Mercury Accumulation in Terrestrial Food Chains of the Liaohe Estuary Wetlands

yuqi wang (976883736@qq.com)
Shenyang University https://orcid.org/0000-0002-9995-4319
Zheng Dongmei
Shenyang University
Ma Huanchi
Shenyang University
Li Huiying
Shenyang University
Wang Bing
Shenyang University

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Abstract

Mercury is a global pollutant that can accumulate in organisms and endanger human health. This paper studied the soil, plants and animals in the light beach, Suaeda wing wetland, reed wetland and rice field in the Liaohe Estuary in 2018 and 2019, and determined the stable carbon and nitrogen isotopes of animals and plants to construct the food chain. The results show that from 2018 to 2019, the accumulation of mercury in the soil of the light beach, Suaeda winged wetland and reed wetland of the Liaohe Estuary continued to increase, but the accumulation of mercury in paddy soil showed a decreasing trend; the mercury content in plant samples also showed a certain degree There is a positive correlation between the accumulation of mercury in the food chain and the construction of trophic levels in the food chain. Mercury can carry out efficient biomagnification and bioaccumulation through the food chain.

1 Introduction

Mercury (Hg) is a global pollutant that can circulate globally in a variety of ways, including through biotic transport and atmospheric circulation (Hao, 2015). It has been shown that Hg monomers reach the Arctic through the global atmospheric circulation, settle to the ground and are absorbed by plants before entering the soil and then eventually entering the Arctic Ocean via rivers, causing harm to animals such as fish (Wang and Feng, 2020). When mercury enters the environment, its location is not fixed, but rather it is diluted and diffused, transported and transformed between various environmental media (Fang and Wang, 2002). Mercury is one of the most harmful elements, especially in its organic form (José, et al., 2021). Because of its high affinity for proteins, mercury is retained in tissues (Bloom, 1992) and is therefore highly bioaccumulative in living organisms. Wetland ecosystems are "active reservoirs" and "sinks" for mercury (Lindqvist, 1991), and wetlands are rich in soluble carbon and humic acids that can form complexes with mercury and can absorb mercury from both natural sources and anthropogenic emissions, while microorganisms in the sediment (sulfate reducing bacteria, methanogenic bacteria, iron-reducing bacteria, *etc.*) can convert inorganic mercury into methylmercury (Xu and He, 2019) which can biomagnify along with the food web from plankton to top predators(José, et al., 2021; Coelho, et al., 2013; Larissa-A, et al., 2006) . The increasing prominence of environmental problems caused by mercury and mercury compounds has contributed to the growing problem of mercury pollution in the environment.

Stable isotope enrichment indices for nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) provide proxies for consumers' trophic levels and carbon sources (or habitats), respectively (Stowasser, et al., 2011).^{15}N is enriched consistently across tissues in the food web, with an average increase of 3.4‰ per trophic level (Masao and Eitaro, 1984).^{13}C is less enriched (on average 1‰ higher per trophic level), but it provides a useful indicator of feeding habitat (Seco, et al., 2021). Several studies have shown that nitrogen isotopes are enriched between adjacent trophic levels. Stable nitrogen isotope ratios can be used to explain trophic relationships between animals, describe trophic levels, and establish trophic levels in food webs (Zheng ,et al., 2018).

The Liaohe Delta marsh area is located in the south of Liaoning Province and on the north coast of Liaodong Bay. It is a low plain formed by the alluvial siltation of rivers entering the sea,and is the main distribution area of coastal marsh wetlands. The study area is located in Panjin City, with a geographical location of 40°39'-41°27'N and 121°25'-123°31'E (Liu et al., 2018). The area's climate is a mid-latitude warm temperate

continental semi-humid and semi-arid monsoon climate with a maritime climate. The winter and spring are relatively cold and dry, while the summer and autumn are hot and rainy (Zheng et al., 2009). Therefore, this study provides a scientific basis for controlling mercury pollution in estuarine wetlands with the transfer of mercury and methylmercury from soils, plants and animals in different locations and types of wetlands in the Liaohe estuary.

2 Materials And Methods

2.1 Sample collection

Soil and biological samples in this study were collected in August 2018 and August 2019 from a total of nine sites in the Liaohe estuary with different types of wetlands: Beigang reed wetland S1, Beinanjingzi rice field S2, Penjialing winged alkali pong wetland S3C, Guangtan S3G, Dongguozhen reed wetland S4, Huanyi rice field S5D, reed wetland S5L, Sandaogou winged alkali pong wetland S6C, Guangtan S6G Soil samples were taken from winged alkaline pine soils, light beach soils, paddy soils and reed soils. The soil samples were mixed with the same type of soil and at the same depth at each sampling site. The soil samples were removed from the soil by removing stones, plant residues and, animal remains. The plant samples were mainly reed (Phragmites communis), rice (Suaeda salsa (L.) Pall.) and,winged alkali puff (Oryza sativa L.). The plant samples were processed according to the different types of plants at each sampling site, washed with distilled water, sorted into different plant types and parts of the same species and, dried naturally, pulverized with a grinder, sieved through 60 mesh and,stored in sealed bags. Animal samples were taken from ants (Pheidole megacephala), spiders (*Araneida*), *etc*. The samples were placed in sealed plastic bags and a 5% solution of formaldehyde and, 95% ethanol was added. The samples were dried naturally according to the area; some with too much moisture needed to be dried at low temperature, ground in a glass mortar and, the soft parts of animals containing hard shells were taken for sample processing; animals that were too large could be processed for part decomposition.

2.2 Determination of stable isotopes

Soil samples are measured at around 0.1 to 0.5mg and, biological samples at around 0.5 to 1mg and, the final mass are weighed for recording.

