Data Article

Data on the concentration of heavy metals and metalloids in lotic water of the Mantaro river watershed and human risk assessment, Peru

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A B S T R A C T

This article contains data on the concentration of heavy metals and metalloids in the water of seven rivers in the Mantaro river watershed in the central Andes of Peru, collected during the autumn of 2019. The concentrations of Cu, Fe, Pb, Zn and As were determined by flame atomic absorption spectrophotometry to assess human risk. The concentration of heavy metals and arsenic varied according to the sector of the rivers evaluated. The cluster analysis identified four different groups among the observation sectors. The risk assessment for humans was conducted on the basis of exposure doses to heavy metals and arsenic in water by ingestion and dermal pathways, using standard methods established by USEPA. These data can be reused as a basis for estimating the cancer risk or as a comparison group for future risk studies. They can also be useful to public health policy makers when

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Specifications table

| Subject                        | Environmental Science |
|-------------------------------|-----------------------|
| Specific subject area         | Water quality and health risk assessment |
| Type of data                  | Tables and figures    |
| How data was acquired         | Analytical determinations of Cu, Fe, Pb, Zn and As by the method of atomic absorption spectrophotometry by flame, using a AA-6800 Atomic Absorption Spectrophotometer, Varian AA240 and standard methods. |
| Data format                   | Raw, analyzed         |
| Parameters for data collection| Definition of sampling sectors, sample collection and digestion of the samples [1]. Determination of human risk from concentrations of heavy metals and arsenic in water. |
| Description of data collection| Two litres of water were collected in each sampling sector, in the opposite direction to the flow of the current at a depth of 20 cm, in autumn 2019. The transport and storage of the samples were carried out according to standard methods [2]. |
| Data source location          | Mantaro, Chua, Shullcas, Cunas, Chilca, Miraflores and Chancha rivers, located in the Andes Mountains, central region of Peru, between parallels 10°34'30" and 13°35'30" south latitude, and meridians 73°55'00" and 76°40'30" west longitude. |
| Data accessibility            | Data is available in the article. |

Value of the data

- High concentrations of Pb and As in water can cause significant changes in organ systems. Therefore, it is urgent to control and reduce contamination levels.
- Data from analyses of heavy metals and metalloids in surface water in this area of study may be useful for public health policy makers in proposing monitoring and control programs through remedial technologies.
- These data can be used as a basis for estimating the carcinogenic risk or as baseline data for future risk studies of heavy metals and metalloids.
- The data could be used by authorities and policy makers to audit water quality.

1. Data description

1.1. Study area

The rivers included in the study are located in the Mantaro River watershed located in the Andes Mountains of Peru, central region, between the parallels 10°34'30" and 13°35'30" south latitude, and the meridians 73°55'00" and 76°40'30" west longitude [3]. The Mantaro River is the main river of the watershed, it runs through areas with great mining influence, from the city of Cerro de Pasco to the Cobriza mine (located in the southeast of the basin). The Cunas River originates in the western mountain range at about 5,180 m above sea level. Its main course describes the shape of the letter S, with a west-east direction. The Shullcas River originates in the snowy Huaytapallana, and similarly to the Chia, Chilca, Miraflores and Chanchas rivers (Fig. 1), it experiences important water derivations for a variety of uses.
1.2. Analytical data

The data presented in this manuscript provide information on the concentration of Cu, Fe, Pb, Zn and As in the waters of seven rivers in the Mantaro River Basin and the ratios and indices to calculate the risk to human health [4,5]. Table 1 presents the data on the concentrations of heavy metals and arsenic detected in the waters of each of the sampling sectors of the rivers evaluated and Table 2 presents the average values ± SD. A cluster analysis by the Ward method (Fig. 2) was also carried out to classify the observations according to the degree of similarity and difference between the rivers evaluated [7].

