. The remaining five sections of the paper are as follows: Segment 2, literature review, problem statement, significance, and objective of the study; Segment 3, the methodology used; Segment 4, the analysis methods; and Segment 5, the conclusion.

**Literature Review**

Since the 1970s, the issue of plastic pollution has drawn considerable attention. After weathering and mechanical wear, large pieces of plastic that are not recycled promptly after use may break down into tiny plastic pellets, or microplastics. Han Lihua (2020) used to research and analysis to demonstrate the enormous range of microplastics. Microplastics can be broadly categorized into four groups based on their exterior morphology: fragment type, particle type, fiber type, and film type. Microplastics can be roughly categorized into ethylene (PE), polyester (PEst), polyvinyl chloride (PVC), and so on based on the sorts of materials they are made of. The intricacy of the ecological risks posed by microplastics is additionally heightened by the variety of morphological traits and material types. Ya (2021) examined in 25 out of 28 water samples, MPs were found, however in very low abundance (584.82 particles m3). The most frequently seen shape was a fiber, the majority of the particle sizes were between 100 and 500 m, and polypropylene accounted for the majority of the MPs.

The primary sources of residential wastewater and tourism in some locations were identified through source analysis. Tian (2020) analyzed microplastics in terrestrial soil and their eco-toxicological impacts on soil ecosystems' physical and chemical features, nutrient cycling, flora, and fauna. Microplastics' impact on the surface microbial community of soil was explored. Yin (2021) examined the abundance, compositions, and fate of MPs in both water and soil media in a representative isolated area of the Tibetan Plateau in China. Pervez (2022) offered a useful illustration for tracing the history of beach sedimentation, which can aid in understanding the processes by which silt is deposited and transported over time on beaches. Ma (2022) used the pollutant tracer module Ecotracer in the

Ecopath modeling program, they used Baiyangdian Lake as an instance to create a simulation of the accumulating impact of MPs throughout the aquatic food webs (China). Zhang et al. (2020) demonstrated Low-Density Microplastic (LDMP) distributions and the primary influencing factors in farming soils were investigated using small- and large-scale field investigations, laboratory simulations, geostatistics, and conventional statistics.

**Problem statement**

The nine highland lakes all have varying levels of pollution. However, the nine highland lakes are currently being studied primarily for the presence of common contaminants like phosphorus and nitrogen. It is important to remember that MPs can act as a vector for some hydrophobic pollutants due to their large surface area and wettability. Persistent organic pollutants (POPs), and others may exacerbate the situation, along with other pollutions and harmful compounds found in living beings. While some progress has been made, it appears that China still has a long way to go before it can fully address the issue of plastic pollution, especially in rural areas. Worst of all, the proliferation of online shopping and meal delivery services are making plastic pollution worse. Nevertheless, given the circumstances, there has recently been a greater focus on plastic pollution, notably the pollution caused by MPs.

**Significance of the study**

- The industrial development of Yunnan's nine highland lakes and the lake economy's strategic position are essential to the province's economic development. Microplastic distribution and migratory paths in nine Yunnan highland lakes were analyzed using human and natural factors. Assessing microplastic pollution in highland lakes can help with water pollution and management. Lake Dian has had a few microplastic investigations, whereas other lakes have had fewer. This research can help analyze the link between regional economic development and lake pollution in Yunnan Province.
- Yuan Haiying (2021) found a link between microplastic pollution and eutrophication in Lake Dian. The other eight lakes have fewer data. Each lake and the external environment can support the management and remediation of highland lakes in China, which can further enrich the data on microplastic pollution in China's freshwater environment and provide a reference for microplastics pollution control in highland lakes.

**The objective of the study**

- Finding suitable microplastics monitoring mechanisms and examining pollution patterns of MP in the water bodies and sediments of the nine highland lakes is possible through scientific research on the distribution, abundance. This information can then be used to restore and treat the nine highland lakes.
- Research and surveys in the nine highland lakes region can explore the relationship between anthropogenic factors such as economic development, industrial patterns, the intensity of human activities, governmental attention to environmental protection, and microplastic pollution. This can

help in controlling anthropogenic pollution in lakes and reducing micro plastics in lakes.