The isotopes were determined using the MAT235 isotope determination instrument. The standards for stable carbon isotopes in this study were based on the PDB national standard with the following equation shown below.

$$\delta^{15}N = \left(\frac{^{15}N/^{14}N_{sample}}{^{15}N/^{14}N_{atmosphere}} - 1 \right) \times 1000 \quad (1)$$

$$\delta^{13}C = \left(\frac{^{13}N/^{12}N_{sample}}{^{13}N/^{12}N_{PDB}} - 1 \right) \times 1000 \quad (2)$$

In equation (1), $^{15}N/^{14}N_{atmosphere}$ is the standard atmospheric nitrogen isotope ratio, and in equation (2), the carbon isotope ratio of $^{13}C/^{12}C_{PDB}$ (Peedee Belemnite carbonated) (Liu, 2018). The results are expressed as $\delta^{13}C‰$ and $\delta^{15}N‰$, which are guaranteed to have an analytical precision of $\delta^{13}C‰ < 0.2‰$ and $\delta^{15}N‰ < 0.3‰$.

During the determination of the instrument regarding the analytical quality, whether the standards are controlled and calibrated with blank reagents, parallel sample settings and, standard samples of isotopes (Urea, IAEA-USGS40 and, IAEA-USGS62). It is ensured that the linear regression coefficient of the standard working curve R⩾0.9984, the recovery of the standard sample determination results ([measured value/standard reference value] × 100%) is 90% to 110%. The relative deviation of the parallel samples should be less than 10% when the determination results are more accurate (Jiang, 2005).

2.3 Determination of mercury

All collected samples were treated by the HNO_3-H_2SO_4-V_2O_5 digestion method (Liu et al., 2007). The content of Hg in the samples was determined using an AFS-8500 atomic fluorescence photometer with an instrumental minimum detection limit value of 0.001 μg/L. During the experiments, the sample treatments should be set up as parallel samples, with all relative standard deviations less than 4%. Two reagent blanks were made in each batch for sample processing and, the national standard sample GBW-07407 Hg (0.061±0.006) mg/kg was used for quality control (Jin et al., 2015). The measured mass content of the national quality standard position of Hg was (0.059±0.001) mg/kg, which was by the valid data of the mass range of the standard national substance of Hg. The nitric acid and sulphuric acid reagents used in the experiments were of superior purity.

2.4 Data processing plants

All data processing in this study was done using WPS 2020 statistical software.

3 Results And Discussion

3.1 Plant and animal isotopes

3.1.1 Plant carbon and nitrogen isotopes

The dominant plant types in this study area were reed, rice, and winged alkali canopy. The carbon and nitrogen isotopes of the dominant plants in each region for 2018 and 2019 were compared as shown in Table 1.

Table 1

Carbon and nitrogen isotope content of plants at each sampling site‰

Sampling sites	$\delta^{13}C$	$\delta^{15}N$
S_1	-5.98 to -26.87	4.30 to 5.24
S_{2S}	-29.80 to -32.02	3.76 to 11.68
S_{2L}	-7.82 to -31.22	-5.76 to 4.88
S_{3C}	-5.84 to -29.09	4.07 to 7.73
S_{4L}	-5.74 to -26.07	0.63 to 5.15
S_{5S}	-7.87 to -27.41	-1.52 to 2.98
S_{5L}	-3.96 to -23.41	-0.87 to 3.72
S_{6C}	-5.28 to -26.17	is 2.69 to 4.21
S_{7S}	-7.84 to -27.78	-1.10~1.77
S_{7L}	-6.00 to -28.31	-2.46 to 6.21
S_8	-25.68 to -7.04	3-2.44 to 5.09
S_{9S}	-7.88 to -26.22	-2.64 to 6.16
S_{9L}	-3.28 to -22.51	-3.77 to 5.96

With the expansion of plant classification studies now being carried out on the different carbon contents of plants, plants are mainly divided into two categories, C3 and C4, with the difference between C3 and C4 being -25 to -35‰ for C3 plants and -10 to -17‰ for C4 plants due to the ratio of stable isotopes ($\delta^{13}C$) (Zhang, 2019). The shows that the plants in our study area are mainly C3 plant types. Different comparisons show that the stable isotope ratios of carbon and nitrogen in the plants in the sampling area, except for the winged alkali ponies, are on an increasing trend in the last two years.However, the ratios of stable carbon isotopes are less variable and, the ratios of stable nitrogen isotopes are more variable in Bei Nan Jingzi. This suggests that the carbon and nitrogen content of the environment affects the carbon and nitrogen content of the organisms.

3.1.2 Animal carbon and nitrogen isotopes

Only organisms from six of the nine sampling sites were collected because some sites did not have sufficient biomass, and the species and carbon and stable nitrogen isotopes in each site are shown in Tables 2 and 3. The range of stable carbon isotopes for different organisms in different environments can be seen in the tables.

Table 2

Carbon and nitrogen isotope content of animals at each sampling site‰

Sampling sites	$\delta^{13}C$	$\delta^{15}N$
S_1	-16.194 to -27.827	4.626 to 8.769
S_3	-11.212 to -21.464	3.976 to 7.414
S_4	-12.909 to -27.797	4.254 to 8.718
S_6	-11.317 to -25.816	4.33 to 9.665
S_7	-15.086 to -32.503	4.171 to 8.417
S_9	-10.569 to -31.073	3.783 to 9.017

Table 3

Stable isotope ratios (‰) of biogenic carbon and nitrogen at different sampling sites

Sampling sites	Species of organisms	$\delta^{13}C$	$\delta^{15}N$
S_1	Fleshworms	-27.827	4.626
	Ants	-16.194	5.506
	Spiders	-20.213	8.796
S_3	Moth	-27.797	4.254
	Leaf A	-12.909	4.785
	Mosquitoes	-26.489	5.225
	Ants	-24.716	5.203
	Spiders	-24.231	8.718
S_4	Mosquitoes	-25.816	5.35
	Spiders	-22.934	9.09
S_6	Flat Hook	-15.086	4.221
	Mosquitoes	-22.594	4.171
	Ants	-20.083	4.484
	Spiders	-27.245	8.417
S_7	Ants	-14.790	5.712
	Spiders	-20.457	9.017

The analysis of the carbon and nitrogen stable isotopes of animals in the food chain shows some differences in the carbon and nitrogen stable isotopes of the same species in different environments. However, there is no positive or negative correlation between the two.