Tables 3 and 4 show the exposure dose values via ingestion (D_{ing}) and dermal (D_{der}) of heavy metals and arsenic in children and adults in lotic waters with mining influence in the Mantaro River watershed. The obtained exposure dose values and the oral/dermal reference dose values (RF_{ing/der}) were used to calculate the risk quotient for ingestion (HQ_{ing}) and dermal via (HQ_{der}) of heavy metals and arsenic shown in Tables 5 and 6. In addition, Fig. 3 shows the Kruskal–Wallis test for HQing in children and adults by element and river evaluated. Table 7 shows the values of the hazard index for ingestion and dermal contact of heavy metals and arsenic in lotic waters with mining influence.

2. Experimental design, materials and methods

The sampling was carried out in established sectors in the Mantaro, Chía, Shullcas, Cunas, Chilca, Miraflores and Chanchas rivers in the Junín region in the autumn of 2019. Water samples were taken in triplicate in each sampling sector in the opposite direction of the flow of the stream at a depth of 20 cm, one meter from the edge of each river [6]. The samples were
Table 1
Concentration of heavy metals and arsenic in lotic waters of the Mantaro river watershed (μg/L).

| River     | Sampling sector | Cu   | Pb   | Zn   | Fe   | As   |
|-----------|-----------------|------|------|------|------|------|
| Mantaro   | S1              | 21.6 | 20.0 | 90.7 | 2841.0 | 26.2 |
|           | S2              | 6.9  | 4.5  | 57.7 | 502.5 | 12.1 |
|           | S3              | 15.3 | 4.0  | 26.6 | 77.9  | 25.0 |
| Cunas     | S1              | 1.9  | nd   | 9.3  | 9.5   | 9.0  |
|           | S2              | 1.7  | nd   | 10.1 | 11.9  | 7.0  |
|           | S3              | 2.1  | nd   | 8.5  | 7.1   | 8.0  |
| Shullcas  | S1              | 1.1  | 0.7  | 13.3 | 91.0  | 3.0  |
|           | S2              | 1.3  | 0.7  | 11.8 | 95.7  | 1.0  |
|           | S3              | 1.0  | 0.8  | 14.8 | 86.3  | 1.0  |
| Chica     | S1              | 1.2  | 0.4  | 6.3  | 157.1 | 0.7  |
|           | S2              | 1.0  | 3.5  | 5.8  | 147.0 | 0.69 |
|           | S3              | 1.4  | 4.5  | 6.8  | 167.2 | 0.71 |
| Miraflores| S1              | 1.7  | nd   | 11.2 | 183.2 | nd   |
|           | S2              | 1.8  | nd   | 11.8 | 188.4 | nd   |
|           | S3              | 1.6  | nd   | 10.6 | 178.0 | nd   |
| Chía      | S1              | 1.4  | nd   | 15.3 | 14.4  | 14.0 |
|           | S2              | 1.4  | nd   | 15.6 | 10.0  | 16.0 |
|           | S3              | 1.3  | nd   | 15.0 | 18.8  | 23.0 |
| Chanchas  | S1              | 1.0  | 4.0  | 13.2 | 217.0 | nd   |
|           | S2              | 8.7  | 3.9  | 16.7 | 145.0 | nd   |
|           | S3              | 1.1  | 4.1  | 9.7  | 289.0 | nd   |

nd: not detected.

Table 2
Mean and standard deviation of heavy metal and arsenic concentrations in the lotic waters of the Mantaro river watershed.

| River     | Cu       | Pb       | Zn       | Fe       | As       |
|-----------|----------|----------|----------|----------|----------|
| Mantaro   | 14.60 ± 7.37 | 9.50 ± 9.10 | 58.30 ± 32.10 | 1140± ± 1488.0 | 21.10 ± 7.82 |
| Cunas     | 1.90 ± 0.20 | nd       | 9.30 ± 0.80 | 9.50 ± 2.40 | 8.00 ± 1.00 |
| Shullcas  | 11.3 ± 0.15 | 0.73 ± 0.06 | 13.30 ± 1.50 | 91.00 ± 4.70 | 1.67 ± 1.16 |
| Cunas     | 1.90 ± 0.20 | nd       | 9.30 ± 0.80 | 9.50 ± 2.40 | 8.00 ± 1.00 |
| Chica     | 1.20 ± 0.20 | 2.80 ± 2.14 | 6.30 ± 5.00 | 157.10 ± 10.30 | 0.70 ± 0.01 |
| Miraflores| 1.70 ± 0.10 | nd       | 11.20 ± 0.60 | 183.20 ± 5.20 | nd       |
| Chía      | 1.37 ± 0.06 | nd       | 15.30 ± 0.30 | 14.40 ± 4.40 | 17.87± ± 4.73 |

