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Original Research

Assessing Heavy Metal Pollution in Surface Sediments of China's Shaying River

Kaisheng Zhou*

Geographical Science School of Nanjing Normal University, Nanjing, China
Center of Environment Science Experiment, Bengbu University, Bengbu, China

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Abstract

To comprehend the contamination levels of heavy metals in surface sediments of Shaying River (Anhui Section, China), samples of sediments were collected using grab samplers in 14 sampling sites in the river. Chromium (Cr), cadmium (Cd), copper (Cu), and lead (Pb) in sediments were monitored via flame atomic absorption spectroscopy, and arsenic (As) via atomic fluorescence spectroscopy. The geo-accumulation index (I_{geo}), pollution load index (*PLI*), and potential ecological risk index (*RI*) were applied to evaluate the sediment pollution of the five heavy metals. The results indicate that the mean concentration levels (range) of Cr, Cd, Cu, Pb, and As in sediments were 58.38 (29.89-116.66), 5.41 (3.14-10.93), 38.51 (23.77-60.83), 35.10 (19.28-82.21), and 0.44 (0.13-1.46) mg/kg, respectively. The mean I_{geo} values of Cr, Cd, Cu, Pb, and As were -0.69, 5.41, 0.36, -0.13, and -4.84, respectively. The average potential ecological coefficients (E_r^i) of Cr, Cd, Cu, Pb, and As were 1.95, 324.70, 6.42, 7.02, and 0.29, respectively. The *RI* values of the five heavy metals ranged from 197.65 to 687.24, and the mean was 340.38. Among the studied heavy metals, Cd was the highest contaminating element, whereas As was the lowest. Especially Cd was the main contributor to *RI* in all the sampling sites. Moreover, Cr, Cd, Pb, and As might have similar sources of contamination based on the Pearson correlation matrix of analysis.

Keywords: heavy metals; heavy metal pollution; potential ecological risk; Shaying River; surface sediments

Introduction

Heavy metal pollution is one of the most serious threats to aquatic environmental quality and human health due to the toxicity [1], persistence [2], non-degradability [2], and bioaccumulation [3] of heavy metals in surroundings. Heavy metals have been known to have direct toxic effects when released into the aquatic environment, and sediments function as a sink for these pollutants [4]. Heavy metal contaminants from urban, industrial, and agricultural sources that are poured into rivers will eventually combine with sediments via physical precipitation, chemical absorption, and biological absorption, and then deposited into surface sediments [5-7]. Heavy metals can accumulate and migrate in surface sediments because of cumulative effects and long-term interactions. Surface sediments serve as the main reservoir of heavy metals in a river

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*e-mail: zks606@sina.com

and are frequently used to reflect heavy metal pollution in rivers [8]. Sediments act as carriers and possible sources of contamination because heavy metals are not perennially adsorbed onto them and may be released back to the water with changes in environmental conditions [9], i.e., heavy metals deposited into sediments will be released, reenter the water body, and cause secondary pollution in the river [10]. The accumulation of heavy metals in surface sediments negatively affects the ecological environmental safety of a catchment area and threatens animals and plants [11]. The heavy metals chromium (Cr), cadmium (Cd), copper (Cu), lead (Pb), and arsenic (As) exhibit considerable environmental toxicity; Cd, Pb, and As are also environmental hormones [12]. Humans and other organisms in nature may be directly or indirectly affected by exposure to these contaminants [4]. The concentrations of heavy metals in surface sediments and their potential ecological hazards differ according to geological conditions and human activities in various catchment areas. The contents of heavy metals vary considerably in surface sediments from disparate sections of the same river. At present, the environmental ecological hazard caused by heavy metal pollution remains a controversial topic [13-14].