3.1.3 Construction of the food chain in the study area.

It has been shown that the value of $\delta^{13}C$ in consumers reflects the $\delta^{13}C$ in the food they consume, with the difference between the two ranging from 0 to 1‰. Therefore, $\delta^{13}C$ is often used to analyze the food sources of consumers in ecosystems. However, the main plants in this study area are C4 plant types. The construction of food chains in animals not only involves understanding the source of consumers but also finding benchmarks for calculating trophic levels in the construction of food chains in different environments, which can have an impact on the construction of the whole food chain if they are not chosen properly (Chen, 2014) Benchmarks are primarily selected for their perennial occurrence in the system environment and for their relatively stable food source, which is thus relatively slow to respond to environmental change (Xu et al., 2010). Another influencing factor for the construction of food chains is the nitrogen stable isotope enrichment factor ($\Delta\delta^{15}N$). As can be seen from Table 3, the variation of $\delta^{15}N$ in animals ranged from -0.221 to 10.310‰, with a smaller variation compared to $\delta^{13}C$, indicating a more pronounced enrichment of $\delta^{15}N$ in the food chain. Some studies have shown that variability in $\Delta\delta^{15}N$ is higher in herbivores than in carnivores (Cabana and Rasmussen, 1996).

Therefore, to reduce the variability of $\Delta\delta^{15}N$ between producers and primary consumers due to differences in nature, crustaceans or some lower herbivores should be selected as the baseline organism and, 3.4‰ should be chosen as the value of $\Delta\delta^{15}N$ (D, J et al., 2006). Thus, by measuring the $\delta^{15}N$ of animal tissues, it is possible to derive the position of the trophic level at which the animal is located and thus to construct food chains in different environments. The equation used was.

$$TL = \left(\delta^{15}N_{consumer} - \delta^{15}N_{rate}\right) / \Delta\delta^{15}N + \lambda \quad (3)$$

(3) where: $\delta^{15}N$ ratio is the nitrogen stable isotope ratio for primary producers or primary consumers in the ecosystem (when λ = 1, the ratio is for primary producers, while when λ = 2, the δ15N ratio is for primary producers), and when the consumer trophic level is greater than 2, the trophic level is generally a non-integer value, meaning that the consumer's food sources are multiple trophic levels (Liu, 2018).

Table 4

Relative trophic position of each organism at different sampling sites

Sampling sites	Species of organisms	N enrichment factor	Trophic level position
S_1	Fleshworms	0.882	0.818
	Ants	1.050	1.259
	Spiders	1.672	3.960
S_3	Moth	0.826	0.736
	Leaf A	0.929	0.892
	Mosquitoes	1.014	1.022
	Ants	1.010	1.015
	Spiders	1.692	2.034
S_4	Mosquitoes	5.36	1.381
	Spiders	2.243	3.100
S_6	Flat Hook	0.830	0.746
	Mosquitoes	0.820	0.731
	Ants	0.882	0.823
	Spiders	1.655	3.157
S_7	Ants	0.949	0.909
	Spiders	1.498	2.972

3.2 Changes in mercury content in the soil

The variation of Hg content in different types of wetland soils are as follows: S_1 variation range, 0.087-0.175mg/kg; S_2 variation range, 0.035-0.197mg/kg; S_3 variation range, 0.089-0.249mg/kg; S_4 variation

rang$_{e,}$ 0.050-0.167mg/kg; S_5 variation range, 0.024-0 The variation of mercury content in the nine sampling points is shown in Figure 1.

There is an increasing trend of Hg in the soils of sample sites S_1, S_2, S_3, S_4 and S6; a decreasing trend of Hg in the soils of sample sites S_5, S_7 and $S_{8;}$ and a decreasing trend of Hg in the surface soils and an increasing trend of Hg in the subsoil of the paddy fields of $S_{9.}$ The sites with increased soil mercury levels in the area include areas of agricultural land and therefore present a potential threat to human health.

3.3 Plant and animal mercury levels

3.3.1 Plant mercury content

The main nutrients in the food chain come from the producers. Therefore the amount of Hg accumulated by producers in each area affects the accumulation of Hg in other components of the food chain. Producers in the area included reed, rice and winged alkali puff. The variation in producer Hg levels at the nine sampling sites was as follows: S_1 ranged from 0.019 to 0.242 mg/kg; S_2 ranged from 0.019 to 0.161 mg/kg; S_3 ranged from 0.025 to 0.142 mg/kg; S_4 ranged from 0.010 to 0.120 mg/kg; S_5 ranged from 0.015 to The variation of Hg content in each part of the different types of plants at the nine sampling sites are shown in Figure 2 and Figure 3.