Conditioned in a cold chain and transported to the laboratory. The concentrations of Cu, Fe, Pb, Zn and As were determined by the method of flame atomic absorption spectrophotometry, according to the methodology recommended by the FAO (1983), using an AA-6800, Varian AA240 atomic absorption spectrophotometer. Previously, the calibration curve was prepared with standard solutions for Cu, Fe, Pb, Zn and As, supplied by Merck with a purity level of 99.98%. Finally, the calibration curve and the concentration of the samples were obtained.

The human risk assessment for exposure to heavy metals and arsenic in water via ingestion and dermal exposure [8,9] was calculated using the following equations:

\[ D_{\text{ing}} = \frac{C_{\text{agua}} \times \text{IngR} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}} \]  \hfill (1)

\[ D_{\text{der}} = \frac{C_{\text{agua}} \times \text{SA} \times \text{KP} \times \text{ET} \times \text{EF} \times \text{ED} \times \text{CF}}{\text{BW} \times \text{AT}} \]  \hfill (2)

The coefficient of dermal permeability for Cu, Pb, Zn, Fe and As is given as 0.001, 0.004, 0.006, 0.001 and 0.001 [10].

\[ HQ_{\text{ing/der}} = D_{\text{ing/der}} / RfD_{\text{ing/der}} \]  \hfill (3)
Table 3
Exposure dose values for ingestion ($D_{ing}$) of heavy metals and arsenic in children and adults in lotic waters with mining influence in the Mantaro River Watershed, Peru.