Shaying River is the largest tributary of the Huai River, with a total length of approximately 620 km and a catchment area of approximately 40 000 km^2. The river originates from Funiu Mountains in Henan Province, China. Shaying River flows through the cities of Zhoukou and Fuyang plus nearly 40 counties and towns before finally flowing into the Huai River in Yingshang County, Anhui Province, China. The climate in its catchment area belongs to a warm temperate semi-humid monsoon climate with an average annual precipitation of 750 mm. With the rapid growth of the population and the development of industry and agriculture, Shaying River is becoming one of the most polluted tributaries of the Huai River due to water quality deterioration [15-16]. The pollution load of Shaying River accounts for approximately 1/3 of the total pollution load of the Huai River basin [17]. For example, the large-scale pollution accidents that occurred in the Huai River in 1994, 2001, 2002, and 2004 were related to sewage discharge from the Shaying River [16-17]. Therefore, the contamination of heavy metals in the surface sediments of the Shaying (Anhui Section, China) should be studied and evaluated. The current study aims to provide a scientific basis for controlling aquatic environmental pollution in the Shaying.

Materials and Methods

Collection of Sediment Samples

Surface sediments (approximately the top 10 cm) were collected using grab samplers in December 2011. Fig. 1 shows the locations of the sampling sites from Jieshou to the estuary of the Shaying River. A total of 14 sample sites were selected, and 3 to 5 samples were collected from each sampling site. For each sample, plastic spoons were used to remove the surface layer (0-2 cm), and the remaining soil was used as a test

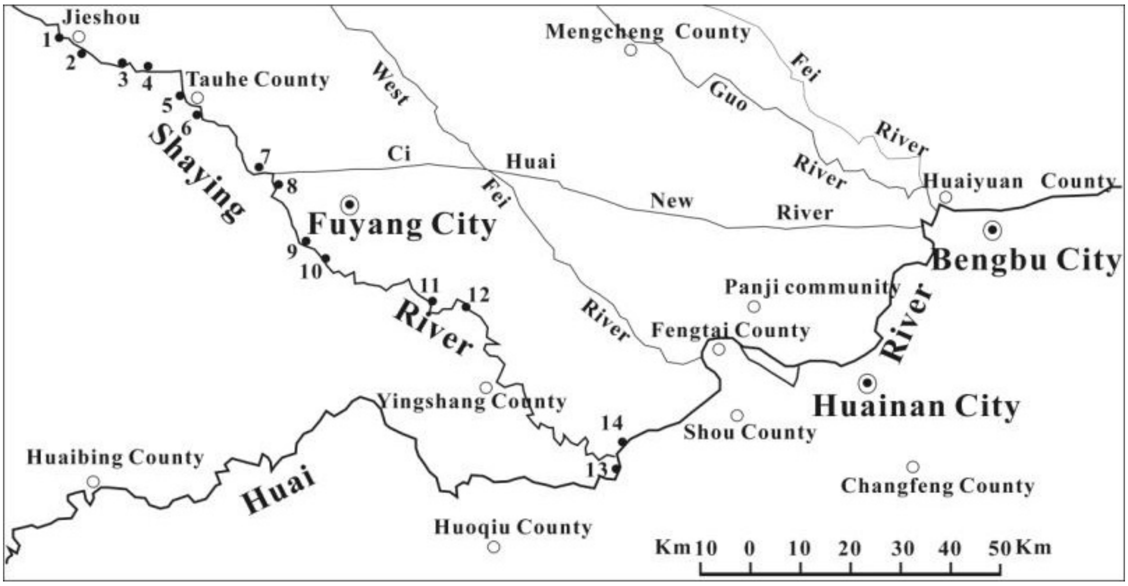

Fig. 1. Map of sampling sites

Notes: 1 - Bridge of Shaying River in Jieshou 1 (JS1); 2 - Bridge of Shaying River in Jieshou 2 (JS2); 3 - Tianying 1 (TY1); 4 - Tianying 2 (TY2); 5 - Old bridge of Shaying River in Taihe County 1 (TH1); 6 - Old bridge of Shaying River in Taihe County 2 (TH2); 7 - Estuary of Ci Huai New River 1 (CH1); 8 - Estuary of Ci Huai New River 2 (CH2); 9 - Fourth bridge of Shaying River 1 (YH1); 10 - Fourth bridge of Shaying River 2 (YH2); 11 - Funan County 1 (FN1); 12 - Funan County 2 (FN2); 13 - Estuary of Shaying River 1 (YK1); 14 - Estuary of Shaying River 2 (YK2) sample and placed in a self-sealing plastic bag. After mixing, sealing, and numbering, the samples were brought back to the laboratory and stored in a refrigerator at 0-4ºC.

