**E-WAter**
Official Publication of the European Water Association (EWA)


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# Distribution of Heavy Metals in Interstitial Waters and Sediments at Different Sites in Ariake Bay, Japan

## ABSTRACT

Wet muddy sediment samples were collected at 95 different points of Ariake bay located in Kyushu, Japan, and were analyzed for different metals after centrifuge to separate sediment and interstitial water. The concentrations (µg/g) of metals (Al, Ba, Cd, Cr, Cu, Co, Fe, Pb, Mn, Ni, Sr, Sn, Zn) in the interstitial waters and the sediments were determined. Major components in the sediments were Al, Fe, Mn and Zn. The significant correlation of Ba, Cd, Cr, Co, Fe, Pb, Mn and Zn with Al suggests a natural source of metal-induction. The poor correlation of Cu, Ni, Sr and Sn with Al or Fe suggests that these metals have been induced by some anthropocentric sources. The western precinct of Ariake bay, in general, has high concentrations of metals as compared to the eastern and the central precincts. The reasonable concentrations of Cr, Sr, Ni, and Sn in interstitial water suggest high potential flux of these metals from sediment into surface water and, therefore, easily available to biota. High percentages of Al, Ba, Cd, Cu, Co, Fe, Pb, Mn and Zn in sediments, however, suggest that potential flux of these metals from sediment into surface water might be very low and thus have less bio-availability. In Ariake bay, in general, the enrichment factor (EF) of Cr and Ni were less than 1, indicating no enrichment, whereas, the enrichment of Fe was minor (EF = 1-3), Co, Cu, Ba and Sn were moderately severe (EF = 5-10), Pb and Zn were very severe and Sr (EF = 25-50), Mn and Cd were extremely severe (EF = >250).

## KEYWORDS:

Sediments, Interstitial waters, Heavy metals, Particle size, Metals correlation co-efficient, Enrichment factor

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## 1. INTRODUCTION

In recent years there has been growing concern over increased contamination of aquatic system from a variety of anthropocentric sources. Heavy metals are natural constitutes of natural waters; some are present at low concentrations and are biologically important in aquatic environment, but some are toxic. Metals in natural waters are induced from various sources. Natural geological weathering of rocks and soils, directly exposed to surface waters, is usually the largest natural source. Another source is anthropocentric input from mining, domestic and industrial activities. Metals are absorbed onto deposits and incorporated into sediments, resulting in higher concentrations [1-5]. A large amount of heavy metals input, therefore, accumulate in the estuaries and costal waters since these are important sinks of suspended matter and associated land derived contaminants [6]. Several studies have shown that metals exist at low concentrations in natural waters, partially in soluble ionic forms and partially forms bound to inorganic or organic particulate matters, and their toxicity can be attributed mainly to their soluble forms [7-9]. The increasing contaminations of aquatic environment by heavy metals released from various sources as a consequence of industrialization and urbanization in this era are major environmental concern of all countries. Heavy metals are some of the main source of toxicity problems in the aquatic environment when they occur above the threshold concentrations [10-12].

In recent years there has been growing concern over increased contamination of sediments from a variety of anthropocentric sources [13]. Reduced circulation or dispersion of sediment-bound heavy metals makes them susceptible to contamination [13, 14].

Sediments are considered to be the ultimate sink for many contaminants and therefore pose the highest risk to aquatic environment as a source of pollution [15, 16]. Sediment usually composed of a combination of lithogenic, authigenic and biogenic components such as mineral grains, organic matters, sulfides and carbonates. Heavy metals may be attached to any of these phases in proportions which depend on the physiochemical conditions of sediment and associated water [17- 19].

The contaminants accumulated in interstitial water may be released by changing hydrological, biological and hydro-chemical conditions. Monitoring of sediment with the determination of heavy metals is fundamental to the realization of toxic pollutants in sea sediment [20-22].

In order to make defensible estimates of the potential risk of metals in sediments and/or develop sediment quality criteria for metals, we analyzed sediment samples collected from 95 different points of Ariake bay and discussed about the concentration, distribution, enrichment, partitioning and correlation of metals.

## 2. MATERIAL AND METHODS

### *2.1. Study Area*

Ariake Bay is located in the north Kyushu, Japan (Fig.1) and surrounded by four prefectures (Saga, Nagasaki, Fukuoka and Kumamoto). The length of Ariake bay is 96 km from north to south, average width is 18 km and total area is about 1700 km$^2$. It is characterized by wide tidal flats and is utilized for shellfish fisheries and Nori (seaweeds) culture growth, resulting in high biological productivity. The Nori production in the regions is about 40% of total production in Japan. The environment of Ariake bay, however, is rapidly changing recently: Rapid increase in reclamation of tidal flats, the construction of sea-dyke in Isahaya Bay and so on. These caused severe environmental problems such as change of the tidal current, eutrophication, oxygen depletion and so on [23-25]. A special phenomenon occurred in winter season of 2000- 2001: Large diatom red tide occurred and damaged seriously to Nori culture [26]. In summer deficiency of dissolved oxygen in the bottom water has been often observed in a wider area of innermost part of this region, resulting in decreased production of shellfish [27, 28].

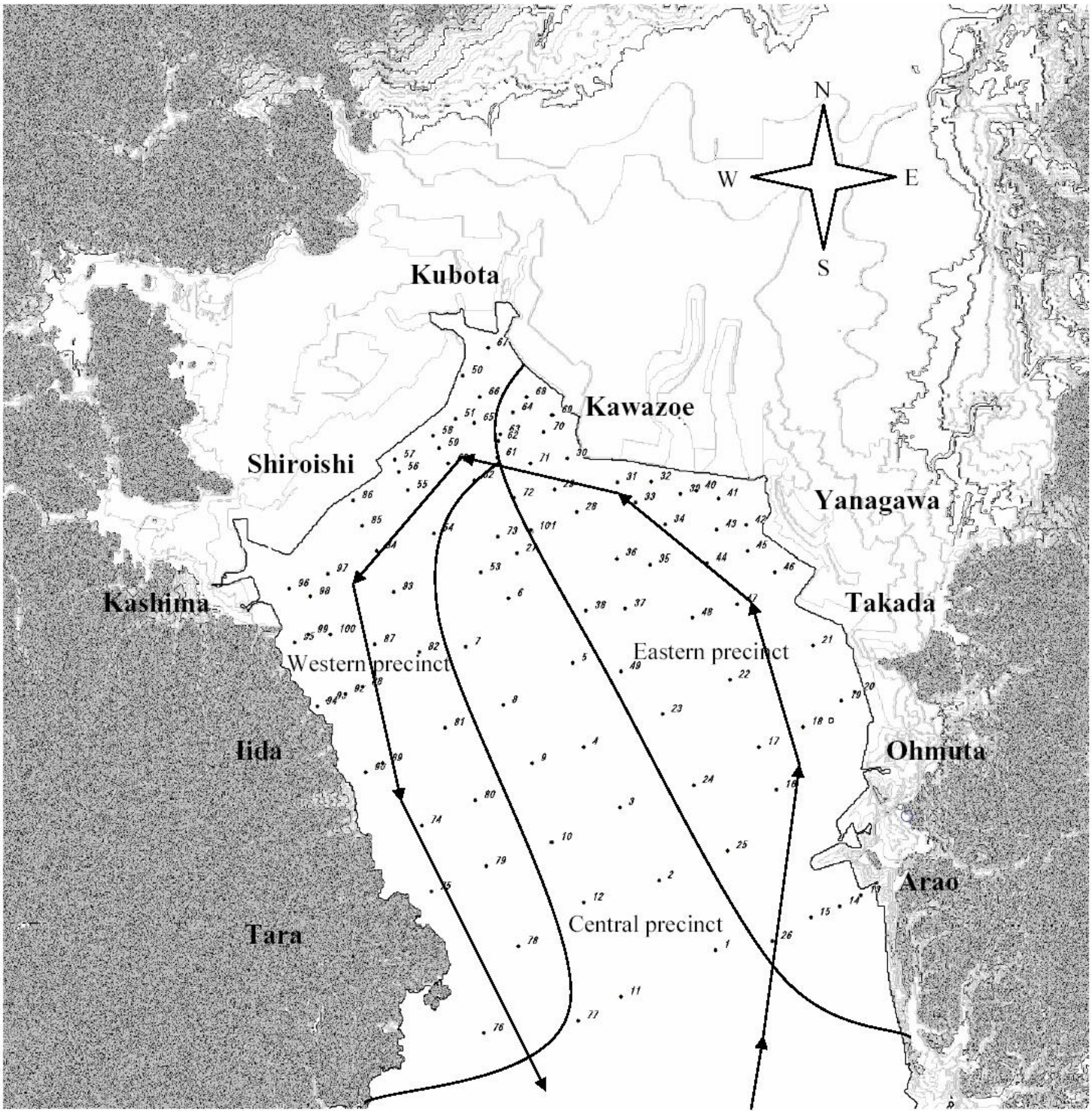


*Fig. 1: Demarcated map of Ariake bay ( ⟶ Direction of tidal flow)*

Ariake bay region is divided into three precincts to facilitate the results and discussion. The eastern precinct includes the area of Kawazoe, Yanagawa, Takada, Ohmuta and Arao. The western precinct includes the areas of Kubota, Shiroishi, Kashima, Iida and Tara, whereas, the central precinct lies in between of these two, as shown in Fig.1. Arao, Ohmuta and Takada regions received industrial waste waters from some industries situated in vicinity. Various rivers, running through urban areas, fall in Ariake bay at Yanagawa, Kawazoe, Kubota, Shiroishi, Kashima, Iida and Tara regions.

### *2.2. Experimental work*

To analyze the metals in sediments and in interstitial water, muddy sediment samples were collected at 95 different points 10 cm in depth using an Ekman Grab Sampler in October 2005. The sampling bottles were soaked in 10% nitric acid solution for 24 hours and then washed sufficiently with deionised water prior to use. The sediment samples were kept in plastic sample bottles and stored at 4 $^{0}$C.