| River        | Sampling sector | $D_{ing}$ Cu Children | $D_{ing}$ Cu Adults | $D_{ing}$ Pb Children | $D_{ing}$ Pb Adults | $D_{ing}$ Zn Children | $D_{ing}$ Zn Adults | $D_{ing}$ Fe Children | $D_{ing}$ Fe Adults | $D_{ing}$ As Children | $D_{ing}$ As Adults |
|--------------|-----------------|------------------------|---------------------|-----------------------|---------------------|-----------------------|---------------------|-----------------------|---------------------|-----------------------|---------------------|
| Mantaro      | S1              | 2.485479449            | 0.650958904         | 2.30136986            | 0.602739726         | 10.4367123           | 2.7342466           | 326.909589            | 85.619781           | 3.01479452           | 0.78958904         |
|              | S2              | 0.793972602            | 0.207945205         | 0.51708219            | 0.135616438         | 6.63945205           | 1.7389041           | 57.8219177            | 15.1438356          | 1.39232877           | 0.364657534        |
|              | S3              | 1.760547943            | 0.46109589          | 0.460273972           | 0.120547945         | 3.06082191           | 0.80164384          | 8.9638356             | 2.34767123          | 2.87671233           | 0.753424568        |
| Cunas        | S1              | 0.218630137            | 0.057260274         | nd                    | nd                   | 1.07013698           | 0.280273977         | 1.09315068            | 0.28630137          | 1.03561644           | 0.271232877        |
|              | S2              | 0.195616438            | 0.051232877         | nd                    | nd                   | 1.16219178           | 0.30438356          | 1.36931507            | 0.35863014          | 0.80547945           | 0.21058904         |
|              | S3              | 0.241643835            | 0.063287671         | nd                    | nd                   | 0.97808219           | 0.25616438          | 0.8169863             | 0.2139726           | 0.92054794           | 0.24109589         |
| Shullcas     | S1              | 0.126575342            | 0.033150685         | 0.080547945           | 0.02109589          | 1.53041096           | 0.40082192          | 10.4712392            | 2.74246575          | 0.34520548           | 0.09041059         |
|              | S2              | 0.149589041            | 0.039178082         | 0.080547945           | 0.02109589          | 1.35780822           | 0.35561644          | 11.0120548            | 2.88410595          | 0.11506849           | 0.03013698         |
|              | S3              | 0.115068493            | 0.030136986         | 0.092054794           | 0.024109589         | 1.7030137            | 0.4460274           | 9.93041095            | 2.60082192          | 0.11506849           | 0.03013698         |
| Chica        | S1              | 0.138082192            | 0.036164384         | 0.046027397           | 0.012054795         | 0.72493151           | 0.18988301          | 18.0772603            | 4.73452055          | 0.08054795           | 0.02109589         |
|              | S2              | 0.115068493            | 0.030136986         | 0.402739726           | 0.105479452         | 0.66739762           | 0.17497452          | 16.9150685            | 4.43013699          | 0.07939726           | 0.02074952         |
|              | S3              | 0.16109589             | 0.042191781         | 0.51780821            | 0.135616438         | 0.78246575           | 0.20493151          | 19.239452             | 5.03890411          | 0.08169863           | 0.02139726         |
| Miraflores   | S1              | 0.195616438            | 0.051232877         | nd                    | nd                   | 1.28876712           | 0.33753425          | 21.0805479            | 5.52109589          | nd                    | nd                  |
|              | S2              | 0.207123287            | 0.054246575         | nd                    | nd                   | 1.35780822           | 0.35561644          | 21.6789041            | 5.67780822          | nd                    | nd                  |
|              | S3              | 0.184109589            | 0.048219178         | nd                    | nd                   | 1.21972603           | 0.31945205          | 20.4821918            | 5.36438356          | nd                    | nd                  |
| Chia         | S1              | 0.16109589             | 0.042191781         | nd                    | nd                   | 1.76054794           | 0.46109589          | 1.6568936             | 0.4339726           | 1.6105984           | 0.42191708        |
|              | S2              | 0.16109589             | 0.042191781         | nd                    | nd                   | 1.79506849           | 0.47013699          | 1.15068493            | 0.30136986          | 1.84105989           | 0.48219178        |
|              | S3              | 0.149589041            | 0.039178082         | nd                    | nd                   | 1.72602743           | 0.452054794         | 2.16328677            | 0.565657534         | 2.64657534           | 0.693150685        |
| Chanchas     | S1              | 0.115068493            | 0.030136986         | 0.460273972           | 0.120547945         | 1.51890411           | 0.39780822          | 24.969863             | 6.53972603          | nd                    | nd                  |
|              | S2              | 1.001095889            | 0.262191781         | 0.448767123           | 0.117534247         | 1.92164383           | 0.50328767          | 16.6849315            | 4.36986301          | nd                    | nd                  |
|              | S3              | 0.126575342            | 0.033150685         | 0.471780821           | 0.123561644         | 1.11616438           | 0.29232877          | 33.2547945            | 8.70958904          | nd                    | nd                  |