Analysis of Samples

The sediment samples were air-dried at room temperature for approximately 2 weeks, ground to powder using an agate mortar and pestle, and then passed through a 100-mesh nylon screen. Undersized materials were gathered and kept in sample containers. A precise weight of each sample (0.200 g) obtained using an electronic balance (Mettler AE200, Switzerland) was used to prepare the solution for the digestion reaction. A mixture of concentrated HCl (10 mL), HNO_3 (5 mL), $HClO_4$ (5 mL), and HF (5 mL) was used for the digestion reaction. Heavy metal (Cr, Cd, Cu, and Pb) concentrations were determined using a graphite furnace atomic absorption spectrophotometer (TAS-990, Beijing General Instrument Co., Ltd., China). Another precise weight of each sample (0.200 g), obtained using an electronic balance (Mettler AE200, Switzerland), was placed in a conical flask with a volume of 150 mL. A mixture of H_2SO_4 solution (7 mL, the volume ratio of H_2SO_4 to water is 1:1), concentrated HNO_3 (10 mL), and $HClO_4$ (2 mL) was used for the digestion reaction to monitor the heavy metal As. The concentration of As in each sample was determined using a double-channel atomic fluorescence photometer (AFS-920, Beijing Beifen-Ruli Analytical Instrument Group Co., Ltd., China).

Assessment Method for Sediment Pollution

Geo-Accumulation Index (I_{geo})

I_{geo} is an effective method for assessing the pollution level of heavy metals in sediments. It is defined by the following equation [18]:

$$I_{geo} = log_2[C_n/(1.5\times B_n)]$$

...where C_n is the concentration of the heavy metal n, and stands for the geo-chemical background level (mg/kg). Factor 1.5 is used for possible lithological variations in the background value based on a previously reported shale value [18]. Müller [19] established seven classes of I_{geo} values for each heavy metal: $I_{geo}\leq 0$, unpolluted; $0<I_{geo}<1$, unpolluted to moderately polluted; $1<I_{geo}<2$, moderately polluted; $2<I_{geo}<3$, moderately to heavily polluted; $3<I_{geo}<4$, heavily polluted; $4<C<5$, heavily to extremely polluted; and $I_{geo}>5$, extremely polluted.

Pollution Load Index (PLI)

The contamination factor (*CF*) was calculated using equation [20]:

Table 1. Reference values (C_n^i) and toxic coefficient (T_r^i) of heavy metals.

Heavy metal elements	Cr	Cd	Cu	Pb	As
C_n^i/(mg/kg)	60	0.5	30	25	15
T_r^i	2	30	5	5	10

$$C_f^i = C_m^i / C_n^i$$

…where C_m^i is the concentration of an element in the analyzed sample, and C_n^i corresponds to the background value [20]. In the present study, the soil background values of Anhui Province [21] were selected as references. The contamination factor (C_f^i) accounts for the pollution of a single element. The following terminology can be used in this method to describe *CF*: $C_f^i<1$, low pollution; $1\leq C_f^i<3$, moderate pollution; $3\leq C_f^i<6$, considerable pollution; and $C_f^i\geq 6$, very high pollution [20, 22].

PLI is calculated using the equation [23]:

$$PLI = (CF_1\times CF_2\times CF_3\times\ldots\times CF_n)^{1/n}$$

…which provides a simple and comparative means to evaluate the polymetallic pollution of sediments. A *PLI* value of 0 is perfect; a value of 1 denotes baseline levels of contaminants; values less than 1 indicate no pollution; and values above 1 signify the progressive deterioration of polymetallic pollution [24-26].