As can be seen in Figures 2 and 3, the mercury content of producers in the area showed an increasing trend from 2018 to 2019.The mercury accumulation content of different parts of the plant was: high accumulation of mercury in roots and leaves and low accumulation of mercury in stems.However there was no pattern in the accumulation of mercury in roots and leaves. Studies have shown that the roots of wetland plants are their main organ for mercury uptake from habitats. The mercury absorbed by roots from water bodies and sediments can be relocated between organs (Liu et al.,2004). Total mercury mainly comes from sediment and, after entering the cortical tissue of roots, can bind to proteins, polysaccharides and nucleic acids in the roots to form stable macromolecular complexes and insoluble organic macromolecules, which are deposited in the cell walls and organelles of the roots.At the same time the stems of the plants mainly play a transport role (Zeng, 2017). Lu Jing found that mercury in the soil can be taken up by plants through the root system and that mercury in the atmosphere and dust can be taken up by plant leaves, but plants still mainly take up mercury from the atmosphere. The uptake, enrichment and transformation of mercury by plants are more related to the species of plants themselves, their growth age, in addition to the influence of environmental factors such as soil and atmosphere (Li and Huang, 2009).

3.3.2. Mercury levels in animals

The accumulation of Hg in the food chain at the nine sampling sites was as follows: S_1 Hg$_{.}$ 0.061-0.355mg/kg; S_4 Hg: 0.051-0.230mg/kg; S_6 H_g: 0.057-0.499mg/kg; S_7 Hg: 0.102-0.195mg/kg; S_9 Hg: 0.086-0.189mg/kg. The accumulation of Hg in the food chain is shown in Figures (4~8).

Combined with the analysis in Figures (4 to 8), the accumulation of mercury in the food chain increases with increasing trophic levels, and the two are positively correlated. Moreover, the producers will have higher levels of heavy metals than the primary consumers due to their small size and limited food intake and accumulation of heavy metals.

3.4 Accumulation of mercury in the food chain

The transport of mercury in plant-ant and organic matter-sandworm systems was investigated by calculating the bioconcentration factor (BCF) in the corresponding systems by studying the transport of mercury in plant-ant and organic matter-sandworm systems.The BCF was defined as

BCF = animal (predator) heavy metal content / plant (producer) heavy metal content

The relationship between producers and primary consumers in each food chain (Table 5). Analysis of the enrichment coefficients for mercury from food sources by the more diverse primary consumers in the different areas shows that ants in S_1, ants in S_4 and mosquitoes in S_7 have a higher capacity for mercury accumulation. Terrestrial animals are mainly reed-based as their main food source.However thees in S_3 and S_6 may be dominated by plants and organic matter in water but may also be influenced by the mercury content of the soil in the area. In the case of ants, for example, the highest enrichment factor was found in S_1, followed by S_4. Both sites had an enrichment factor of nearly 1, but the plant mercury levels were not the highest at these two sites. It has been suggested that when ants do not have significant amounts of mercury in their food sources, these elevated concentrations may be related to their direct contact between the cuticle and dredged sediment during the larval cycle when the epidermis is in contact with the soil for too long and mercury from the soil can enter the epidermis by absorption or passive diffusion (Zhang et al., 2012). The life stages of insects play an important role transferring mercury from aquatic to terrestrial ecosystems (Martin-Creuzburg et al., 2017). Indeed, aquatic insects such as shaker mosquitoes or dragonflies migrate to terrestrial biota and can act as both prey and biological carriers of contaminants to local terrestrial consumers, including ants or spiders (Loïc et al., 2019). Exposure of terrestrial insects is therefore linked to the proximity of aquatic physical and chemical factors (e.g., dissolved organic carbon, amount of aqueous nutrients) in these systems (Ramsa et al., 2016). For strictly terrestrial habitats, factors such as insect habitat may influence mercury accumulation in terrestrial insects (Li and Huang, 2009; Cruz et al., 2015).

The transport of mercury from phytophagous insects to carnivorous insects in the food chain at different sampling sites is based on the enrichment coefficients between animals (Table 4): the enrichment coefficients of the higher consumers in different areas differ, on the one hand, because of the different types of food sources, and on the other hand, because of the different accumulation of heavy metals by phytophagous animals. In the case of spiders, for example, the highest enrichment factor was 8.686 for S_6 spiders, followed by an overall high enrichment factor of 4.477 for S_6 spiders; all others were below 3. Chan found that although invertebrates have slightly lower levels of mercury than songbirds, long-term exposure may also affect their health and population size, as methylmercury can bioaccumulate at any time. The bioaccumulation of mercury in invertebrates, especially spiders, is another important issue because of their trophic position and importance in the food chain (Chan et al., 2021). Yung et al. found that insects in direct contact with terrestrial or

submerged sediments (e.g. Aedes and Aedes) constituted the main source of entry for mercury in the terrestrial nettle-insect food web. These insects may constitute direct food for higher trophic levels (birds, mammals) or polyphagous predatory insects. The latter is likely to play a role in exporting large amounts of mercury at high trophic levels and to be another major carrier of mercury transfer, as recently demonstrated in temperate forest environments (Loïc et al., 2019).

Table 5

Enrichment factors for each trophic level in the food chain

Sample Points	Type of organism	Hg (mg/kg)	Enrichment factor (primary consumers/producers)	Enrichment factor (consumer/primary consumer)
S_1	Producers	0.138		
	Ants (Primary consumers)	0.134	0.970	2.657
	Spider (consumer)	0.355		
S_3	Producers	0.198	0.643	
	Sandworms (primary consumers) (*Nereis succinea*)	0.127		
S_4	Plant leaves	0.089		
	Moth (primary consumer)	0.052	0.580	4.434
	Leaf A (Primary Consumer)	0.051	0.575	4.477
	Mosquitoes (primary consumers)	0.060	0.675	3.811
	Ants (Primary consumers)	0.086	0.968	2..660
	Spider (consumer)	0.230		
S_6	Producers	0.064		
	Mosquitoes (primary consumers)	0.057	0.931	8.686
	Spider (consumer)	0.499		
S_7	Plants	0.14		
	Flattened Gully (Primary consumers)	0.119	0.850	0.164
	Mosquitoes (primary consumers)	0.128	0.916	1.523
	Ants (Primary consumers)	0.102	0.730	1.911
	Spider (consumer)	0.195		
S_9	Plants	0.109		
	Ants (Primary consumers)	0.086	0.790	2.186
	Spider (consumer)	0.189		

4 Conclusion

Accumulation of Hg from producers to consumers of the food chain by measuring carbon and nitrogen isotopes from soils, plants and animals in different estuarine wetlands.