nd: not detected.
| River      | Sampling sector | $D_{\text{der}}$ Cu | Children | Adults | $D_{\text{der}}$ Pb | Children | Adults | $D_{\text{der}}$ Zn | Children | Adults | $D_{\text{der}}$ As | Children | Adults |
|------------|-----------------|---------------------|----------|--------|---------------------|----------|--------|---------------------|----------|--------|---------------------|----------|--------|
| Mantaro    | S1              | 0.009113425         | 0.003089094 | 0.033753425 | 0.011441088 | 0.229607671 | 0.077828001 | 1.198668493 | 0.406301638 | 0.011054247 | 0.003746956 |
|            | S2              | 0.002911233         | 0.000986794 | 0.007594521 | 0.002574245 | 0.146067945 | 0.049511308 | 0.212013699 | 0.071864334 | 0.005105205 | 0.001730465 |
|            | S3              | 0.006455342         | 0.002188108 | 0.006750685 | 0.002288218 | 0.067338082 | 0.022824971 | 0.032867397 | 0.011140759 | 0.010547954 | 0.00357534 |
| Cunas      | S1              | 0.000801644         | 0.000271726 | nd       | nd        | 0.023543014 | 0.007981509 | 0.00408219 | 0.003158629 | 0.00379726 | 0.001287122 |
|            | S2              | 0.00071726          | 0.000243123 | nd       | nd        | 0.025568219 | 0.008666624 | 0.005020822 | 0.001708162 | 0.002953425 | 0.000101905 |
|            | S3              | 0.000886027         | 0.000300329 | nd       | nd        | 0.021517808 | 0.007293694 | 0.002995616 | 0.001015397 | 0.00143104 | 0.0002295324 |
| Shulcas    | S1              | 0.00046411          | 0.000157315 | 0.00118137 | 0.000400438 | 0.033690941 | 0.011142485 | 0.038394521 | 0.013014238 | 0.001265753 | 0.000429041 |
|            | S2              | 0.000548493         | 0.000185918 | 0.00118137 | 0.000400438 | 0.029871781 | 0.010125363 | 0.04377534 | 0.011386402 | 0.00421918 | 0.000143014 |
|            | S3              | 0.000421918         | 0.000143014 | 0.001350137 | 0.000457644 | 0.037463001 | 0.012699608 | 0.036411507 | 0.012342074 | 0.0000229198 | 0.0000143014 |
| Chilca     | S1              | 0.000506301         | 0.000171616 | 0.000675068 | 0.000228822 | 0.015948493 | 0.005405914 | 0.066283288 | 0.022467437 | 0.000295342 | 0.00010101 |
|            | S2              | 0.000421918         | 0.000143014 | 0.005906849 | 0.000200219 | 0.014682743 | 0.004976873 | 0.062021918 | 0.020122999 | 0.000291123 | 9.86794E-05 |
|            | S3              | 0.000590685         | 0.000200219 | 0.007594521 | 0.002574245 | 0.017214247 | 0.005839555 | 0.070546657 | 0.023911874 | 0.002959562 | 0.00010154 |
| Miraflores | S1              | 0.00071726          | 0.000243123 | nd       | nd        | 0.028352877 | 0.009610514 | 0.077295342 | 0.026200092 | nd         | nd                                |
|            | S2              | 0.000759452         | 0.000257424 | nd       | nd        | 0.029871781 | 0.010125363 | 0.079489315 | 0.026943762 | nd         | nd                                |
|            | S3              | 0.000675068         | 0.000228822 | nd       | nd        | 0.026833973 | 0.009056653 | 0.07510137 | 0.025456421 | nd         | nd                                |
| Chía       | S1              | 0.000590685         | 0.000200219 | nd       | nd        | 0.038732055 | 0.013128648 | 0.006075616 | 0.002059396 | 0.000590689 | 0.000200219 |
|            | S3              | 0.000548493         | 0.000185918 | nd       | nd        | 0.039491507 | 0.013386073 | 0.004219785 | 0.001431016 | 0.0006750685 | 0.0002288218 |
| Chanchas   | S1              | 0.000421918         | 0.000143014 | 0.006750685 | 0.002288218 | 0.033415896 | 0.011326677 | 0.091556164 | 0.031033951 | nd         | nd                                |
|            | S2              | 0.003670685         | 0.000124428 | 0.006581918 | 0.002231012 | 0.042276164 | 0.014329963 | 0.061178082 | 0.020736972 | nd         | nd                                |
|            | S3              | 0.00046411          | 0.000157315 | 0.006919452 | 0.002345423 | 0.024555616 | 0.008323392 | 0.121934247 | 0.04133093 | nd         | nd                                |

nd: not detected.
Table 5
Hazard quotient values for ingestion (HQ_{ing}) of heavy metals and arsenic for children and adults in lotic waters with mining influence in the Mantaro River Watershed, Peru.