- Data on external natural elements such as geographical location and climatic conditions of the nine highland lakes' regions were compiled to assess and examine the association between microplastic dispersion features in the water bodies and sediments and external natural conditions. This can provide theoretical support for analyzing lake pollution sources and a data basis for controlling and treating microplastic pollution in highland lakes.

**Methodology Used**

To analyze and study the relationship between the distribution characteristics of microplastics in water bodies and sediments in the nine lakes and external natural conditions, additional external factors, such as geographic location and climatic conditions of the study area of the nine highland lakes, were collected and collated. In this study, microplastics were identified by visual inspection. The methodology of this study was mainly based on the research protocol of Yin Lingshi (2020). In the experiments, the collected microplastics need to be separated from the water and sediment samples to be easily identified. Figure 2 indicates the methodology used in this research.

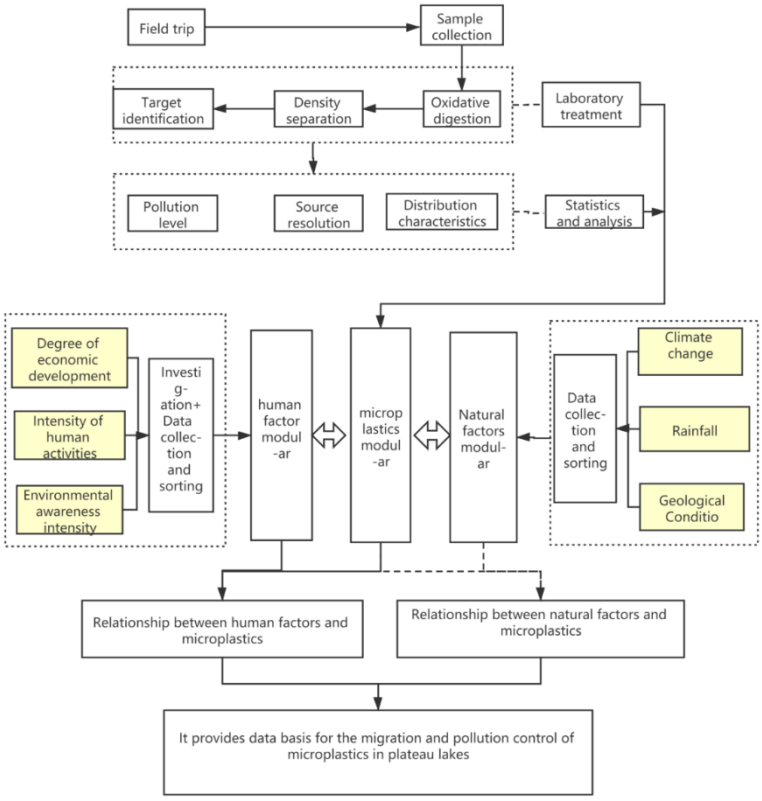


Figure 2. Methodology used

**Sample collection**

During the collection of surface water samples, a pre-cleaned pull sampler (KLL-S4, SEBA, USA) was used to gather 30 L of surface water (0–30 cm below the water's surface). At the sampling location, the gathered surface water must be filtered via a stainless steel screen with a 4S pore size. Using a wash bottle, the solids that were still on the screen's surface were discharged into a glass bottle with a 1L capacity. A 5% formalin solution was added as a preservative to each glass vial. Each sampling site yielded three parallel samples. To prevent cross-contamination, the sampler and sieve were cleaned with deionized water in between each sampling. A stainless steel engineer's shovel was used to gather 0–2 cm of sediment from the lake shore's surface layer to gather sediment samples. We averaged two samples from each lakeside location. The lake's sampling stations were above the water's surface, and they were only once collected. Each sampling site had five sediment samples taken from it, spaced 5–20 meters apart. The samples that were taken at each location weighed about 200 g. This indicates that each sampling station received about 1 kilogram of sediment samples. To ensure tight wrapping, sediment samples were each wrapped in pristine aluminum foil. All samples were to be labeled and sent out in separate sampling bags after the work at a sampling location was finished. All samples were immediately transported back to the lab for processing after being stored in a constant temperature sampling box at 5°C. It is best to prevent shaking and temperature changes during shipping.