Potential Ecological Risk Index (RI)

RI, which was developed by Hakanson [20], was used to assess the ecological hazard of each investigated metal in the aquatic environment. This index is calculated using the equation:

$$E_r^i = T_r^i \quad C_f^i$$

…where C_f^i and T_r^i refer to the contamination factor and toxic-response factor of a given substance, respectively. The following terminology can be used to describe the risk factor: $E_r^i<40$, low risk; $40\leq E_r^i<80$, moderate risk; $80\leq E_r^i<160$, considerable risk; $160\leq E_r^i<320$, high risk; and $E_r^i\geq 320$, very high risk. *R* is defined as the sum of the risk factors, i.e.,

$$RI = \sum_{i=1}^{n} E_r^i = \sum_{i=1}^{n} T_r^i \times C_f^i = \sum_{i=1}^{n} T_r^i \times C_m^i / C_n^i$$

The *RI* value may be used with the following terminology: *RI*<150, low ecological risk; 150≤*RI*<300, moderate risk; 300≤*RI*<600, considerable risk; and *RI*≥600, very high risk [24-25]. The reference values

Table 2. Heavy metal concentrations (Cr, Cd, Cu, Pb, and As) in Shaying River (Anhui Section, China) sediments (mg/kg).

Samples	Cr	Cd	Cu	Pb	As
JS1	60.48	5.06	31.63	34.42	0.21
JS2	47.07	5.82	32.15	27.73	0.30
TY1	52.20	6.10	29.83	39.78	0.14
TY2	29.89	5.06	24.40	22.42	0.13
TH1	69.27	4.76	33.56	35.70	0.91
TH2	52.36	4.90	29.40	36.89	0.17
CH1	81.49	4.92	54.80	64.63	0.77
CH2	116.66	10.93	60.83	82.21	1.46
YH1	47.94	4.40	52.55	34.75	0.60
YH2	45.51	4.57	29.14	21.19	0.40
FN1	89.17	6.05	31.49	36.02	0.28
FN2	41.47	3.64	51.23	24.56	0.23
YK1	39.91	3.14	23.77	19.28	0.16
YK2	41.23	5.15	35.22	19.33	0.33
Mean	58.19	5.32	37.14	35.64	0.44
Background value [21]	62.6	0.0837	19.3	26.0	8.4

(C_n^i) [26] and toxic coefficient (T_r^i) [24] of heavy metals in this study are presented in Table 1.

Data Analysis

In this study, the statistical analysis software SPSS Statistics 16.0 (SPSS Inc., Chicago, USA) was used for the correlation matrix analysis of heavy metals in surface sediments. Microsoft Excel (version 2007) was used for the processing and statistical analysis of test data.

Results and Discussion

Heavy Metal Contents in Sediments

The obtained heavy metal contents in the surface sediments of Shaying River (Anhui Section, China) are provided in Table 2. The elemental contents were 29.89-116.66 for Cr (mean: 58.19), 3.14-10.93 for Cd (mean: 5.32), 23.77-60.83 for Cu (mean: 37.14), 19.28-82.21 for Pb (mean: 35.64), and 0.13-1.46 for As (mean: 0.44) mg/kg, respectively. The heavy metal contents in surface sediments in this study ranked in decreasing order are as follows: Cr>Cu>Pb>Cd>As.

With the exception of Cr and As, the mean contents of the other studied heavy metals in all the sampling sites exceeded their corresponding background values [21]. If the 14 sampling sites were classified into 7 sampling areas, the sums of the mean content of the 5 heavy metals in each sampling area that were deposited into the surface sediments of Shaying River ranged from high to low were as follows: CH (239.3 mg/kg)>FN (142.2 mg/kg)>TH (133.9 mg/kg)>JS (122.5 mg/kg)>YH (120.6 mg/kg) >TY (105.0 mg/kg)>YK (93.9 mg/kg).

Compared with other published studies on rivers in China, the average concentration value of Cd in the current research was higher than those of the Huai [27], Yellow [28], Yangtze [26], Pearl [29], Hai [30], Liao [31], Songhua [32], and Jialu [33] rivers. By contrast, the mean concentration value of As was lower than those of the Huai [27], Yellow [28], Yangtze [26], Pearl [29], Hai [34], Liao [31], Songhua [32], and Jialu [33] rivers. The mean concentration value of Cr was lower than those of the Yellow [28], Yangtze [26], Pearl [29], Hai [34], Songhua [32], and Jialu [33] rivers, but higher than those of the Huai [27] and Liao [31] rivers. The mean concentration value of Cu was lower than those of the Yellow [28], Yangtze [26], Pearl [29], Hai [30], and Jialu [33] rivers, but higher than those of the Huai [27], Liao [31], and Songhua [32] rivers. The average concentration value of Pb was higher than those of the Huai [27],

Table 3. Heavy metal concentrations in the riverbed sediments of Shaying River (Anhui Section, China) and other rivers in China (mg/kg) based on published studies.