| River   | Sampling sector | HQ_{ing} Cu Children | HQ_{ing} Cu Adults | HQ_{ing} Pb Children | HQ_{ing} Pb Adults | HQ_{ing} Zn Children | HQ_{ing} Zn Adults | HQ_{ing} Fe Children | HQ_{ing} Fe Adults | HQ_{ing} As Children | HQ_{ing} As Adults |
|---------|-----------------|-----------------------|-------------------|----------------------|-------------------|---------------------|--------------------|----------------------|--------------------|---------------------|--------------------|
| Mantaro | S1              | 0.062137              | 0.016274          | 1.64384              | 0.43053           | 0.034789            | 0.780978          | 0.467014             | 0.122313           | 10.049315          | 2.631963          |
|         | S2              | 0.019849              | 0.005199          | 0.36986              | 0.09687           | 0.022132            | 0.496830          | 0.082603             | 0.021634           | 4.641096           | 1.215525           |
|         | S3              | 0.044014              | 0.011527          | 0.32877              | 0.08611           | 0.010203            | 0.229041          | 0.012805             | 0.003354           | 9.589041           | 2.511416           |
| Cunas   | S1              | 0.005466              | 0.001432          | nd                   | nd                | 0.003567            | 0.080078          | 0.001562             | 0.000409           | 3.452055           | 0.904110           |
|         | S2              | 0.004890              | 0.001281          | nd                   | nd                | 0.003874            | 0.086967          | 0.001956             | 0.000512           | 2.684932           | 0.703916           |
|         | S3              | 0.006041              | 0.001582          | nd                   | nd                | 0.003260            | 0.073190          | 0.001167             | 0.000306           | 3.068493           | 0.804953           |
| Shullcas| S1              | 0.003164              | 0.000829          | 0.05753              | 0.01507           | 0.005101            | 0.114521          | 0.014959             | 0.003918           | 1.150685           | 0.301370           |
|         | S2              | 0.003740              | 0.000979          | 0.05753              | 0.01507           | 0.004526            | 0.101605          | 0.015732             | 0.004120           | 0.383562           | 0.100457           |
|         | S3              | 0.002877              | 0.000753          | 0.06575              | 0.01722           | 0.005677            | 0.127436          | 0.014186             | 0.003715           | 0.383562           | 0.100457           |
| Chica   | S1              | 0.003452              | 0.000904          | 0.03288              | 0.00861           | 0.002416            | 0.054247          | 0.025825             | 0.006764           | 0.268493           | 0.070320           |
|         | S2              | 0.002877              | 0.000753          | 0.28767              | 0.07534           | 0.002225            | 0.049941          | 0.024164             | 0.006329           | 0.264658           | 0.069315           |
|         | S3              | 0.004027              | 0.001055          | 0.36986              | 0.09687           | 0.002608            | 0.058552          | 0.027485             | 0.007198           | 0.272329           | 0.071324           |
| Mirafleres| S1         | 0.004890              | 0.001281          | nd                   | nd                | 0.004296            | 0.096438          | 0.030115             | 0.007887           | nd                 | nd                 |
|         | S2              | 0.005178              | 0.001356          | nd                   | nd                | 0.004526            | 0.101605          | 0.030970             | 0.008111           | nd                 | nd                 |
|         | S3              | 0.004603              | 0.001205          | nd                   | nd                | 0.004066            | 0.091272          | 0.029206             | 0.007663           | nd                 | nd                 |
| Chia    | S1              | 0.004027              | 0.001055          | nd                   | nd                | 0.005868            | 0.131742          | 0.002367             | 0.000620           | 5.369863           | 1.406393           |
|         | S2              | 0.004027              | 0.001055          | nd                   | nd                | 0.005984            | 0.134325          | 0.001644             | 0.000431           | 6.136986           | 1.607306           |
|         | S3              | 0.003740              | 0.000979          | nd                   | nd                | 0.005753            | 0.129159          | 0.003090             | 0.000809           | 8.821918           | 2.310502           |
| Chanchas| S1              | 0.002877              | 0.000753          | 0.32877              | 0.08611           | 0.005063            | 0.113659          | 0.035671             | 0.009342           | nd                 | nd                 |
|         | S2              | 0.025027              | 0.006555          | 0.32055              | 0.08395           | 0.006405            | 0.143796          | 0.023836             | 0.006243           | nd                 | nd                 |
|         | S3              | 0.003164              | 0.000829          | 0.33699              | 0.08826           | 0.003721            | 0.083523          | 0.047507             | 0.012442           | nd                 | nd                 |
Table 6
Hazard quotient values for the dermal pathway (HQ_{der}) of heavy metals and arsenic for children and adults in lotic waters with mining influence in the Mantaro River Watershed, Peru.