**Materials used**

Instruments and devices: sampler, sample dispensing device (glass bottles, disposable dispensing bags), stainless steel sieve filtration, magnetic stirrer, dissecting electron microscope, scanning electron microscope. Pharmacological agents: 5% formalin solution, 30% hydrogen peroxide solution, ferrous sulfate, stroke-physiological saline solution (1.5g/cm3), zinc oxide solution (1.5g/$cm^3$).

**Laboratory treatment**

To facilitate easy identification in the studies, the collected microplastics must be isolated from the water and sediment samples. The separation of this sample was carried out with certain specific improvements by the aforementioned separation procedure, which was based on the microplastic separation method published by the National Oceanic and Atmospheric Administration (NOAA). When treating surface water sample crystals, a 30% hydrogen peroxide solution is used to destroy any visible organisms that could interfere with visual assessment. As a catalyst for the procedure, ferrous sulfate heptahydrate solution was used. When there were no visible organisms in the sample, the ablation was considered complete. To remove contaminants like soil that was incorporated into the sample; the microplastics were next separated by density using a zinc oxide solution with a density of 1.5 g/$cm^3$. The separation was carried out using a straightforward density separation apparatus: a glass funnel mounted on a wire stand. Under the glass funnel, a rubber hose with a long end clip was fastened. The supernatant was taken out after 48 hours of resting. The particles from the supernatant were transferred onto a glass fiber filter membrane with a 0.22 µm

pore size using a vacuum extraction apparatus. The larger, more pronounced contaminants, such as plant and animal corpses, were separated from the freeze-dried sediment samples. To prepare the sample, 50 g of dry sediment was weighed and put into a 1 L glass beaker that had already been cleaned. 400 mL of a ClCl solution (1.5 g/cm$^3$) was then added, and the mixture was agitated for 30 minutes to disseminate the material in a pooling form. The supernatant was removed after standing for 24 hours.

The subsequent procedures were carried out in the same manner as those for the surface water samples described in the preceding paragraph. Each filter membrane that was collected was put onto a clean Petri dish individually for inspection. The materials were magnified throughout the observation using a dissecting electron microscope. According to their surface features, all particles thought to be microplastics can be categorized. Each particle's size, shape, and color can be noted and categorized by particle size. Appropriate questions were created for an environmental awareness study of those living near the lake (environmental awareness, degree of knowledge about the lake, etc.). For each lake, at least 200 questionnaires were utilized to gather and arrange the pertinent policies created and activities done by the management on lake protection over the previous three years. Figure 3 indicates the distribution map of the nine highland lakes in Yunnan.

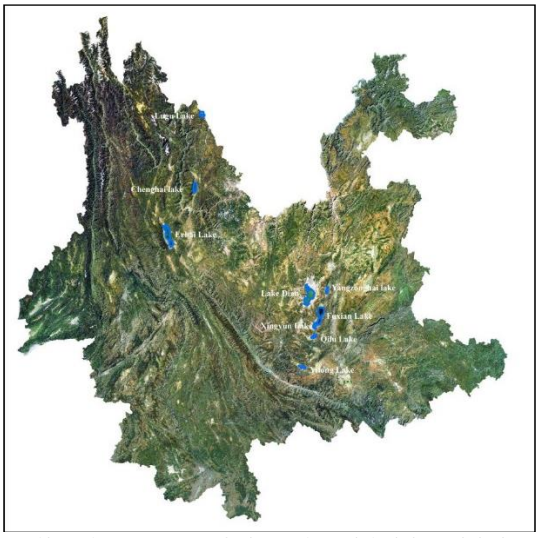


Figure 3. Distribution map of the nine highland lakes in Yunnan

**Analysis Methods**

In surface water samples, the number of microplastics was measured in items/m$^3$. The number of microplastics per kilogram in sediment samples was measured. To ascertain the significance of differences, one-way ANOVA, the Tamhane-Dunnett test, and the Student's t-test were utilized. These statistical evaluations were all carried out utilizing Origin 9.0 and SPSS 22.0. ArcGIS 10.3 software was used to make geographic location maps (sample point location maps). We analyze the Gantt chart of the individual research proposal, Analyses