Metal were analyzed in sediments and interstitial waters as follows. A wet sediment sample was centrifuged at 2800 rpm for 25 minutes. The supernatant was filtered using 0.2 µm syringe membrane filter. The filtered supernatant (24 ml) was taken and 1 ml HCl (3 mol/dm$^3$ = M, ultra-pure grade) was added to 25 ml volumetric flak. The solution was used to analyze the metal concentration in the supernatant. The residue sediment, after extraction of interstitial water, was dried at 105 $^{0}$C for 24 hours and kept at 25 $^{0}$C for 24 hour. About 4 gm of each sediment sample was soaked in 20 ml of 1 M HCl and shaken for one hour at 190 rpm, followed by centrifuge at 1500 rpm for 10 minutes. The supernatant was filtered by a membrane filter (0.2 µm) and analyzed for metals. Interstitial water and sediment samples were analyzed for different metals by using an ICP-AES (Perkin-Elmer Optima 3100 RL) for Al (45 ppb), Ba (4 ppb), Cd (3 ppb), Co (7 ppb), Cr (7ppb), Cu (5ppb), Fe (4 ppb), Mn (1 ppb), Ni (15 ppb), Pb (42 ppb), Sr (103 ppb) and Zn (ppb). Sn (2ppb) was determined by a polarized Zeeman atomic absorption spectrophotometer (graphite furnace atomizer, Hitachi Z-2000) by adding Pd/Mg mixture (500 ppm) to sample solutions in acidic medium. The values given in parentheses are detection limits of each metal in ppb.

Particle size distributions of sediments were first measured by using different sieves. The particle size distribution of the material passed through the sieves with diameter less than 75 µm was measured by a Laser Diffraction Particle Size Analyzer (SALD –3100, Shimadzu Co., Ltd.) after treatment of the sediments by 1 M HCl to get rid of the debris of shellfish. Median diameter is expressed by $\phi$ scale in logarithm as below:

$$\phi = -\log_2 d$$

where, $d$ is diameter of sediment particle in millimetre and $\phi$ is median diameter which is 50% diameter in the cumulative particle size distribution chart and expressed as $M_d \phi$ .

## 3. RESULTS

### *3.1 Metals concentrations*

The concentrations (µg/g) of metals determined, in sediments and in interstitial waters, were summarized in Table 1 and 2 (see Annex). The average concentrations of metals in studied area are summarized as;

Al > Fe > Mn > Sr > Ba > Zn > Pb > Co > Cu > Cd > Cr > Ni > Sn

The concentration of Al was high in the western precinct and seems to drift towards the central precinct (Fig. 2). The concentration of Ba was high in Yanagawa and Takada regions of the eastern precinct and was high at Shiroishi region in the western precinct.

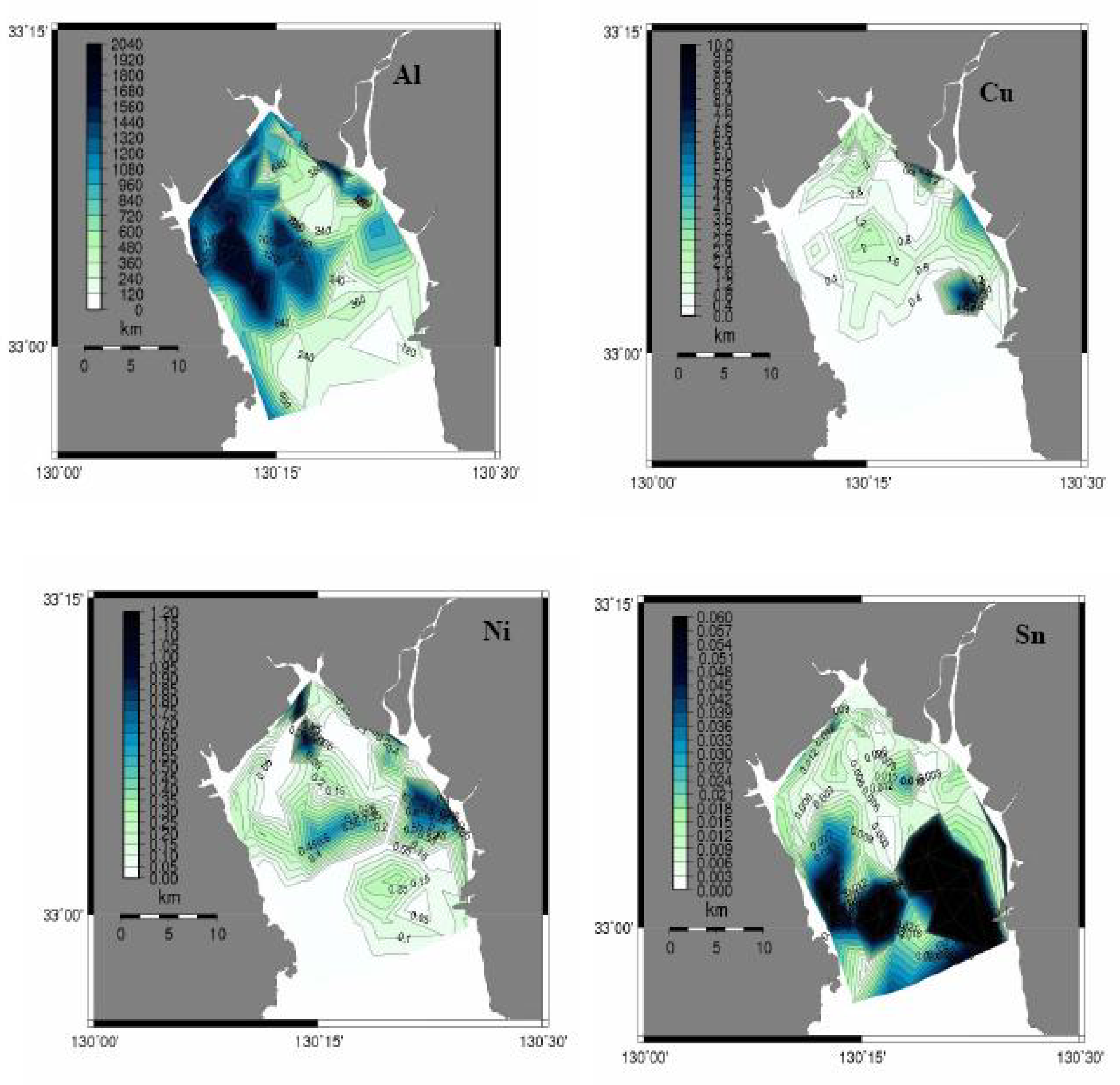


*Fig. 2. Concentrations (µg/g) of metals at different stations of Ariake bay*

Cd distributed in all three precincts but high concentration was found in Shiroishi area. The concentration of Co was high at Yanagawa and Takada area of the eastern precinct, and in the western precinct it was high at Shiroishi and Kashima areas. The concentration of Cr was high at Kubota and Shiroishi regions of the western precinct and was ignorable in the eastern precinct. The concentration of Cu was low in the central and the western precincts, whereas was observed high at Ohmuta region in the eastern precinct (Fig. 2). The concentration of Fe and Pb was high at Shiroishi, Kashima and Iida regions of the western precinct. Shiroishi and Kashima regions of the western precinct have high concentration of Mn and concentration appeared to drift from Shiroishi region to the central precinct, whereas in the eastern precinct Mn concentrated mainly at Yanagawa area. The concentration of Ni was high at Takada area of the eastern precinct and at Shiroishi area of the western precinct (Fig. 2). The concentration of Sr was high at Iida region of the western precinct and at Ohmuta area of the eastern precinct. The concentration of Zn was high in Kawazoe and Yanagawa regions of the eastern precinct and at the Shiroishi region of the western precinct. The concentration of Sn was high at Arao region of the eastern precinct and at Iida region of the western precinct (Fig. 2).

In the central precinct concentration of Sn was high at main water body of Ariake bay. The particle size of the sediment was determined and was observed that the sediments of the western precinct have fine particles, whereas the sediments of the eastern and central precinct have course particle as shown in Fig. 3.

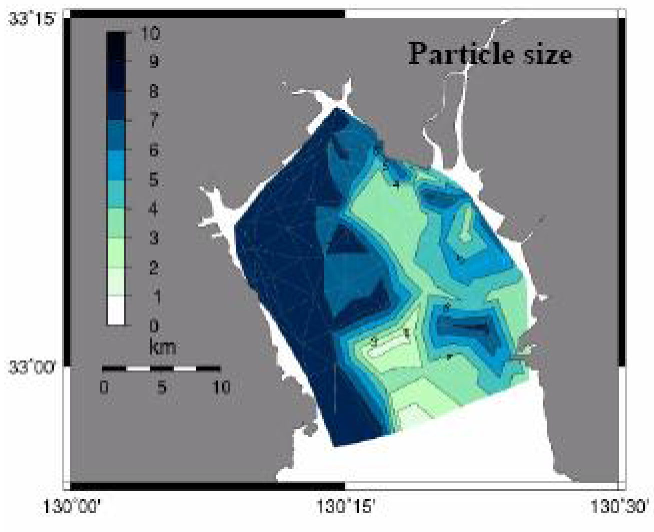


*Fig. 3. Particle size (μm) of sediments at different stations in Ariake bay*

### *3.2. Metals partition between sediment and interstitial water*

The metals can exist either in interstitial water as dissolved forms or bind to sediment particles. The percentage of metals in sediments and interstitial water was calculated by using formulas:

$M_{sed.} = (Cs/Ct) \times 100$

$M_{int.water} = 100 - M_{sed}$

$M_{sed.}$ = metals (%) in sediments, $M_{int.water}$ = metals (%) in interstitial water, Cs = metals in sediments and Ct = total concentration of metals (sediment + interstitial water).

The percentages for metals in sediments suggest different partition ratio of metals at different stations. In general, Al, Ba, Co, Cu, Fe, Pb, Mn and Zn were mainly existed in sediments, whereas Cr, Ni, Sn and Sr have considerable concentrations in interstitial water. The partitioning trend and average % of metals are shown in Fig. 4 and Table 3, respectively.