Location	Cr	Cd	Cu	Pb	As	References
Shaying River	58.19	5.32	37.14	35.64	0.44	this study
Huai River	56.10	0.17	22.20	20.40	NA	[27]
Yellow River	62.40	0.085	40.70	15.2	2.46	[28]
Yangtze River	73.11	0.44	44.50	34.55	25.33	[26]
Pearl River	93.10	1.72	348.00	102.60	NA	[29]
Hai River	81.90	0.36	53.30	20.00	10.16	[30, 34]
Liao River	36.45	1.42	18.36	11.47	10.22	[31]
Songhua River	121.40	0.27	13.33	18.80	10.13	[32]
Jialu River	60.80	2.93	39.22	29.35	6.31	[33]

Table 4. I_{geo}, *CFs*, and *PLI* of the studied metals in Shaying River sediments (Anhui Section, China).

Sample	Cr		Cd		Cu		Pb		As		*PLI*
	I_{geo}	*CF*	I_{geo}	*CF*	I_{geo}	*CF*	I_{geo}	*CF*	I_{geo}	*CF*	
JS1	−0.63	1.01	5.33	10.12	0.13	1.05	−0.18	1.38	−5.91	0.01	0.73
JS2	−1.00	0.78	5.53	11.64	0.15	1.07	−0.49	1.11	−5.39	0.02	0.74
TY1	−0.85	0.87	5.60	12.20	0.04	0.99	0.03	1.59	−6.49	0.01	0.69
TY2	−1.65	0.50	5.33	10.11	−0.25	0.81	−0.80	0.90	−6.60	0.01	0.50
TH1	−0.44	1.15	5.24	9.52	0.21	1.12	−0.13	1.43	−3.79	0.06	1.01
TH2	−0.84	0.87	5.29	9.80	0.02	0.98	−0.08	1.48	−6.21	0.01	0.68
CH1	−0.20	1.36	5.29	9.84	0.92	1.83	0.73	2.59	−-4.03	0.05	1.27
CH2	0.31	1.94	6.44	21.86	1.07	2.03	1.08	3.29	−3.11	0.10	1.94
YH1	−0.97	0.80	5.13	8.80	0.86	1.75	−0.17	1.39	−4.39	0.04	0.93
YH2	−1.04	0.76	5.19	9.14	0.01	0.97	−0.88	0.85	−4.98	0.03	0.69
FN1	−0.07	1.49	5.59	12.10	0.12	1.05	−0.11	1.44	−5.49	0.02	0.87
FN2	−1.18	0.69	4.86	7.28	0.82	1.71	−0.67	0.98	−5.78	0.02	0.66
YK1	−1.23	0.67	4.64	6.28	−0.28	0.79	−1.02	0.77	−6.30	0.01	0.49
YK2	−1.19	0.69	5.36	10.30	0.28	1.17	−1.01	0.77	−5.25	0.02	0.68
Mean	−0.69	0.97	5.41	10.64	0.36	1.24	−0.13	1.43	−4.84	0.03	0.88

Yellow [28], Yangtze [26], Hai [30], Liao [31], Songhua [32], and Jialu [33] rivers, but lower than that of the Pearl [29] River (Table 3).

Assessment of Sediment Contamination

The results of I_{geo}, *CFs*, and *PLI* in this study are presented in Table 4. Heavy metals were categorized according to various classes based on I_{geo} values related to the degree of pollution. The I_{geo} values of the elements ranged from −1.65 to 0.31 for Cr (mean: −0.69), −6.60 to 0.33 for As (mean: −4.84), and −1.02 to 1.08 for Pb (mean: −0.13), which indicate unpolluted; −0.28 to 1.07 for Cu (mean: 0.36), which denote unpolluted to polluted; and 4.64 to 6.44 for Cd (mean: 5.41), which signify heavily to extremely polluted. The elements exhibited the following order: Cd>Cu>Pb>Cr>As.