(1) The carbon and nitrogen isotopes of the plants were measured and showed that most of the plants in the sampling area were on an increasing trend in carbon and nitrogen stable isotopes in the last two years. However the change in carbon was smaller and the change in nitrogen was larger in Bei Nan Jing Zi. In particular, the carbon and nitrogen stable isotopes of the winged alkali ponies at two sites, Penjia Ling and Sandao Gou, were on a decreasing trend in the last two years.

(2) Certain constructions of food chains were made following the determination of animal stable isotopes: S_1 food chain: plants < carnivorous insects < ants < spiders; S_4 food chain: plants < moths, leaf beetles (crustaceans), mosquitoes, ants < spiders; S_6 food chain: plants < mosquitoes < spiders; S_7 food chain: plants < flattened hooks, mosquitoes, ants < spiders; S_9 food chain: plants < ants < spiders.

(3) The level of Hg in the soil at most sampling sites in the Liaohe estuary increased incrementally from 2018 to 2019. However there was a decreasing trend in the accumulation of Hg in the soil in the Huan Yi, Shuguang Bridge, and Xinsheng Street areas.

(4) Plant samples from 2018 and 2019 also showed an increasing trend in Hg, with the most significant increases being in rice from Huan Yi and Aurora Bridge.

(5) The ability of consumers in the food chain to accumulate mercury from food sources varies, and the accumulation of dietary mercury by the same organism varies from region to region.

(6) The accumulation of heavy metals in the food chain is positively correlated with the construction of trophic levels in the food chain, but the levels of mercury in organisms at the same trophic level also vary somewhat depending on their food habits.

Declarations

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Code availability:

WPS2020

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Figures

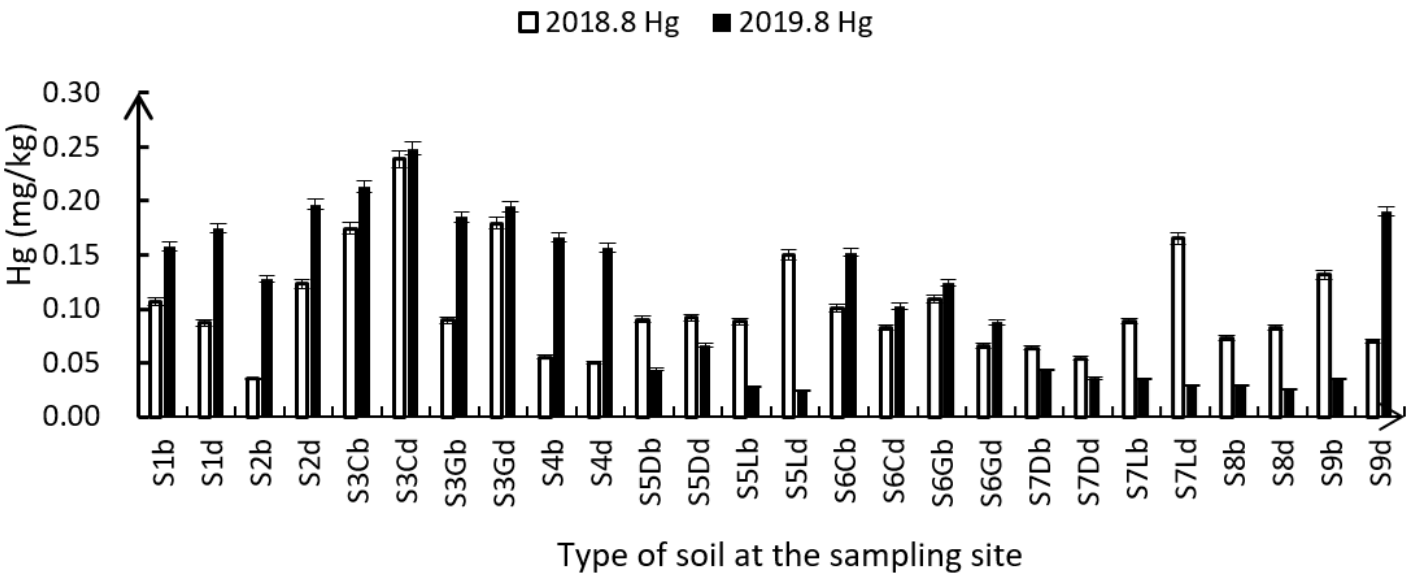

Figure 1

Levels of Hg in different soils at sampling sites in August 2018 and August 2019 (b for surface, d for substrate)