*Table 3: Average (%) of metals in sediments and in interstitial water*

| | **Average (% ) of metals in** | |
|---|---|---|
| **Metals** | **Sediments** | **Interstitial water** |
| Al | 99.9 | 0.1 |
| Ba | 96 | 4 |
| Cd | 99 | 1 |
| Co | 99 | 1 |
| Cr | 82 | 18 |
| Cu | 99 | 1 |
| Fe | 99 | 1 |
| Mn | 96 | 4 |
| Ni | 67 | 33 |
| Pb | 98 | 2 |
| Sn | 66 | 44 |
| Sr | 90 | 10 |
| Zn | 98 | 2 |

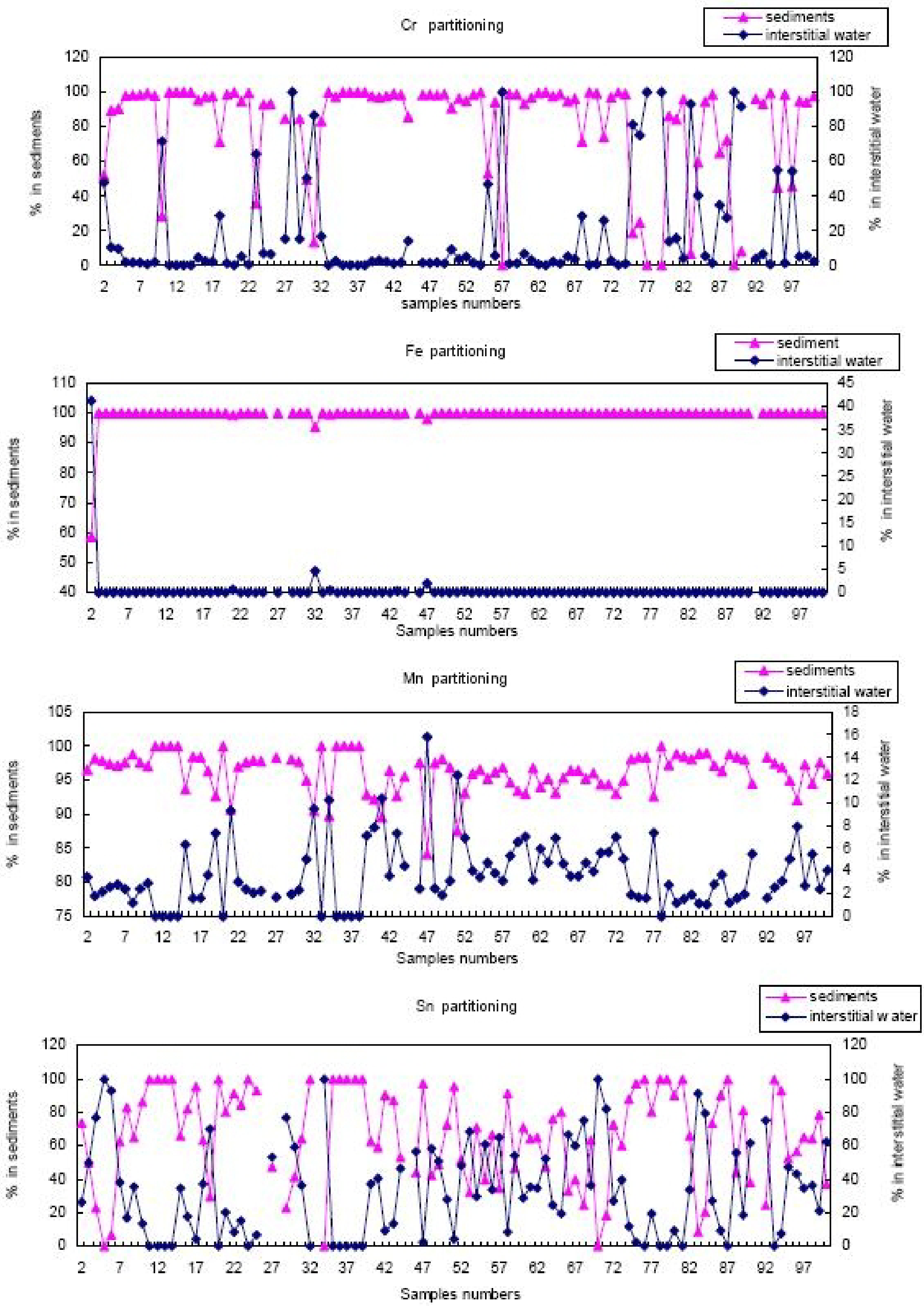


*Fig. 4: Metals partitioning in interstitial water and sediment of Ariake bay*

### *3.3. Metals concentration correlation co-efficient*

The concentration correlation co-efficient (*r*) between metal at different stations was studied. Al had a significant correlation co-efficient with Ba, Co, Cr and Fe, and considerable correlation with Cd, Mn, Pb and Zn. But in case of Cu, Ni, Sr and Sn the correlation was ignorable with Al as shown in Table 4 (see Annex).

### *3.4. Enrichment Factors of metals in sediments*

The enrichment factors (EF) were calculated to evaluate the abundance of metals in sediments. The enrichment factor of the element is generally defined as a normalized concentration ratio of an element in the sample to that in the continental crust [31], expressed by following equation:

$$\text{EF} = \frac{[M]_{sample}/[Al]_{sample}}{[M]_{crust}/[Al]_{crust}}$$

where $[M]_{sample}$ and $[Al]_{sample}$ are the concentrations of metal and Al in the sample and $[M]_{crust}$ and $[Al]_{crust}$ are the concentrations of metal and Al in the continental crust, respectively [29]. Aluminium is chemically inactive element relative to other diverse elements and therefore was used as a normalization element to estimate the relative abundances of diverse elements in a sample to those in the continental crust [30, 31]. The enrichment factors of metals in sediments are given in Table 5 (see Annex).

The average enrichments factors of metals in total Ariake bay (Fig. 5) are summarized as;

Cd > Mn > Zn > Sr > Pb > Co> Ba> Cu > Fe > Sn > Ni (negative) > Cr (negative)

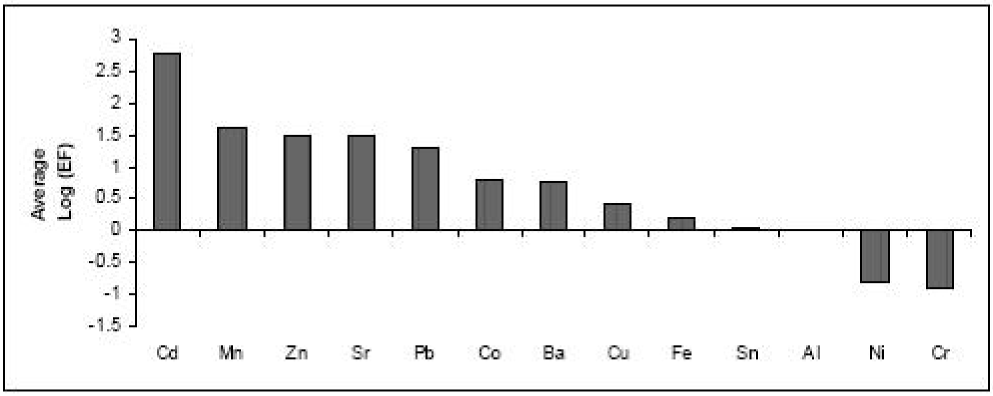


*Fig. 5. Average enrichment factors of metals in Ariake bay*

Metals have higher enrichment factor in the eastern precinct as compared to the western and the central precinct. In the eastern precinct, Yanagawa, Takada, Ohmuta and Arao regions have high enrichments of metals.

## 4. DISCUSSION

### 4.1. Metals concentrations

The concentration of metals was high in the western precinct as compared to the eastern and the central precinct. In the eastern precinct Yanagawa region (received two rivers coming from mountains and urban areas) has higher concentrations of Mn, Ba, Zn and Co and significant correlation co-efficient (0.73-0.81) between these metals suggest a common source. Takada region has high concentration of Ba and Ni, whereas, Ohmuta region has high concentrations of Sr and Cu. Takada and Ohmuta regions have drainage outfall from industrial areas; therefore, it was assumed that Ni and Cu have been induced through industrial effluents/waste. The concentration of Zn was high at Kawazoe region of the eastern precinct.

In the western precinct two rivers fall in Ariake bay at Kubota region, therefore high concentrations of metals was expected in this area but concentration of metals was low in this region. Shiroishi region, adjacent to Kubota area, has higher concentrations of Mn, Cd, Ni, Pb, Zn, Fe, Co and Cr. The accumulations of these metals in Shiroishi area is worth mentioning as no river falls in Ariake bay at this point. The high concentrations of Mn, Cd, Ni, Pb, Zn, Fe, Co and Cr, in Shiroishi region, could be justified by its fine particle sediment and by the effect of anticlockwise residual current [32]. Kashima region with fine grain sediments, two rivers from urban areas flow into Ariake bay at this point, has low concentrations of metals other than Mn. Iida region with muddy nature sediments, no river falls in this area, has high concentrations of Sr, Pb and Fe. Low concentrations of metals in Kashima and high concentrations of metals in Iida region could also be due to anticlockwise residual current that drifted metals from Kashima to Iida region. In comparison of all three precincts, generally, it was observed that the concentrations of Cu, Ni, Ba, Sr, Co were high in the eastern precinct and Al, Cd, Cr, Fe, Pb, Mn, Zn were high in the western precinct, whereas the concentration of Sn was high in the eastern and the central precincts. High concentration of Sn in Takada, Ohmuta and Arao regions (industrial areas) of the eastern precinct, suggest that Sn has been inducing through industrial effluent/waste.

The concrete reason of higher concentrations of Cu, Ni, Ba, Sr and Co in the eastern precinct and Al, Cd, Cr, Fe, Pb, Mn, and Zn in the western precinct could be justified by location of rivers fall in Ariake bay and the anticlockwise residual current. This anticlockwise residual current might drift metals from the eastern to the western precinct as suggested by Yokoyama and Yamamoto [33].

### 4.2 Metals partition between Sediment and interstitial water

The percentage of metals in sediments and in interstitial water was calculated to acquire the knowledge of partition of trace metals at the sediment-interstitial water. The high partitioning percentage of Al, Ba, Cd, Cu, Co, Fe, Pb, Mn and Zn in sediments, suggest that potential flux of these metals from sediment into the surface water might be very low and thus have less bio-availability. The reasonable concentrations of Cr, Sr, Ni, and Sn in interstitial water suggest a high potential flux of these metals from sediment into the surface water, therefore might be easily available to biota.

### *4.3. Metals correlation co-efficient*

The significant correlation co-efficient between metal concentration at various stations was found. High correlations of Ba, Cd, Co, Cr, Fe, Mn, Pb and Zn (0.72-0.87) with Al, which is a major component of sediment, suggest a natural source of metals induction. The poor correlation of Cu, Ni, Sr and Sn with Al suggest that these metals have been induced by some anthropocentric sources. The concentrations of these metals were higher at the Ohmuta region (Cu, Sr), and Takada (Ni) and Arao (Sn). As these regions are associated with industrial areas, therefore these metals (Cu, Sr, Ni and Sn) might have been induced by industrial activities. The spatial distribution of heavy metals contaminants did not have linear correlation with sampling stations, suggesting strong variation of induction source, eddy flow, and sediment mobility existed in Ariake bay system.

### *4.4. Enrichment factor*

The enrichment values of metals in sediments were evaluated as suggested by Birch [34], where EF < 1 indicates no enrichment, <3 is minor; 3-5 is moderate; 5-10 is moderate severe; 10-25 is severe; 25-50 is very severe; and > 50 is extremely severe. The average EF values in studied area for Cd (745.3), Co (8.29), Cu (7.25), Cr (0.2). Ba (7.7), Fe (1.95), Mn (57.9), Ni (0.49), Pb (23.1), Sn (10.5), Sr (57.3), Zn (38.6), Co (8.29) were observed as shown in Fig.5. The EF values of Cr and Ni were less than 1, indicating no enrichment, whereas, the enrichment of Fe was minor (EF <3), Co, Cu, Ba and Sn was moderately severe (EF = 5-10), Pb and Zn was very severe (EF = 25-50) and Sr, Mn and Cd was extremely severe (EF >50).