All five heavy metals accumulated to different extents, except for As. Nearly 64.3% of the sites presented Cu, and Pb accumulation, whereas 100% of the sites exhibited Cd accumulation. The *CF* values were 6.28-21.86 for Cd (mean: 10.64), which indicate very high contamination; 0.77-3.29 for Pb (mean: 1.43) and 0.79-2.03 for Cu (mean: 1.24), which denote moderate contamination; and 0.50-1.94 for Cr (mean: 0.97) and 0.01-0.1 for As (mean: 0.03), which suggest low contamination. The degree of contamination followed the order of Cd>Pb>Cu>Cr>As. From the preceding analysis, a conclusion can be drawn that Cd, Pb, Cu, and Cr are the main metals that can have detrimental impacts on the riverine ecosystem.

The *PLI* values ranged from 0.49 to 1.94, with a mean of 0.88. Among all the sampling sites, 3 of 14 values were >1, thereby suggesting that 21.4% of the sites were a progressive deterioration of polymetallic pollution. The most substantial contamination occurred in CH2, CH1, and TH1, as shown in the spatial distribution of the *PLI* values.

Risk Associated with Heavy Metals

Potential ecological risk assessment appropriately combines ecological effects and toxicology. It has been widely used to assess the risks posed by heavy metals to an ecosystem and to humans. The potential hazard to aquatic organisms related to the measured metal concentrations was assessed using potential ecological risks. The results of E_r^i and *RI* are presented in Table 5. The E_r^i values were 188.4-655.8 for Cd (mean: 319.3), which indicated high to very high ecological risk; 3.9-16.4 for Pb (mean: 7.1), 4.0-10.1 for Cu (mean: 6.2), 1.0-3.9 for Cr (mean: 1.9), and 0.1-1.0 for As (mean: 0.3), which implied low potential ecological risk. Therefore, the degree of potential ecological risk of the five elements exhibited the following order based on their mean values: Cd>Pb>Cu>Cr>As.

The *RI* values of the five heavy metals ranged from 197.65 to 687.24, which denoted moderate to very high ecological risk. Among them, 1 of 14 *RI* values in CH2 was >600, which indicated very high ecological risk; 9 of 14 *RI* values were $300 \leq RI < 600$, which denoted considerable ecological risk; and 4 of 14 *RI* values were $150 \leq RI < 300$, which implied moderate ecological

Table 5. E_r^i, *RI*, and the hazards of heavy metals in Shaying River riverbed sediments (Anhui Section, China).

Samples	E_r^i					*R*
	Cr	Cd	Cu	Pb	As	
JS1	2.02	303.60	5.27	6.88	0.14	317.91
JS2	1.57	349.20	5.36	5.55	0.20	361.87
TY1	1.74	366.00	4.97	7.96	0.09	380.76
TY2	1.00	303.36	4.07	4.48	0.09	312.99
TH1	2.31	285.60	5.59	7.14	0.61	301.25
TH2	1.75	294.00	4.90	7.38	0.11	308.14
CH1	2.72	295.20	9.13	12.93	0.51	320.49
CH2	3.89	655.80	10.14	16.44	0.97	687.24
YH1	1.60	264.00	8.76	6.95	0.40	281.71
YH2	1.52	274.20	4.86	4.24	0.27	285.08
FN1	2.97	363.00	5.25	7.20	0.19	378.61
FN2	1.38	218.40	8.54	4.91	0.15	233.39
YK1	1.33	188.40	3.96	3.86	0.11	197.65
YK2	1.37	309.00	5.87	3.87	0.22	320.33

risk. The *RI* values of each site decreased in the following order: CH2>TY1>FN1>JS2>CH1>YK2>JS1 >TY2>TH2>TH1>YH2>YH1>FN2>YK1. Cd was the main contributor to *RI* in all the sampling sites. The *RI* values in all the sites were >150 and were all above the threshold (i.e., 150).