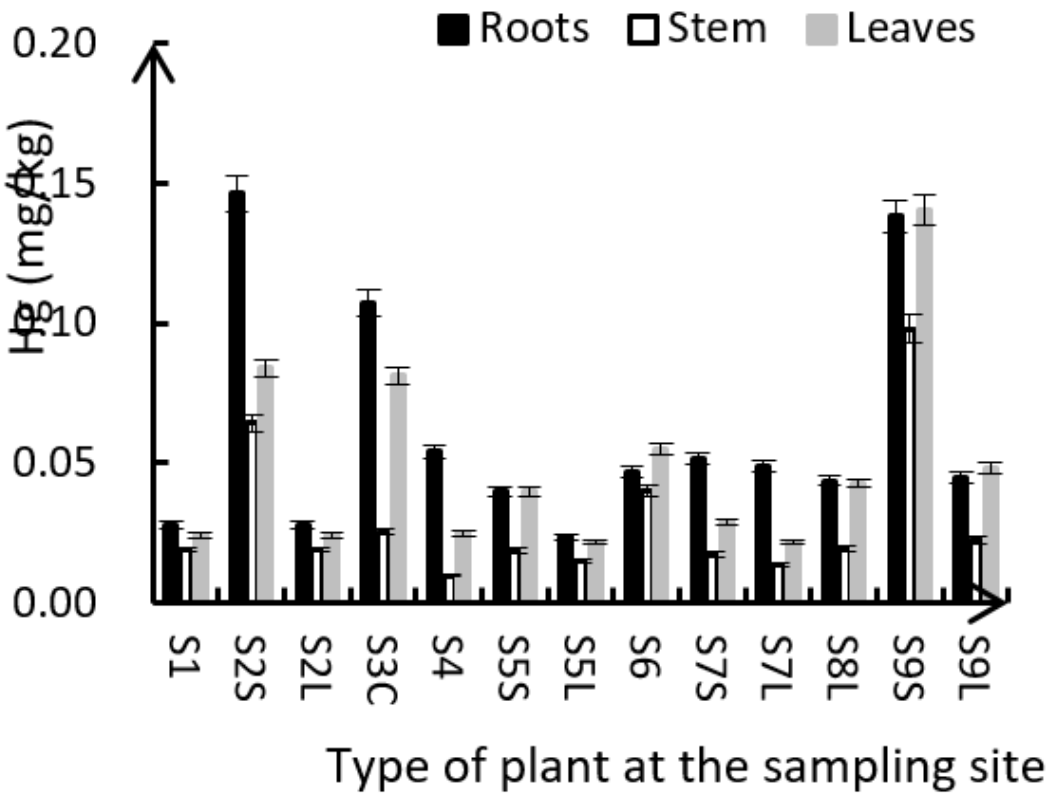

Figure 2

Levels of Hg in different plant types at the 2018 sampling sites

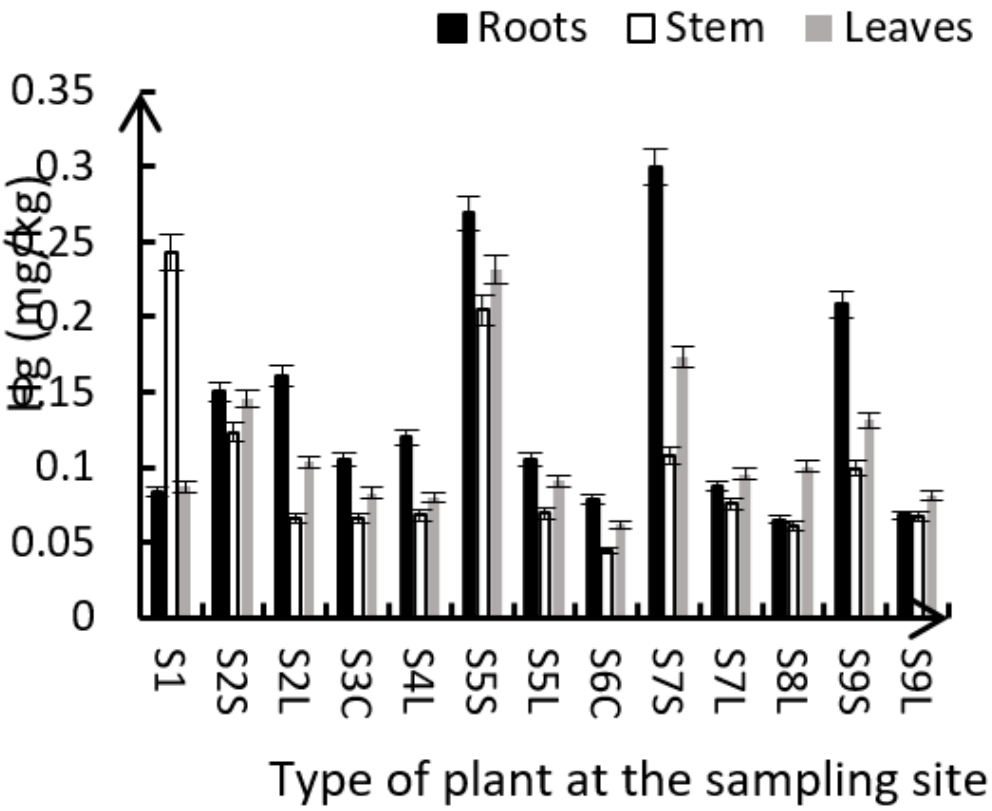

Figure 3

Levels of Hg in different plant types at the 2019 sampling sites