## 5. CONCLUSION

It is evident from the study that the concentration of metals in Ariake bay is highly influenced by residual current and fine sediment. The largest Chikugo river falls to Ariake bay and supplies mud, sand and other organic compounds with metals. Anti-clock wise residual current in Ariake bay drifts the metals from the eastern precinct to the western precinct and the metals accumulated in this precinct due to its fine grain sediments. The main components of the sediments were Al, Fe, Mn and Zn. These metals control the accumulation of other minor metals. The eastern precinct has been receiving higher concentrations of metals and the metals shifts to the western precinct along with anti-clock wise tidal flow, resulting high concentrations of metals in the western precinct as at Shiroishi and Iida regions. It was, therefore, concluded that metals concentrations depends on residual current and the fine sediment particle.

The significant concentration correlations of Ba, Cd, Cr, Co, Fe, Pb, Mn and Zn with Al, which is a major component of the sediments, suggest a natural source of these metals. In contrast, weak correlations of Cu, Ni, Sr, and Sn with Al suggest a point source. The partitioning percentage of metals suggest that Al, Ba, Cd, Cu, Co, Fe, Pb, Mn and Zn, mainly present in sediments and therefore potential flux of these metals from sediment into the surface water might be very low. The Cr, Sr, Ni and Sn have reasonable concentration in interstitial water which suggests that these metals might be more mobile and potential flux of these metals from sediment into the surface water might be high. The EF values of Pb, Zn, Sr, Cd and Mn show very high enrichment in the sediment of Ariake bay. The severe enrichment of these metals can suppress high contamination of metals in sea water, but some metals exist in interstitial water. As Ariake bay is used for high production of fisheries and sea weeds, therefore, the severe enrichment of these metals might have a real danger of contamination.

## ACKNOWLEDGEMENTS

The authors appreciate the support of Grants in Aid of Exploratory (No. 19350041) (M. Tabata) from the Ministry of Education, Science, Technology, Sports and Culture of Japan and thank the staffs of Ariake research project at Saga University for their help and suggestion on seawater and sediments of Ariake bay.

## ANNEX

*TABLE 1: Concentrations (μg/g) of metals in sediments samples*

| Station No. | Al | Ba | Cd | Co | Cr | Cu | Fe | Mn | Ni | Pb | Sn | Sr | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 168 | 11.4 | 0.15 | 0.43 | 0.06 | 0.09 | 0.06 | 49.9 | 0.16 | 0.77 | 0.011 | 58.4 | 3.7 |
| 3 | 352 | 12.1 | 0.22 | 0.72 | 0.11 | 0.10 | 371 | 73.5 | 0.27 | 1.03 | 0.026 | 54.4 | 5.7 |
| 4 | 1420 | 30.0 | 0.68 | 1.68 | 0.11 | 1.02 | 867 | 224 | 0.00 | 5.79 | 0.003 | 81.4 | 29.7 |
| 5 | 1320 | 27.9 | 0.56 | 1.49 | 0.27 | 1.64 | 613 | 240 | 0.61 | 4.66 | 0.000 | 79.0 | 26.2 |
| 6 | 1600 | 32.0 | 0.83 | 2.12 | 0.35 | 2.46 | 970 | 403 | 0.00 | 6.09 | 0.006 | 85.9 | 31.8 |
| 7 | 713 | 18.7 | 0.48 | 0.91 | 0.17 | 2.02 | 468 | 134 | 0.37 | 2.45 | 0.026 | 68.8 | 14.1 |
| 8 | 1290 | 24.3 | 0.83 | 1.86 | 0.25 | 1.14 | 505 | 257 | 0.64 | 4.68 | 0.010 | 66.5 | 29.9 |
| 9 | 822 | 24.7 | 0.93 | 1.61 | 0.21 | 0.45 | 191 | 203 | 0.00 | 3.55 | 0.028 | 83.4 | 27.7 |
| 10 | 229 | 13.4 | 0.13 | 0.45 | 0.07 | 0.08 | 571 | 52.0 | 0.00 | 0.87 | 0.117 | 70.2 | 3.7 |
| 11 | 96 | 12.2 | 0.06 | 0.22 | 0.05 | 0.00 | 105 | 43.1 | 0.00 | 0.37 | 0.034 | 55.8 | 1.4 |
| 12 | 247 | 11.5 | 0.18 | 0.51 | 0.08 | 0.19 | 272 | 52.0 | 0.00 | 0.87 | 0.023 | 50.9 | 4.5 |
| 13 | 255 | 14.3 | 0.22 | 0.68 | 0.09 | 0.00 | 320 | 255 | 0.17 | 1.06 | 0.009 | 61.1 | 7.1 |
| 14 | 125 | 12.1 | 0.10 | 0.38 | 0.05 | 0.06 | 197 | 372 | 0.10 | 0.53 | 0.063 | 61.7 | 2.8 |
| 15 | 133 | 11.9 | 0.11 | 0.30 | 0.04 | 0.08 | 124 | 76.4 | 0.10 | 0.29 | 0.060 | 67.2 | 2.4 |
| 16 | 103 | 12.7 | 0.14 | 0.28 | 0.05 | 0.07 | 129 | 69.6 | 0.08 | 0.53 | 0.091 | 67.7 | 3.7 |
| 17 | 241 | 14.5 | 0.18 | 0.44 | 0.08 | 9.48 | 172 | 84.8 | 0.00 | 0.76 | 0.116 | 76.5 | 5.6 |
| 18 | 215 | 15.6 | 0.21 | 0.53 | 0.02 | 0.98 | 232 | 214 | 0.00 | 1.12 | 0.017 | 62.3 | 7.9 |
| 19 | 266 | 25.3 | 0.47 | 0.83 | 0.13 | 0.12 | 539 | 156 | 0.34 | 1.95 | 0.004 | 55.5 | 15.2 |
| 20 | 184 | 14.5 | 0.85 | 0.60 | 0.02 | 2.88 | 194 | 199 | 0.00 | 1.27 | 0.065 | 66.8 | 19.3 |
| 21 | 815 | 41.7 | 0.69 | 1.98 | 0.23 | 2.29 | 805 | 276 | 0.82 | 4.75 | 0.009 | 92.6 | 27.0 |

| Station No. | Al | Ba | Cd | Co | Cr | Cu | Fe | Mn | Ni | Pb | Sn | Sr | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **22** | 754 | 29.3 | 0.47 | 1.17 | 0.25 | 0.50 | 574 | 234 | 0.58 | 2.93 | 0.022 | 101.1 | 20.3 |
| **23** | 52 | 12.5 | 0.18 | 0.61 | 0.02 | 0.00 | 117 | 68.8 | 0.00 | 0.04 | 0.211 | 71.6 | 5.7 |
| **24** | 439 | 19.9 | 0.29 | 0.99 | 0.12 | 0.09 | 266 | 216 | 0.33 | 0.64 | 0.072 | 92.4 | 12.5 |
| **25** | 14 | 10.3 | 0.07 | 0.32 | 0.02 | 0.19 | 33.0 | 77.6 | 0.00 | 0.00 | 0.219 | 80.5 | 1.0 |
| **27** | 353 | 14.6 | 0.28 | 0.92 | 0.11 | 0.83 | 392 | 171 | 0.31 | 1.44 | 0.007 | 51.2 | 7.9 |
| **29** | 530 | 17.8 | 0.55 | 1.57 | 0.12 | 0.38 | 676 | 216 | 0.00 | 2.19 | 0.004 | 50.5 | 18.5 |
| **30** | 391 | 18.8 | 0.60 | 1.46 | 0.02 | 0.19 | 588 | 214 | 0.00 | 2.17 | 0.004 | 50.2 | 20.1 |
| **31** | 313 | 18.6 | 0.32 | 0.88 | 0.00 | 0.18 | 330 | 165 | 0.00 | 1.50 | 0.009 | 65.9 | 10.8 |
| **32** | 1750 | 47.6 | 0.63 | 3.04 | 0.15 | 5.95 | 827 | 368 | 0.13 | 3.38 | 0.005 | 70.5 | 28.8 |
| **33** | 244 | 15.7 | 0.18 | 0.75 | 0.06 | 1.31 | 336 | 125 | 0.16 | 0.89 | 0.000 | 38.0 | 6.0 |
| **34** | 952 | 44.9 | 0.39 | 1.46 | 0.07 | 0.29 | 523 | 225 | 0.49 | 2.72 | 0.000 | 57.6 | 18.3 |
| **35** | 259 | 17.0 | 0.22 | 0.64 | 0.02 | 0.03 | 504 | 152 | 0.15 | 1.30 | 0.002 | 38.2 | 5.9 |
| **36** | 165 | 13.9 | 0.11 | 0.40 | 0.04 | 0.07 | 182 | 49.5 | 0.00 | 0.41 | 0.029 | 66.7 | 2.6 |
| **37** | 197 | 12.2 | 0.16 | 0.51 | 0.05 | 0.06 | 306 | 81.0 | 0.08 | 0.80 | 0.008 | 49.7 | 3.8 |
| **38** | 168 | 12.4 | 0.12 | 0.54 | 0.07 | 0.70 | 301 | 86.7 | 0.20 | 0.83 | 0.005 | 36.3 | 3.6 |
| **39** | 452 | 19.9 | 0.39 | 1.54 | 0.09 | 1.26 | 667 | 123 | 0.42 | 1.99 | 0.002 | 36.4 | 14.8 |
| **40** | 522 | 27.3 | 0.39 | 1.26 | 0.10 | 0.71 | 610 | 143 | 0.51 | 2.23 | 0.003 | 40.8 | 16.8 |
| **41** | 405 | 21.1 | 0.39 | 1.33 | 0.08 | 0.87 | 598 | 165 | 0.02 | 1.80 | 0.007 | 34.2 | 14.5 |
| **42** | 576 | 25.0 | 0.67 | 1.66 | 0.14 | 5.39 | 575 | 414 | 0.00 | 2.73 | 0.019 | 74.7 | 25.1 |
| **43** | 1300 | 38.1 | 0.74 | 2.24 | 0.18 | 0.12 | 695 | 480 | 0.05 | 3.96 | 0.006 | 56.3 | 38.6 |
| **44** | 268 | 12.6 | 0.39 | 0.90 | 0.01 | 1.66 | 477 | 291 | 0.28 | 1.35 | 0.014 | 42.3 | 11.5 |
| **46** | 886 | 24.1 | 0.45 | 1.47 | 0.14 | 5.39 | 588 | 255 | 0.00 | 3.25 | 0.007 | 50.7 | 22.0 |
| **47** | 1060 | 37.1 | 0.61 | 1.77 | 0.16 | 2.86 | 884 | 227 | 0.90 | 3.81 | 0.009 | 54.9 | 26.6 |
| **48** | 571 | 19.0 | 0.44 | 1.15 | 0.11 | 1.49 | 741 | 163 | 0.01 | 2.26 | 0.006 | 45.8 | 15.0 |
| **49** | 1010 | 18.2 | 0.56 | 1.93 | 0.13 | 1.28 | 595 | 234 | 0.49 | 2.92 | 0.010 | 44.0 | 27.0 |
| **50** | 1210 | 32.2 | 0.54 | 1.76 | 0.24 | 3.01 | 824 | 338 | 0.96 | 4.31 | 0.006 | 64.0 | 24.5 |
| **51** | 1310 | 45.7 | 0.67 | 1.87 | 0.22 | 2.61 | 1030 | 397 | 1.20 | 5.09 | 0.015 | 76.2 | 28.3 |
| **52** | 169 | 43 | 0.76 | 2.04 | 0.26 | 2.09 | 1060 | 425 | 1.07 | 5.56 | 0.004 | 80.9 | 31.4 |
| **53** | 917 | 25.4 | 0.51 | 1.39 | 0.41 | 0.76 | 611 | 243 | 0.19 | 3.63 | 0.006 | 77.2 | 18.7 |
| **54** | 1280 | 34.1 | 0.83 | 1.73 | 0.7 | 0.26 | 1210 | 319 | 0.01 | 4.68 | 0.013 | 86.7 | 28.4 |
| **55** | 1000 | 27.9 | 0.63 | 1.21 | 0.48 | 1.10 | 1020 | 258 | 0.00 | 3.20 | 0.005 | 79.4 | 19.6 |
| **56** | 1030 | 27.8 | 0.62 | 1.42 | 0.50 | 0.22 | 849 | 237 | 0.17 | 3.87 | 0.014 | 71.6 | 21.1 |
| **57** | 1210 | 33.5 | 0.61 | 1.28 | 0.00 | 1.12 | 987 | 411 | 0.20 | 3.65 | 0.008 | 83.3 | 22.8 |
| **58** | 1500 | 32.8 | 0.83 | 1.8 | 0.68 | 0.58 | 1160 | 513 | 0.19 | 4.99 | 0.031 | 76.0 | 29.5 |
| **59** | 1001 | 28 | 0.59 | 1.35 | 0.58 | 0.50 | 954 | 296 | 0.00 | 3.60 | 0.007 | 71.4 | 19.6 |
| **60** | 1470 | 39.7 | 0.68 | 1.76 | 0.08 | 1.89 | 1260 | 402 | 0.01 | 5.42 | 0.011 | 83.7 | 26.3 |
| **61** | 1090 | 27.3 | 0.77 | 1.64 | 0.08 | 2.28 | 1100 | 347 | 0.00 | 4.48 | 0.008 | 66.0 | 28.7 |
| **62** | 916 | 26.0 | 0.65 | 1.49 | 0.58 | 2.56 | 817 | 283 | 0.13 | 4.19 | 0.019 | 59.8 | 23.7 |