| River   | Sampling sector | HQ_{der} Cu | HQ_{der} Cu | HQ_{der} Pb | HQ_{der} Pb | HQ_{der} Zn | HQ_{der} Zn | HQ_{der} Fe | HQ_{der} Pb | HQ_{der} As | HQ_{der} As |
|---------|----------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|
|         |                | Children    | Adults      | Children   | Adults     | Children   | Adults     | Children   | Adults     | Children   | Adults     |
| Mantaro | S1             | 0.000380    | 0.000129    | 0.080365   | 0.027241   | 0.001913   | 0.000649   | 0.008562   | 0.002902   | 0.036847   | 0.012490   |
|         | S2             | 0.000121    | 0.000041    | 0.018082   | 0.006129   | 0.001217   | 0.000413   | 0.001514   | 0.000513   | 0.017017   | 0.005768   |
|         | S3             | 0.000269    | 0.000091    | 0.016073   | 0.005448   | 0.000561   | 0.000190   | 0.000235   | 0.000080   | 0.035160   | 0.011918   |
| Cunas   | S1             | 0.000033    | 0.000011    | nd         | nd         | 0.000196   | 0.000067   | 0.000029   | 0.000010   | 0.012658   | 0.004290   |
|         | S2             | 0.000030    | 0.000010    | nd         | nd         | 0.000213   | 0.000072   | 0.000036   | 0.000012   | 0.009845   | 0.003337   |
|         | S3             | 0.000037    | 0.000013    | nd         | nd         | 0.000179   | 0.000061   | 0.000021   | 0.000007   | 0.011251   | 0.003814   |
| Shulcas | S1             | 0.000019    | 0.000007    | 0.002813   | 0.000953   | 0.000281   | 0.000095   | 0.000274   | 0.000093   | 0.004219   | 0.001430   |
|         | S2             | 0.000023    | 0.000008    | 0.002813   | 0.000953   | 0.000249   | 0.000084   | 0.000288   | 0.000098   | 0.010406   | 0.000477   |
|         | S3             | 0.000018    | 0.000006    | 0.003215   | 0.001090   | 0.000312   | 0.000106   | 0.000260   | 0.000088   | 0.014060   | 0.000477   |
| Chilca  | S1             | 0.000021    | 0.000007    | 0.001607   | 0.000545   | 0.000133   | 0.000045   | 0.000473   | 0.000160   | 0.000984   | 0.000334   |
|         | S2             | 0.000018    | 0.000006    | 0.014064   | 0.004767   | 0.000122   | 0.000041   | 0.000443   | 0.000150   | 0.000970   | 0.000329   |
|         | S3             | 0.000025    | 0.000008    | 0.018082   | 0.006129   | 0.000143   | 0.000049   | 0.000504   | 0.000171   | 0.000999   | 0.000338   |
| Miraflores | S1            | 0.000030    | 0.000010    | nd         | nd         | 0.000236   | 0.000080   | 0.000552   | 0.000187   | 0.000099   | 0.000338   |
|         | S2             | 0.000032    | 0.000011    | nd         | nd         | 0.000249   | 0.000084   | 0.000568   | 0.000192   | 0.000099   | 0.000338   |
|         | S3             | 0.000028    | 0.000010    | nd         | nd         | 0.000224   | 0.000076   | 0.000536   | 0.000182   | 0.000099   | 0.000338   |
| Chía    | S1             | 0.000025    | 0.000008    | nd         | nd         | 0.000323   | 0.000109   | 0.000043   | 0.000015   | 0.019689   | 0.006674   |
|         | S2             | 0.000025    | 0.000008    | nd         | nd         | 0.000329   | 0.000112   | 0.000030   | 0.000010   | 0.022502   | 0.007627   |
|         | S3             | 0.000023    | 0.000008    | nd         | nd         | 0.000316   | 0.000107   | 0.000057   | 0.000019   | 0.032347   | 0.010964   |
| Chanchas | S1            | 0.000018    | 0.000006    | 0.016073   | 0.005448   | 0.000278   | 0.000094   | 0.000654   | 0.000222   | 0.000148   | 0.000148   |
|         | S2             | 0.000015    | 0.000052    | 0.015671   | 0.005312   | 0.000352   | 0.000119   | 0.000437   | 0.000148   | 0.000148   | 0.000148   |
|         | S3             | 0.000019    | 0.000007    | 0.016475   | 0.005584   | 0.000205   | 0.000069   | 0.000871   | 0.000295   | 0.000295   | 0.000295   |