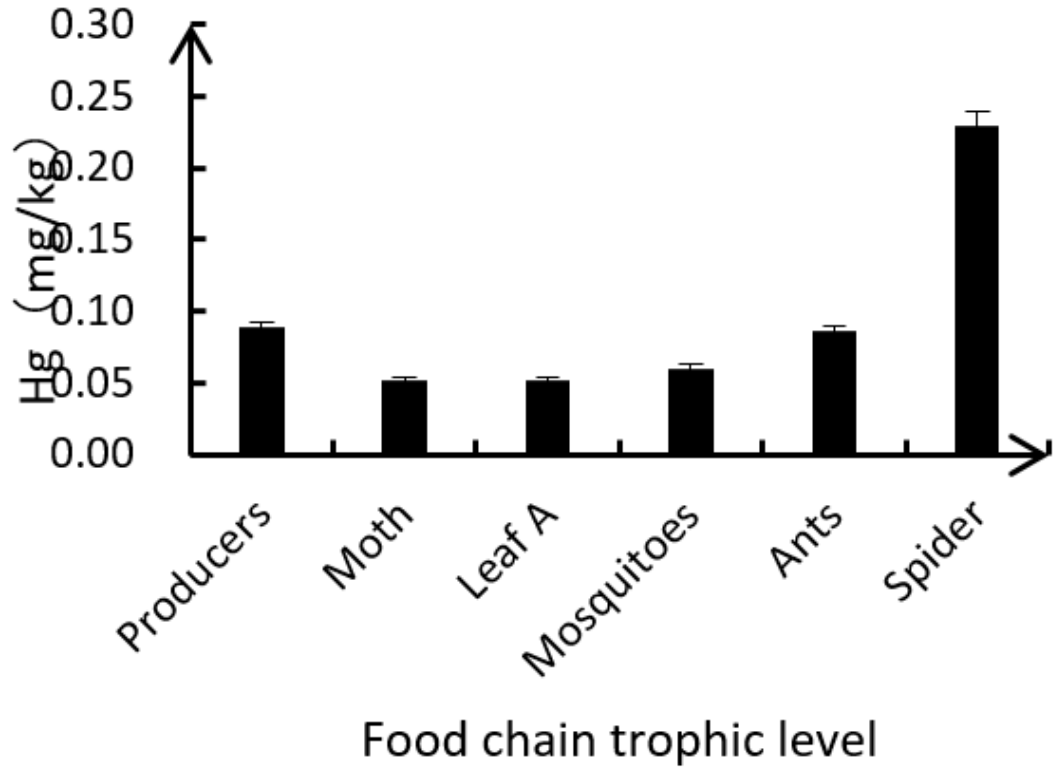

Figure 4

Accumulation of Hg in the terrestrial food chain of S1

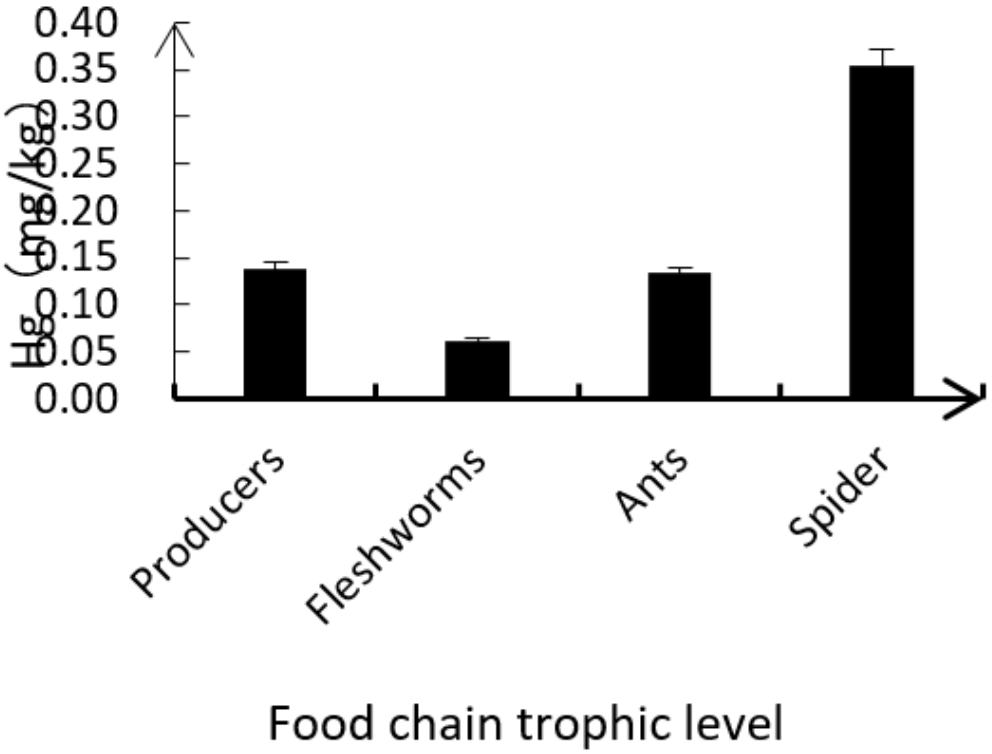

Figure 5

Accumulation of Hg in the terrestrial food chain of S4

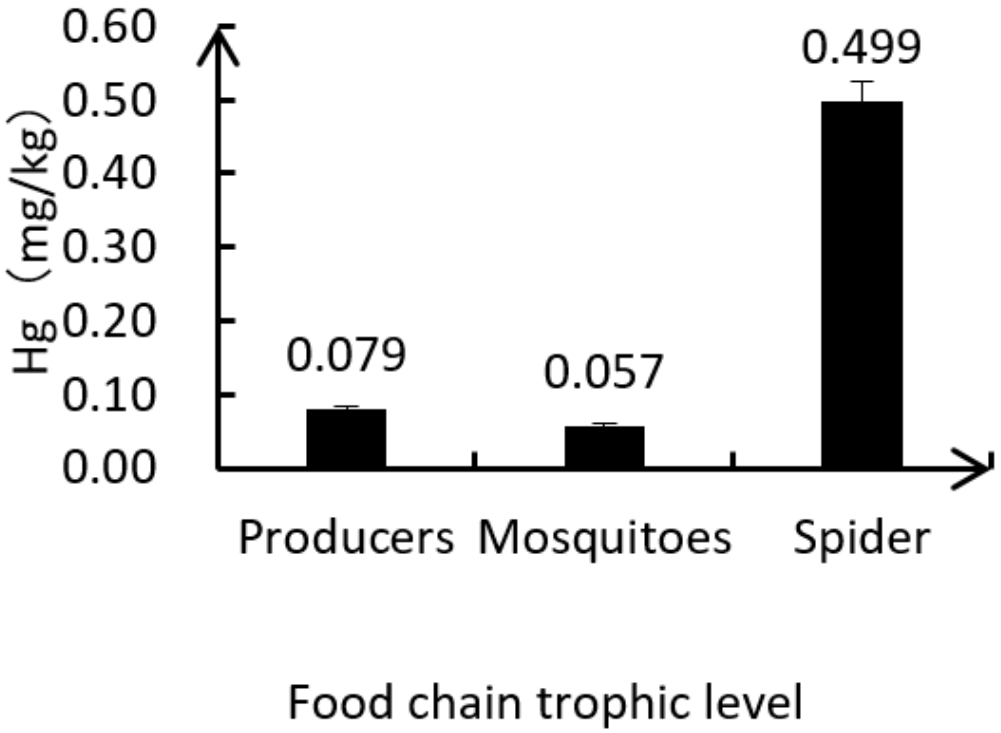

Figure 6