| Station No. | Al | Ba | Cd | Co | Cr | Cu | Fe | Mn | Ni | Pb | Sn | Sr | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **63** | 895 | 24.5 | 0.73 | 1.68 | 0.75 | 2.54 | 716 | 315 | 0.11 | 3.70 | 0.011 | 60.4 | 26.4 |
| **64** | 906 | 27.2 | 0.97 | 2.11 | 0.67 | 2.08 | 776 | 437 | 0.12 | 3.83 | 0.016 | 57.4 | 36.7 |
| **65** | 907 | 24.5 | 0.68 | 1.76 | 0.58 | 0.16 | 779 | 294 | 0.00 | 3.75 | 0.011 | 57.0 | 26.2 |
| **66** | 859 | 28.8 | 0.62 | 1.30 | 0.43 | 1.78 | 881 | 340 | 0.17 | 3.24 | 0.004 | 74.2 | 22.6 |
| **67** | 1140 | 32.6 | 0.55 | 1.71 | 0.70 | 1.62 | 546 | 305 | 0.16 | 3.56 | 0.004 | 76.8 | 23.6 |
| **68** | 93 | 24.4 | 0.83 | 1.75 | 0.07 | 2.55 | 732 | 336 | 0.14 | 3.43 | 0.006 | 55.2 | 31.8 |
| **69** | 889 | 24.8 | 0.94 | 1.85 | 0.6 | 0.97 | 636 | 394 | 0.14 | 3.87 | 0.007 | 55.3 | 38.5 |
| **70** | 540 | 19.9 | 0.73 | 1.49 | 0.38 | 0.91 | 575 | 281 | 0.00 | 2.46 | 0.00 | 50.6 | 26.2 |
| **71** | 621 | 20.3 | 0.65 | 1.59 | 0.03 | 0.11 | 623 | 241 | 0.00 | 2.50 | 0.006 | 52.8 | 22.5 |
| **72** | 385 | 17.7 | 0.41 | 1.22 | 0.26 | 0.43 | 484 | 206 | 0.08 | 1.76 | 0.008 | 53.0 | 13.0 |
| **73** | 1350 | 33.7 | 0.68 | 1.83 | 0.68 | 0.23 | 1080 | 410 | 0.22 | 4.90 | 0.006 | 89.2 | 26.6 |
| **74** | 825 | 27.8 | 0.33 | 1.02 | 0.26 | 0.25 | 384 | 165 | 0.00 | 2.21 | 0.075 | 107.6 | 11.1 |
| **75** | 931 | 25.9 | 0.34 | 1.07 | 0.01 | 0.00 | 426 | 131 | 0.00 | 2.77 | 0.031 | 103.6 | 11.7 |
| **76** | 1265 | 36.1 | 0.5 | 1.43 | 0.01 | 0.00 | 760 | 203 | 0.00 | 2.73 | 0.009 | 109.8 | 15.5 |
| **77** | 245 | 17.8 | 0.1 | 0.37 | 0.00 | 0.00 | 116 | 35.7 | 0.00 | 0.54 | 0.04 | 52 | 2.5 |
| **78** | 137 | 13.1 | 0.07 | 0.25 | 0.00 | 0.04 | 77 | 42.3 | 0.00 | 0.54 | 0.001 | 68.7 | 1.4 |
| **79** | 369 | 18.5 | 0.19 | 0.61 | 0.00 | 0.10 | 203 | 92.3 | 0.00 | 1.04 | 0.044 | 96.5 | 5.6 |
| **80** | 1510 | 23.8 | 0.79 | 1.85 | 0.02 | 1.04 | 1180 | 298 | 0.03 | 4.45 | 0.008 | 130.6 | 29.0 |
| **81** | 1840 | 33.4 | 0.87 | 2.19 | 0.16 | 0.41 | 1030 | 307 | 0.28 | 5.56 | 0.047 | 95.0 | 32.7 |
| **82** | 1730 | 38 | 0.9 | 2.01 | 0.66 | 0.22 | 1270 | 327 | 0.00 | 4.70 | 0.032 | 106.7 | 31.1 |
| **83** | 1680 | 29.1 | 1.12 | 1.95 | 0.00 | 0.22 | 1390 | 309 | 0.00 | 4.43 | 0.002 | 92.1 | 42.5 |
| **84** | 1480 | 29.5 | 0.93 | 2.08 | 0.04 | 0.20 | 1410 | 264 | 0.01 | 4.36 | 0.005 | 92.6 | 31.3 |
| **85** | 1550 | 32.6 | 0.98 | 2.07 | 0.47 | 1.10 | 1480 | 404 | 0.24 | 4.65 | 0.011 | 101.5 | 32.0 |
| **86** | 1800 | 36.7 | 1.05 | 2.41 | 0.73 | 0.42 | 1320 | 542 | 0.05 | 5.52 | 0.023 | 80.9 | 38.0 |
| **87** | 1890 | 36.3 | 0.94 | 2.05 | 0.05 | 1.04 | 1630 | 384 | 0.01 | 4.64 | 0.001 | 100.3 | 30.3 |
| **88** | 1651 | 36.9 | 0.78 | 1.99 | 0.08 | 0.41 | 956 | 322 | 0.30 | 5.09 | 0.009 | 92.4 | 27.2 |
| **89** | 605 | 22.2 | 0.35 | 0.97 | 0.00 | 0.00 | 461 | 210 | 0.00 | 0.92 | 0.040 | 106.9 | 10.0 |
| **90** | 558 | 19.9 | 0.28 | 0.67 | 0.00 | 0.00 | 428 | 186 | 0.02 | 1.63 | 0.016 | 73.9 | 8.0 |
| **92** | 1400 | 31.4 | 0.69 | 1.59 | 0.02 | 0.00 | 943 | 328 | 0.21 | 4.50 | 0.006 | 87.6 | 22.2 |
| **93** | 1320 | 28.2 | 0.62 | 1.6 | 0.43 | 0.27 | 779 | 418 | 0.20 | 4.16 | 0.017 | 117.8 | 21.6 |
| **94** | 1510 | 35.9 | 0.57 | 1.58 | 0.45 | 1.35 | 799 | 482 | 0.22 | 4.52 | 0.007 | 86.2 | 22.1 |
| **95** | 1580 | 36.9 | 0.71 | 1.77 | 0.01 | 1.11 | 769 | 490 | 0.22 | 5.15 | 0.015 | 82.1 | 26.1 |
| **96** | 1380 | 34.3 | 0.63 | 1.51 | 0.53 | 0.20 | 644 | 366 | 0.01 | 4.21 | 0.013 | 68.6 | 24.1 |
| **97** | 1320 | 32 | 0.69 | 1.86 | 0.03 | 0.23 | 848 | 339 | 0.18 | 4.63 | 0.008 | 72.4 | 26.8 |
| **98** | 1380 | 35.6 | 0.68 | 1.59 | 0.53 | 0.26 | 1020 | 361 | 0.20 | 4.44 | 0.013 | 78.0 | 23.9 |
| **99** | 1580 | 34.4 | 0.79 | 1.80 | 0.49 | 0.12 | 1260 | 433 | 0.25 | 4.69 | 0.018 | 89.0 | 27.4 |
| **100** | 878 | 24.8 | 0.46 | 1.01 | 0.26 | 0.10 | 775 | 235 | 0.16 | 2.56 | 0.01 | 77.4 | 13.8 |