nd: not detected.
Fig. 2. Distribution of observations and hierarchical clustering by river.

Table 7
Hazard index for ingestion and dermal contact of heavy metals and arsenic in lotic waters with mining influence in the Mantaro River Watershed, Peru.

| River  | Sampling sector | $H_{\text{ing}}$ Children | $H_{\text{ing}}$ Adults | $H_{\text{der}}$ Children | $H_{\text{der}}$ Adults |
|--------|-----------------|---------------------------|-------------------------|---------------------------|-------------------------|
| Mantaro| S1              | 12.257095                 | 3.982058                | 0.128067                  | 0.043411                |
|        | S2              | 5.13554                   | 1.830859                | 0.037951                  | 0.012864                |
|        | S3              | 9.984833                  | 2.829921                | 0.052298                  | 0.017727                |
| Cunas  | S1              | 3.46265                   | 0.984597                | 0.012916                  | 0.004378                |
|        | S2              | 2.695652                  | 0.790675                | 0.010124                  | 0.003431                |
|        | S3              | 3.078961                  | 0.877149                | 0.011488                  | 0.003895                |
| Shullcas| S1            | 1.231439                  | 0.434879                | 0.007606                  | 0.002578                |
|        | S2              | 0.46509                   | 0.221252                | 0.004779                  | 0.00162                 |
|        | S3              | 0.472052                  | 0.248828                | 0.005211                  | 0.001767                |
| Chilca | S1              | 0.333066                  | 0.139941                | 0.003218                  | 0.001091                |
|        | S2              | 0.581594                  | 0.200925                | 0.015617                  | 0.005293                |
|        | S3              | 0.676309                  | 0.233944                | 0.019753                  | 0.006695                |
| Miraflores| S1           | 0.039301                  | 0.104325                | 0.000818                  | 0.000277                |
|        | S2              | 0.040674                  | 0.109716                | 0.000849                  | 0.000287                |
|        | S3              | 0.037929                  | 0.098935                | 0.000788                  | 0.000268                |
| Chía   | S1              | 5.382125                  | 1.538755                | 0.02008                   | 0.006806                |
|        | S2              | 6.148641                  | 1.742062                | 0.022886                  | 0.007757                |
|        | S3              | 8.834501                  | 2.44047                 | 0.032743                  | 0.011098                |
| Chanchas| S1            | 0.372381                  | 0.209111                | 0.017023                  | 0.00577                 |
|        | S2              | 0.375818                  | 0.233989                | 0.016613                  | 0.005631                |
|        | S3              | 0.391382                  | 0.184225                | 0.01757                   | 0.005955                |
Fig. 3. Kruskal–Wallis test for HQ\textsubscript{ing} in children and adults by element and river evaluated.
The oral and dermal reference dose (RfD_{oral/der}) has been obtained from the literature [11].

\[ \text{HI} = \sum_{i=1}^{n} \text{HQ}_{\text{oral/der}} \]  

(4)

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**Conflict of Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Supplementary materials**

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.dib.2020.105493.

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