Natural and anthropogenic sources contribute to the levels of Cd found in sediments from sources, such as mine/smelter wastes, phosphate fertilizers, sewage sludge, and municipal waste landfills [35]. The high contents and ecological risk of Cd in the sediments of Shaying River (Anhui, China) are closely related to the discharge of industrial wastewater (such as mining, smelting, electroplating, and dyeing wastewater) and of farmland wastewater [36]. Heavy metal pollution in Shaying River sediments mainly comes from its mainstream and tributaries in the middle and upper reaches of the Shaying River [36]. Ruyang County, which belongs to the Shaying River system, is located in the upper and middle reaches of the Shaying River, where mineral resources are abundant, especially the metal mines, whose mining and smelting generate a large amount of Cd pollution. The Jialu River is one of the tributaries of the Shaying, of which the stream segment with typical black smelly water flows through Zhengzhou City. The new materials and the opto-mechatronics industry are the pillar industries of the high-tech zone of Zhengzhou City, Henan Province, China. Substantial amounts of raw or industrial wastewater were discharged into the Jialu River without treatment, leading to Cd pollution. The Beiru River is another tributary of the Shaying flowing through Ye County, which is a famous industrial county of Pingdingshan City, Henan Province, China. The shipping, mining, and chemical industries of Ye County are advanced, thereby easily causing serious Cd pollution [36]. The Cd from the upstream with running water sinks into the bottom sediments along with the floating particles in the water. Moreover, the middle and lower reaches of the Shaying flow through regions, including Jieshou, Fuyang City, Taihe County, and Yingshang County, where the population density is high and the mining, chemical, and agricultural industries are advanced, thereby resulting in high content and ecological risk of Cd in the surface sediments of the Shaying. Cd and its compounds are highly toxic, which can enter the body through food, water, or dust inhalation [37]. Long-term Cd exposure can have chronic and acute effects on human health, and Cd poisoning can cause lung, kidney, and bone damage, and itai-itai disease [37]. As an important carcinogen, Cd and its compounds have

Table 6. Pearson correlation coefficient matrix of heavy metals in Shaying River surface sediments (Anhui Section, China).

	Cr	Cd	Cu	Pb	As
Cr	1				
Cd	0.764**	1			
Cu	0.552*	0.422	1		
Pb	0.878**	0.765**	0.702**	1	
As	0.772**	0.671**	0.715**	0.793**	1

Notes: ** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

been classified as Group I by the International Agency for Research on Cancer [35]. Chen et al. [38] reported that the contents of heavy metals and cancer-causing health risk in the environment of the Shaying River Basin were significantly higher in high-incidence areas of typical cancer than in other areas, and the contents of Cd were more than twice that of other areas. Therefore, further attention should be given to Cd because it poses a high risk of heavy metal contamination to the Shaying sediments (Anhui Section, China).

Source Apportionment of Heavy Metal Pollutants

The Pearson correlation matrix of analysis is useful for determining the source and pathway of contaminants in riverbed sediments [39]. The corresponding analytical results are presented in Table 6. All the confidence levels among Cr, Cd, Pb, and As reached 95%, thereby indicating that these heavy metals might have similar sources of contamination [32, 40]. Cu presented significant correlations with Cr, Pb, and As, with confidence levels of 99%, 99%, and 95%, respectively, thereby implying that the sources of Cu might be similar to those of Cr, Pb, and As. However, Cu demonstrated weak positive correlation with Cd, which indicates that Cu may have other sources of contamination that differ from those of Cd [41].

Conclusion

From the preceding analysis, different levels of heavy metal contamination were identified in the surface sediments of Shaying River (Anhui Section, China). Among the studied metals, Cd was the highest contaminating element, whereas As was the lowest contaminating element. The ecological risk of Cd ranged from high to very high, whereas Cu, Pb, Cr, and As posed low potential ecological risk. The comprehensive potential ecological risk of the five elements belonged to considerable ecological risk, and Cd was the main contributor to *RI* in all the sampling sites. Moreover, Cr, Cd, Pb, and As might have similar sources of contamination based on the Pearson correlation matrix of analysis.

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Conflict of Interest

The authors declare no conflict of interest.

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