*TABLE 2: Concentrations (μg/g) of metals in interstitial water*

| Station No. | Al | Ba | Cd | Cr | Co | Cu | Fe | Mn | Ni | Pb | Sn | Sr | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2** | 0.12 | 0.63 | 0.01 | 0.06 | 0.00 | 0.00 | 0.04 | 1.79 | 0.010 | 0.03 | 9.04 | 0.004 | 0.71 |
| **3** | 0.10 | 0.64 | 0.00 | 0.11 | 0.02 | 0.00 | 0.01 | 1.35 | 0.049 | 0.03 | 9.47 | 0.026 | 0.54 |
| **4** | 0.10 | 0.89 | 0.01 | 0.11 | 0.00 | 0.01 | 0.08 | 4.98 | 0.016 | 0.04 | 2.85 | 0.009 | 0.70 |
| **5** | 0.10 | 0.98 | 0.01 | 0.27 | 0.01 | 0.02 | 0.09 | 6.40 | 0.019 | 0.05 | 9.23 | 0.010 | 1.39 |
| **6** | 0.04 | 0.83 | 0.00 | 0.35 | 0.06 | 0.00 | 0.00 | 11.69 | 0.015 | 0.02 | 8.72 | 0.081 | 0.18 |
| **7** | 0.02 | 0.73 | 0.01 | 0.17 | 0.00 | 0.00 | 0.02 | 3.33 | 0.004 | 0.03 | 9.22 | 0.016 | 0.27 |
| **8** | 0.03 | 0.66 | 0.00 | 0.25 | 0.03 | 0.00 | 0.02 | 3.15 | 0.002 | 0.04 | 9.32 | 0.002 | 1.67 |
| **9** | 0.07 | 0.73 | 0.00 | 0.21 | 0.00 | 0.00 | 0.14 | 5.05 | 0.006 | 0.03 | 9.26 | 0.015 | 0.19 |
| **10** | 0.31 | 0.47 | 0.00 | 0.07 | 0.00 | 0.00 | 0.30 | 1.57 | 0.012 | 0.05 | 8.97 | 0.019 | 0.10 |
| **11** | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.00 | 0.000 | 0.00 |
| **12** | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.00 | 0.000 | 0.00 |
| **13** | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.00 | 0.000 | 0.00 |
| **14** | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.00 | 0.000 | 0.00 |
| **15** | 0.08 | 0.89 | 0.00 | 0.04 | 0.00 | 0.00 | 0.02 | 5.15 | 0.003 | 0.03 | 8.40 | 0.032 | 0.17 |
| **16** | 0.08 | 0.65 | 0.00 | 0.05 | 0.00 | 0.00 | 0.03 | 1.12 | 0.000 | 0.02 | 8.62 | 0.020 | 0.08 |
| **17** | 0.03 | 0.77 | 0.01 | 0.08 | 0.01 | 0.00 | 0.02 | 1.39 | 0.000 | 0.01 | 8.8 | 0.005 | 0.07 |
| **18** | 0.04 | 0.94 | 0.00 | 0.02 | 0.00 | 0.00 | 0.02 | 8.15 | 0.004 | 0.00 | 8.65 | 0.010 | 0.13 |
| **19** | 0.01 | 2.34 | 0.01 | 0.13 | 0.01 | 0.00 | 0.45 | 12.39 | 0.000 | 0.03 | 8.74 | 0.010 | 0.08 |
| **20** | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.00 | 0.000 | 0.00 |
| **21** | 0.08 | 2.66 | 0.00 | 0.23 | 0.00 | 0.01 | 5.32 | 28.37 | 0.000 | 0.02 | 8.31 | 0.002 | 0.33 |
| **22** | 0.00 | 1.31 | 0.01 | 0.25 | 0.00 | 0.00 | 0.01 | 7.32 | 0.002 | 0.01 | 8.97 | 0.002 | 0.07 |
| **23** | 0.04 | 0.51 | 0.00 | 0.02 | 0.00 | 0.00 | 0.01 | 1.69 | 0.011 | 0.01 | 8.00 | 0.039 | 0.10 |
| **24** | 0.17 | 0.69 | 0.00 | 0.12 | 0.00 | 0.00 | 0.04 | 4.56 | 0.006 | 0.02 | 8.23 | 0.000 | 0.24 |
| **25** | 0.03 | 0.79 | 0.00 | 0.02 | 0.00 | 0.00 | 0.02 | 1.78 | 0.000 | 0.02 | 8.80 | 0.016 | 0.13 |
| **27** | 0.11 | 1.16 | 0.00 | 0.11 | 0.01 | 0.00 | 0.04 | 2.97 | 0.000 | 0.01 | 8.36 | 0.008 | 0.09 |
| **29** | 0.00 | 1.75 | 0.00 | 0.12 | 0.00 | 0.00 | 0.42 | 4.31 | 0.009 | 0.01 | 8.37 | 0.015 | 0.04 |
| **30** | 0.01 | 1.46 | 0.00 | 0.02 | 0.01 | 0.00 | 0.04 | 5.08 | 0.000 | 0.00 | 8.31 | 0.006 | 0.08 |
| **31** | 0.07 | 1.45 | 0.00 | 0.00 | 0.00 | 0.01 | 0.05 | 8.76 | 0.001 | 0.01 | 8.34 | 0.005 | 0.11 |
| **32** | 0.24 | 5.31 | 0.02 | 0.15 | 0.00 | 0.00 | 39.89 | 38.6 | 0.008 | 0.02 | 8.02 | 0.000 | 0.18 |
| **33** | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.001 | 0.00 | 0.00 | 0.000 | 0.00 |
| **34** | 0.10 | 3.17 | 0.00 | 0.07 | 0.00 | 0.00 | 2.23 | 25.72 | 0.012 | 0.00 | 8.21 | 0.004 | 0.11 |
| **35** | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.00 | 0.000 | 0.00 |
| **36** | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.00 | 0.000 | 0.00 |
| **37** | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.00 | 0.000 | 0.00 |
| **38** | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.00 | 0.000 | 0.00 |
| **39** | 0.16 | 1.50 | 0.00 | 0.09 | 0.02 | 0.00 | 0.26 | 9.43 | 0.000 | 0.03 | 8.29 | 0.000 | 0.11 |
| **40** | 0.13 | 2.04 | 0.00 | 0.10 | 0.01 | 0.00 | 0.07 | 12.15 | 0.000 | 0.02 | 8.04 | 0.002 | 0.09 |

| Station No. | Al | Ba | Cd | Cr | Co | Cu | Fe | Mn | Ni | Pb | Sn | Sr | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **41** | 0.15 | 1.71 | 0.00 | 0.08 | 0.00 | 0.00 | 0.06 | 19.24 | 0.007 | 0.03 | 8.33 | 0.004 | 0.09 |
| **42** | 0.17 | 1.25 | 0.00 | 0.14 | 0.00 | 0.00 | 0.05 | 15.32 | 0.000 | 0.04 | 8.25 | 0.002 | 0.07 |
| **43** | 0.08 | 2.16 | 0.00 | 0.18 | 0.00 | 0.00 | 1.98 | 37.92 | 0.000 | 0.03 | 8.24 | 0.001 | 0.18 |
| **44** | 0.1 | 1.46 | 0.01 | 0.01 | 0.00 | 0.00 | 0.04 | 13.54 | 0.000 | 0.03 | 8.59 | 0.012 | 0.12 |
| **46** | 0.26 | 1.29 | 0.00 | 0.14 | 0.01 | 0.01 | 0.06 | 6.38 | 0.000 | 0.04 | 8.48 | 0.009 | 0.24 |
| **47** | 0.26 | 4.19 | 0.01 | 0.16 | 0.00 | 0.00 | 17.64 | 42.81 | 0.000 | 0.02 | 8.59 | 0.000 | 0.22 |
| **48** | 0.16 | 1.10 | 0.00 | 0.11 | 0.03 | 0.00 | 0.47 | 4.13 | 0.000 | 0.04 | 8.94 | 0.009 | 0.10 |
| **49** | 0.25 | 1.23 | 0.01 | 0.13 | 0.02 | 0.00 | 0.25 | 4.48 | 0.005 | 0.03 | 8.87 | 0.010 | 0.00 |
| **50** | 0.18 | 1.39 | 0.00 | 0.24 | 0.00 | 0.00 | 0.04 | 10.95 | 0.022 | 0.00 | 7.75 | 0.002 | 0.06 |
| **51** | 0.15 | 1.50 | 0.00 | 0.22 | 0.00 | 0.00 | 0.57 | 56.46 | 0.015 | 0.02 | 7.38 | 0.001 | 0.16 |
| **52** | 0.17 | 1.45 | 0.00 | 0.26 | 0.00 | 0.00 | 1.89 | 31.55 | 0.009 | 0.01 | 8.08 | 0.004 | 0.10 |
| **53** | 0.11 | 0.97 | 0.00 | 0.41 | 0.00 | 0.00 | 0.04 | 10.22 | 0.005 | 0.01 | 8.24 | 0.014 | 0.07 |
| **54** | 0.06 | 1.23 | 0.00 | 0.70 | 0.00 | 0.00 | 0.31 | 11.43 | 0.012 | 0.00 | 8.24 | 0.005 | 0.19 |
| **55** | 0.09 | 1.06 | 0.00 | 0.48 | 0.02 | 0.00 | 0.07 | 12.82 | 0.006 | 0.01 | 7.98 | 0.008 | 0.07 |
| **56** | 0.05 | 0.87 | 0.00 | 0.50 | 0.03 | 0.00 | 0.07 | 9.41 | 0.006 | 0.00 | 7.81 | 0.007 | 0.09 |
| **57** | 0.28 | 1.31 | 0.00 | 0.00 | 0.03 | 0.00 | 0.13 | 13.34 | 0.005 | 0.02 | 8.21 | 0.015 | 0.11 |
| **58** | 0.10 | 1.09 | 0.00 | 0.68 | 0.02 | 0.00 | 0.73 | 28.89 | 0.002 | 0.01 | 8.07 | 0.003 | 0.12 |
| **59** | 0.14 | 1.05 | 0.00 | 0.58 | 0.05 | 0.00 | 0.09 | 20.80 | 0.011 | 0.00 | 8.00 | 0.008 | 0.22 |
| **60** | 0.17 | 1.50 | 0.00 | 0.08 | 0.00 | 0.00 | 0.26 | 30.38 | 0.003 | 0.02 | 8.30 | 0.005 | 0.07 |
| **61** | 0.03 | 1.17 | 0.00 | 0.08 | 0.00 | 0.00 | 0.05 | 11.51 | 0.002 | 0.00 | 8.20 | 0.005 | 0.07 |
| **62** | 0.31 | 1.13 | 0.00 | 0.58 | 0.00 | 0.00 | 0.12 | 17.97 | 0.002 | 0.02 | 7.83 | 0.010 | 1.87 |
| **63** | 0.11 | 1.31 | 0.00 | 0.75 | 0.01 | 0.00 | 0.05 | 15.70 | 0.000 | 0.02 | 8.31 | 0.012 | 0.07 |
| **64** | 0.12 | 1.44 | 0.00 | 0.67 | 0.00 | 0.00 | 0.09 | 32.37 | 0.002 | 0.00 | 8.11 | 0.005 | 0.14 |
| **65** | 0.21 | 1.18 | 0.00 | 0.58 | 0.00 | 0.00 | 0.06 | 14.38 | 0.001 | 0.01 | 8.15 | 0.003 | 0.06 |
| **66** | 0.07 | 1.52 | 0.00 | 0.43 | 0.00 | 0.00 | 0.03 | 12.54 | 0.004 | 0.00 | 7.98 | 0.009 | 0.05 |
| **67** | 0.15 | 1.07 | 0.00 | 0.70 | 0.00 | 0.00 | 0.03 | 11.19 | 0.003 | 0.02 | 7.61 | 0.006 | 0.06 |
| **68** | 0.17 | 1.32 | 0.00 | 0.07 | 0.00 | 0.00 | 0.06 | 16.67 | 0.002 | 0.02 | 8.20 | 0.017 | 0.06 |
| **69** | 0.10 | 1.13 | 0.00 | 0.60 | 0.00 | 0.00 | 0.08 | 16.19 | 0.013 | 0.02 | 8.03 | 0.004 | 0.12 |
| **70** | 0.14 | 1.04 | 0.00 | 0.38 | 0.01 | 0.00 | 0.31 | 16.70 | 0.001 | 0.00 | 8.12 | 0.005 | 1.56 |
| **71** | 0.17 | 1.19 | 0.00 | 0.03 | 0.07 | 0.00 | 0.09 | 14.39 | 0.000 | 0.01 | 8.11 | 0.026 | 0.11 |
| **72** | 0.07 | 1.19 | 0.00 | 0.26 | 0.00 | 0.00 | 0.00 | 15.56 | 0.013 | 0.01 | 8.06 | 0.003 | 0.10 |
| **73** | 0.27 | 1.25 | 0.00 | 0.68 | 0.01 | 0.00 | 0.08 | 21.94 | 0.009 | 0.01 | 8.51 | 0.004 | 0.08 |
| **74** | 0.12 | 0.94 | 0.00 | 0.26 | 0.01 | 0.00 | 0.02 | 3.24 | 0.003 | 0.02 | 8.54 | 0.010 | 0.18 |
| **75** | 0.01 | 0.65 | 0.00 | 0.01 | 0.02 | 0.00 | 0.00 | 2.23 | 0.007 | 0.00 | 8.08 | 0.001 | 0.09 |
| **76** | 0.14 | 0.70 | 0.00 | 0.01 | 0.00 | 0.00 | 0.06 | 3.33 | 0.013 | 0.02 | 8.18 | 0.000 | 0.24 |
| **77** | 0.05 | 0.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.83 | 0.003 | 0.02 | 8.06 | 0.010 | 0.09 |
| **78** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.00 | 0.00 | 0.000 | 0.00 |
| **79** | 0.05 | 0.53 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 2.63 | 0.000 | 0.01 | 8.25 | 0.000 | 0.10 |