S6 Accumulation of Hg in the terrestrial food chain

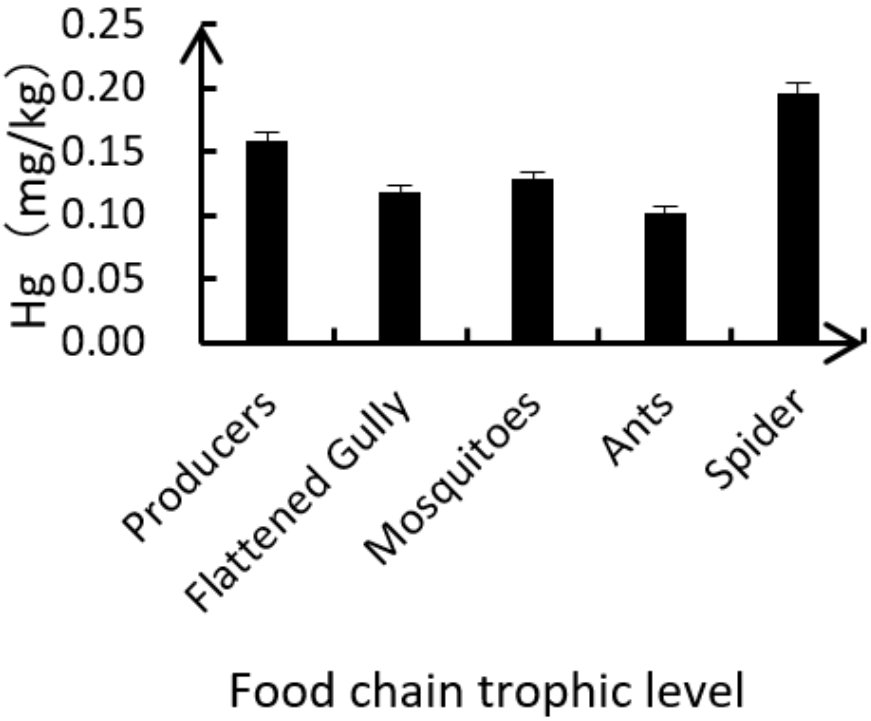

Figure 7

S7 Accumulation of Hg in the terrestrial food chain

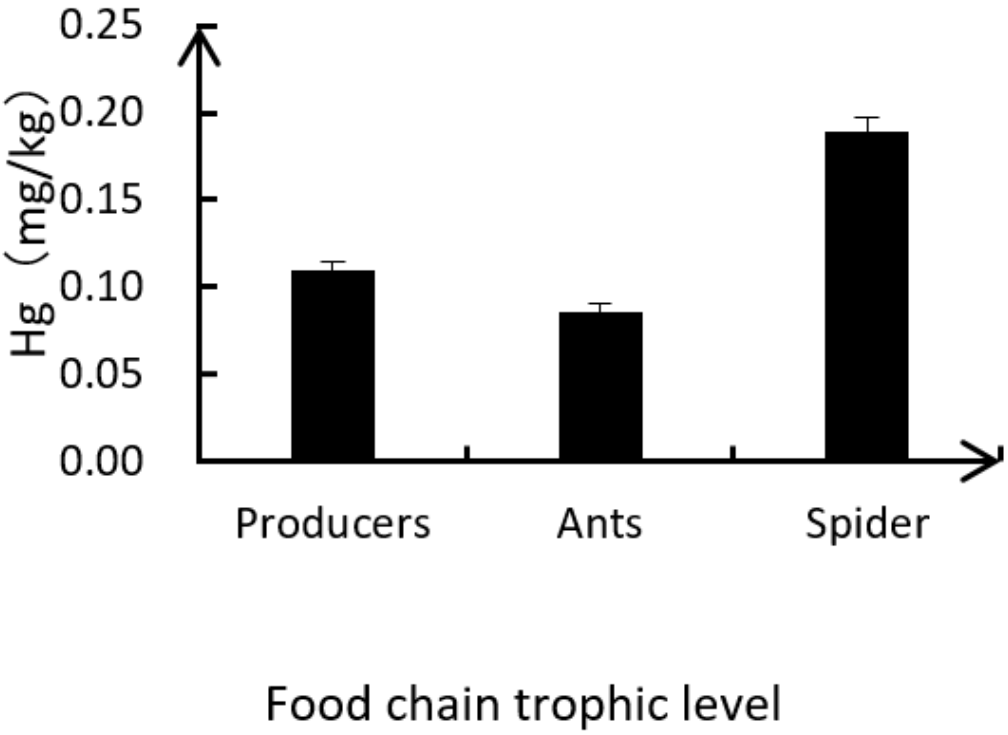

Figure 8

Accumulation of Hg in the terrestrial food chain of S9