are done on the microplastic distribution characteristics and abundance in Yunnan's nine plateau lakes, the richness of the microplastics in altitude, and annual rainfall. A Gantt chart is a type of bar chart used to illustrate the tasks, deadlines, and durations of a project. As the project progresses, the bars in the chart will be coloured to reflect the status of their respective tasks. Figure 4 depicts the Gantt chart of the individual research proposal.

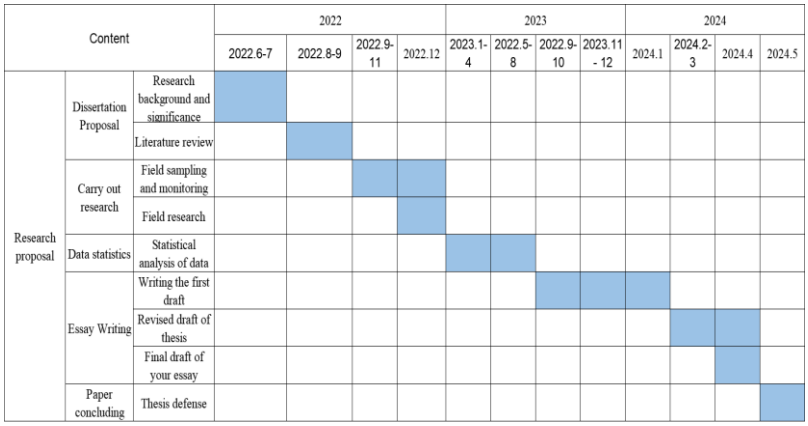


Figure 4. Gantt chart of Individual Research Proposal

The distribution characteristics of microplastics in the nine plateau lakes in Yunnan are analyzed in figure 5. The distribution characteristics of microplastics are lower in the center of the lake and higher in concentration around the lake. Figure 6 analyses the richness of microplastics in the nine plateau lakes in Yunnan. The richness of microplastics is higher around the lake and lower in the lake's center. The pollution pattern shown by the distribution characteristics and richness of microplastics in Yunnan's nine plateau lakes was a low concentration of microplastics in the middle of the lake and a high concentration of microplastics around the lake;