| Station No. | Al | Ba | Cd | Cr | Co | Cu | Fe | Mn | Ni | Pb | Sn | Sr | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **80** | 0.08 | 0.61 | 0.00 | 0.02 | 0.03 | 0.00 | 0.02 | 3.53 | 0.011 | 0.01 | 8.29 | 0.001 | 0.22 |
| **81** | 0.10 | 0.52 | 0.00 | 0.16 | 0.02 | 0.00 | 0.04 | 4.80 | 0.000 | 0.01 | 8.35 | 0.000 | 0.08 |
| **82** | 0.03 | 0.54 | 0.00 | 0.66 | 0.01 | 0.00 | 0.01 | 6.37 | 0.005 | 0.00 | 8.25 | 0.016 | 0.13 |
| **83** | 0.08 | 0.54 | 0.00 | 0.00 | 0.05 | 0.00 | 0.02 | 3.53 | 0.005 | 0.01 | 8.17 | 0.021 | 0.09 |
| **84** | 0.05 | 0.59 | 0.00 | 0.04 | 0.00 | 0.00 | 0.06 | 2.76 | 0.046 | 0.00 | 8.06 | 0.020 | 0.11 |
| **85** | 0.07 | 0.83 | 0.00 | 0.47 | 0.02 | 0.00 | 0.02 | 11.80 | 0.008 | 0.01 | 8.11 | 0.004 | 0.18 |
| **86** | 0.22 | 0.96 | 0.00 | 0.73 | 0.00 | 0.00 | 0.10 | 20.66 | 0.013 | 0.02 | 7.96 | 0.002 | 0.16 |
| **87** | 0.08 | 0.64 | 0.00 | 0.05 | 0.00 | 0.00 | 0.01 | 4.65 | 0.005 | 0.01 | 8.13 | 0.000 | 0.06 |
| **88** | 0.05 | 0.63 | 0.00 | 0.08 | 0.00 | 0.00 | 0.01 | 5.24 | 0.004 | 0.01 | 8.09 | 0.012 | 0.14 |
| **89** | 0.03 | 0.59 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.22 | 0.007 | 0.02 | 8.01 | 0.009 | 0.07 |
| **90** | 0.02 | 0.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.87 | 0.009 | 0.03 | 7.99 | 0.026 | 0.08 |
| **92** | 0.11 | 0.60 | 0.00 | 0.02 | 0.00 | 0.00 | 0.04 | 5.41 | 0.000 | 0.00 | 7.95 | 0.017 | 0.07 |
| **93** | 0.06 | 0.79 | 0.00 | 0.43 | 0.00 | 0.00 | 0.01 | 10.97 | 0.008 | 0.00 | 7.63 | 0.000 | 0.08 |
| **94** | 0.09 | 0.87 | 0.00 | 0.45 | 0.01 | 0.00 | 0.01 | 15.51 | 0.023 | 0.00 | 7.88 | 0.001 | 0.06 |
| **95** | 0.11 | 0.84 | 0.00 | 0.01 | 0.04 | 0.00 | 0.08 | 26.02 | 0.008 | 0.00 | 7.90 | 0.014 | 0.08 |
| **96** | 0.15 | 0.95 | 0.00 | 0.53 | 0.03 | 0.00 | 0.25 | 31.53 | 0.010 | 0.00 | 7.90 | 0.010 | 0.22 |
| **97** | 0.24 | 0.92 | 0.00 | 0.03 | 0.01 | 0.00 | 0.11 | 9.43 | 0.013 | 0.01 | 7.77 | 0.004 | 0.11 |
| **98** | 0.17 | 1.26 | 0.00 | 0.53 | 0.01 | 0.00 | 0.07 | 21.00 | 0.010 | 0.00 | 8.27 | 0.007 | 0.10 |
| **99** | 0.11 | 0.77 | 0.00 | 0.49 | 0.03 | 0.00 | 0.02 | 10.65 | 0.095 | 0.01 | 7.83 | 0.005 | 0.28 |
| **100** | 0.07 | 0.86 | 0.00 | 0.26 | 0.02 | 0.00 | 0.03 | 9.99 | 0.006 | 0.00 | 8.11 | 0.017 | 0.11 |

*Table 4: Correlation co-efficient between metals in sediments of Ariake bay.*
*r = correlation coefficient; $R^2$ = coefficient of determination*

| Metals | | Al | Ba | Cd | Co | Cr | Cu | Fe | Mn | Ni | Pb | Sn | Sr | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Al** | r | 1.00 | 0.80 | 0.76 | 0.81 | 0.87 | 0.00 | 0.81 | 0.72 | 0.00 | 0.76 | 0.10 | 0.33 | 0.78 |
| | $R^2$ | 1.00 | 0.64 | 0.58 | 0.66 | 0.76 | 0.00 | 0.66 | 0.52 | 0.00 | 0.56 | 0.01 | 0.11 | 0.61 |
| **Ba** | r | | 1.00 | 0.45 | 0.81 | 0.84 | 0.02 | 0.74 | 0.73 | 0.12 | 0.67 | 0.14 | 0.20 | 0.75 |
| | $R^2$ | | 1.00 | 0.20 | 0.66 | 0.70 | 0.00 | 0.55 | 0.53 | 0.01 | 0.45 | 0.02 | 0.04 | 0.57 |
| **Cd** | r | | | 1.00 | 0.87 | 0.86 | 0.01 | 0.80 | 0.77 | 0.00 | 0.74 | 0.12 | 0.15 | 0.96 |
| | $R^2$ | | | 1.00 | 0.75 | 0.74 | 0.00 | 0.64 | 0.59 | 0.00 | 0.55 | 0.01 | 0.02 | 0.93 |
| **Co** | r | | | | 1.00 | 0.87 | 0.03 | 0.79 | 0.78 | 0.03 | 0.77 | 0.16 | 0.11 | 0.93 |
| | $R^2$ | | | | 1.00 | 0.75 | 0.00 | 0.62 | 0.61 | 0.00 | 0.60 | 0.02 | 0.01 | 0.87 |
| **Cr** | r | | | | | 1.00 | 0.00 | 0.84 | 0.80 | 0.01 | 0.24 | 0.03 | 0.03 | 0.89 |
| | $R^2$ | | | | | 1.00 | 0.00 | 0.70 | 0.64 | 0.00 | 0.06 | 0.00 | 0.00 | 0.80 |
| **Cu** | r | | | | | | 1.00 | 0.00 | 0.02 | 0.07 | 0.01 | 0.00 | 0.00 | 0.20 |
| | $R^2$ | | | | | | 1.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.04 |
| **Fe** | r | | | | | | | 1.00 | 0.73 | 0.00 | 0.70 | 0.14 | 0.19 | 0.79 |
| | $R^2$ | | | | | | | 1.00 | 0.53 | 0.00 | 0.49 | 0.02 | 0.04 | 0.62 |
| **Mn** | r | | | | | | | | 1.00 | 0.02 | 0.64 | 0.12 | 0.11 | 0.80 |
| | $R^2$ | | | | | | | | 1.00 | 0.00 | 0.41 | 0.01 | 0.01 | 0.64 |
| **Ni** | r | | | | | | | | | 1.00 | 0.05 | 0.04 | 0.00 | 0.21 |
| | $R^2$ | | | | | | | | | 1.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| **Pb** | r | | | | | | | | | | 1.00 | 0.16 | 0.21 | 0.49 |
| | $R^2$ | | | | | | | | | | 1.00 | 0.02 | 0.04 | 0.24 |
| **Sn** | r | | | | | | | | | | | 1.00 | 0.01 | -0.40 |
| | $R^2$ | | | | | | | | | | | 1.00 | 0.00 | 0.16 |
| **Sr** | r | | | | | | | | | | | | 1.00 | 0.30 |
| | $R^2$ | | | | | | | | | | | | 1.00 | 0.09 |
| **Zn** | r | | | | | | | | | | | | | 1.00 |
| | $R^2$ | | | | | | | | | | | | | 1.00 |