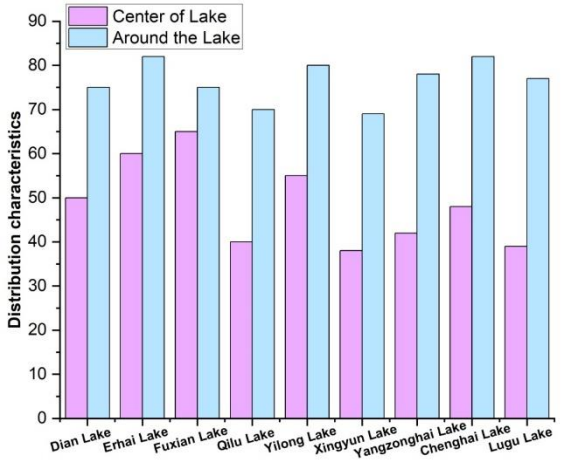

Figure 5. Distribution characteristics of microplastics

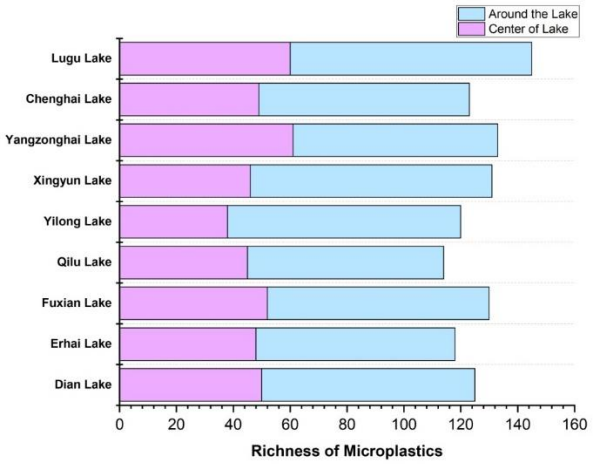


Figure 6. Richness of microplastics

Altitude and richness of microplastics in Yunnan province as shown in figure 7. When it comes to Yunnan's nine plateau lakes, the level of richness and the number of different forms of microplastics increases along with both the altitude and the amount of yearly precipitation. Annual rainfalls of microplastics in Yunnan province are illustrated in figure 8.

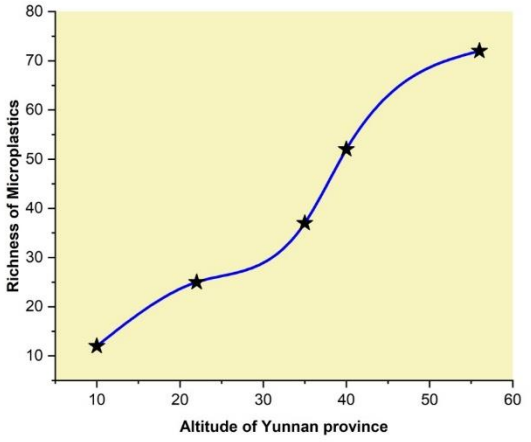


Figure 7. Altitude and richness of microplastics in Yunnan province

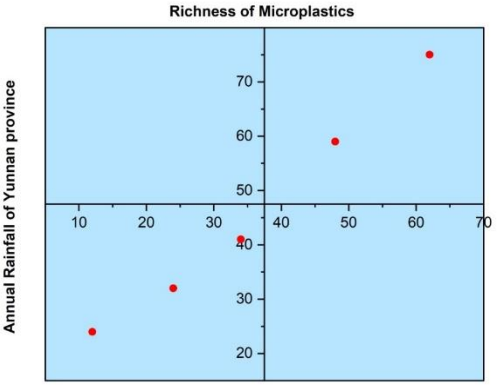


Figure 8. Annual rainfall richness of microplastics in Yunnan province

**Conclusion**

The purpose of this study was to scientifically sample and analyse the distribution characteristics, richness, and species of microplastic particles in the bodies of water and sediments of nine highland lakes to investigate the microplastic pollution patterns in highland lakes and to identify the most effective microplastic monitoring techniques. The number of microplastics in surface water samples was calculated in items/$m^3$. Measurements were made of the number of microplastics per kilogram in sediment samples. The number of microplastic particles per kilogram in sediment samples was measured. To assess the importance of differences, one-way ANOVA, the Tamhane-Dunnett test, and the Student's t-test were utilized. SPSS 22.0 and Origin 9.0 were used for all of these statistical studies. The distribution and richness of microplastics in Yunnan's nine plateau lakes showed low concentration in the lake's centre and high concentration around it.

The nine plateau lakes in Yunnan have more microplastics and are richer in altitude and annual rainfall. Several scientific challenges remain, including the lack of a comprehensive and detailed global MP distribution, the lack of standardized sampling techniques and methods for rapid and accurate MP determination (such as digestion, flotation, and identification), the absence of theories and models of MP distribution and transportation at a wider region, and the absence of ecotoxicological effects at the individual, population, or ecosystem level. Finally, resolving MPs' ecological concerns should be a coordinated, cross-institutional effort. The significant and long-lasting linkages between plastics and human development mean that MP pollution will continue to exist despite efforts from important sectors including academic institutions, multi-level government, the media, and NOGs (Non-Governmental Organizations) in China. Even if all usage of plastics were to be ceased worldwide over the next ten years, and substitutes seemed to be found shortly after, the consequences on the environment and human health would continue.

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