*TABLE 5: Enrichment factors of metals at different stations.*

| Station No. | Ba | Cd | Co | Cr | Cu | Fe | Mn | Ni | Pb | Sn | Sr | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 9.74 | 768 | 8.52 | 0.45 | 1.81 | 0.00 | 34.1 | 1.43 | 25.6 | 3.09 | 95.87 | 31.97 |
| 3 | 4.95 | 512 | 6.92 | 0.21 | 0.90 | 1.94 | 23.6 | 1.30 | 16.1 | 5.06 | 43.37 | 21.88 |
| 4 | 2.97 | 385 | 3.94 | 0.06 | 2.31 | 1.13 | 18.0 | 0.02 | 22.1 | 0.28 | 14.21 | 26.29 |
| 5 | 2.97 | 344 | 3.74 | 0.13 | 3.99 | 0.85 | 20.7 | 0.68 | 19.1 | 0.26 | 15.95 | 25.60 |
| 6 | 2.79 | 415 | 4.51 | 0.14 | 4.88 | 1.12 | 28.7 | 0.01 | 20.4 | 1.88 | 14.11 | 24.45 |
| 7 | 3.71 | 540 | 4.24 | 0.15 | 9.05 | 1.21 | 21.5 | 0.75 | 18.7 | 2.00 | 26.15 | 24.66 |
| 8 | 2.65 | 519 | 4.89 | 0.13 | 2.83 | 0.72 | 22.5 | 0.71 | 19.7 | 0.32 | 14.09 | 30.05 |
| 9 | 4.23 | 901 | 6.51 | 0.16 | 1.75 | 0.43 | 28.1 | 0.01 | 23.4 | 1.80 | 26.94 | 41.58 |
| 10 | 8.27 | 464 | 6.48 | 0.69 | 1.20 | 4.60 | 26.0 | 0.07 | 21.5 | 20.55 | 82.64 | 20.37 |
| 11 | 17.38 | 519 | 7.75 | 0.35 | 0.00 | 2.02 | 50.1 | 0.00 | 20.9 | 12.24 | 139.60 | 17.51 |
| 12 | 6.35 | 570 | 6.85 | 0.21 | 2.40 | 2.03 | 23.3 | 0.00 | 18.8 | 3.29 | 49.23 | 22.25 |
| 13 | 7.66 | 692 | 8.88 | 0.21 | 0.00 | 2.32 | 111.0 | 0.93 | 22.4 | 1.22 | 57.30 | 34.11 |
| 14 | 13.18 | 654 | 9.97 | 0.27 | 1.57 | 2.90 | 331.0 | 1.19 | 22.9 | 17.43 | 117.90 | 27.12 |
| 15 | 13.10 | 679 | 7.53 | 0.22 | 1.91 | 1.72 | 67.9 | 1.06 | 13.1 | 23.84 | 135.50 | 23.33 |
| 16 | 17.54 | 1082 | 9.08 | 0.29 | 2.38 | 2.31 | 76.1 | 1.07 | 28.5 | 37.15 | 176.70 | 44.64 |
| 17 | 8.65 | 602 | 6.18 | 0.21 | 125.40 | 1.32 | 39.8 | 0.00 | 17.4 | 17.50 | 84.71 | 28.89 |
| 18 | 10.49 | 778 | 8.24 | 0.07 | 14.48 | 1.99 | 115.0 | 0.03 | 28.0 | 4.32 | 78.92 | 45.53 |
| 19 | 14.16 | 1411 | 10.50 | 0.30 | 1.42 | 3.74 | 70.6 | 1.84 | 39.9 | 1.87 | 57.84 | 70.33 |
| 20 | 10.79 | 3664 | 10.85 | 0.06 | 49.95 | 1.94 | 120.0 | 0.00 | 37.0 | 12.25 | 86.90 | 128.50 |
| 21 | 7.42 | 673 | 8.06 | 0.19 | 8.95 | 1.83 | 41.5 | 1.43 | 31.4 | 0.46 | 29.60 | 41.09 |
| 22 | 5.53 | 500 | 5.15 | 0.21 | 2.12 | 1.41 | 35.7 | 1.09 | 20.9 | 1.12 | 34.93 | 33.04 |
| 23 | 34.26 | 2843 | 39.14 | 0.56 | 0.00 | 4.17 | 150.0 | 0.31 | 5.5 | 166.70 | 366.50 | 136.50 |
| 24 | 6.41 | 541 | 7.50 | 0.18 | 0.62 | 1.12 | 55.9 | 1.10 | 8.1 | 5.68 | 54.82 | 35.43 |
| 25 | 109.50 | 4167 | 77.32 | 0.88 | 45.13 | 4.51 | 638.0 | 0.00 | 8.2 | 589.00 | 1543.90 | 97.69 |
| 27 | 6.11 | 636 | 8.78 | 0.23 | 7.54 | 2.05 | 54.9 | 1.30 | 22.0 | 1.43 | 40.35 | 27.92 |
| 29 | 5.03 | 835 | 9.82 | 0.17 | 2.31 | 2.35 | 46.2 | 0.00 | 22.2 | 1.27 | 26.52 | 42.76 |
| 30 | 7.06 | 1219 | 12.42 | 0.06 | 1.51 | 2.78 | 62.5 | 0.03 | 29.9 | 0.86 | 35.76 | 63.11 |
| 31 | 8.72 | 824 | 9.37 | 0.07 | 1.91 | 1.95 | 62.0 | 0.00 | 25.7 | 1.53 | 56.70 | 42.70 |
| 32 | 4.13 | 292 | 5.78 | 0.06 | 10.85 | 0.91 | 25.9 | 0.12 | 10.4 | 0.10 | 10.74 | 20.32 |
| 33 | 8.81 | 581 | 10.24 | 0.16 | 17.16 | 2.54 | 57.3 | 0.92 | 19.6 | 0.00 | 37.29 | 30.07 |
| 34 | 6.88 | 331 | 5.10 | 0.04 | 0.98 | 1.02 | 29.3 | 0.74 | 15.3 | 0.14 | 16.52 | 23.74 |
| 35 | 8.97 | 673 | 8.21 | 0.05 | 0.43 | 3.59 | 65.6 | 0.81 | 26.9 | 0.25 | 35.33 | 28.01 |
| 36 | 11.44 | 515 | 8.05 | 0.16 | 1.32 | 2.03 | 33.2 | 0.00 | 13.2 | 6.13 | 96.48 | 19.26 |
| 37 | 8.43 | 654 | 8.51 | 0.17 | 1.02 | 2.86 | 45.6 | 0.55 | 21.8 | 1.45 | 60.18 | 23.36 |
| 38 | 10.07 | 591 | 10.71 | 0.27 | 13.28 | 3.31 | 57.5 | 1.66 | 26.5 | 0.99 | 51.69 | 26.24 |
| 39 | 6.44 | 697 | 11.40 | 0.12 | 8.91 | 2.72 | 32.5 | 1.34 | 24.0 | 0.18 | 23.60 | 40.33 |
| 40 | 7.66 | 604 | 8.09 | 0.13 | 4.35 | 2.16 | 33.0 | 1.39 | 23.2 | 0.36 | 22.37 | 39.55 |
| 41 | 7.67 | 779 | 10.94 | 0.13 | 6.83 | 2.72 | 50.7 | 0.07 | 24.2 | 0.94 | 25.14 | 44.13 |

| Station No. | Ba | Cd | Co | Cr | Cu | Fe | Mn | Ni | Pb | Sn | Sr | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **42** | 6.22 | 925 | 9.58 | 0.16 | 29.80 | 1.84 | 82.9 | 0.00 | 25.8 | 1.28 | 34.41 | 53.49 |
| **43** | 4.21 | 454 | 5.70 | 0.09 | 0.29 | 0.99 | 44.2 | 0.05 | 16.4 | 0.19 | 11.85 | 36.43 |
| **44** | 7.16 | 1177 | 11.16 | 0.04 | 19.71 | 3.28 | 126.0 | 1.50 | 27.7 | 3.34 | 45.36 | 53.03 |
| **46** | 3.90 | 407 | 5.54 | 0.10 | 19.38 | 1.22 | 32.8 | 0.01 | 19.9 | 0.65 | 15.96 | 30.66 |
| **47** | 5.31 | 467 | 5.57 | 0.10 | 8.59 | 1.57 | 28.4 | 1.24 | 19.4 | 0.29 | 14.34 | 31.04 |
| **48** | 4.80 | 623 | 6.88 | 0.13 | 8.31 | 2.39 | 32.6 | 0.04 | 21.6 | 0.89 | 22.91 | 32.44 |
| **49** | 2.61 | 445 | 6.37 | 0.08 | 4.02 | 1.08 | 26.1 | 0.69 | 15.6 | 0.66 | 12.45 | 32.55 |
| **50** | 3.80 | 360 | 4.83 | 0.14 | 7.95 | 1.26 | 32.2 | 1.13 | 19.2 | 0.22 | 14.20 | 24.89 |
| **51** | 4.91 | 406 | 4.75 | 0.11 | 6.34 | 1.45 | 38.5 | 1.32 | 20.98 | 0.41 | 15.25 | 26.59 |
| **52** | 35.84 | 3613 | 40.00 | 1.04 | 39.50 | 11.64 | 300.7 | 9.05 | 177.20 | 1.49 | 125.90 | 228.20 |
| **53** | 3.92 | 444 | 5.03 | 0.28 | 2.64 | 1.23 | 30.8 | 0.30 | 21.33 | 0.76 | 22.28 | 25.06 |
| **54** | 3.78 | 517 | 4.49 | 0.35 | 0.67 | 1.76 | 28.8 | 0.02 | 19.71 | 0.50 | 17.78 | 27.46 |
| **55** | 3.93 | 498 | 4.05 | 0.57 | 3.48 | 1.88 | 30.0 | 0.01 | 17.18 | 0.43 | 20.77 | 24.01 |
| **56** | 3.79 | 481 | 4.66 | 0.32 | 0.69 | 1.51 | 26.6 | 0.24 | 20.15 | 0.71 | 18.36 | 25.12 |
| **57** | 3.92 | 405 | 3.58 | 0.02 | 2.94 | 1.51 | 39.1 | 0.24 | 16.33 | 0.64 | 18.10 | 23.20 |
| **58** | 3.08 | 441 | 4.02 | 0.29 | 1.23 | 1.43 | 40.1 | 0.18 | 17.93 | 0.79 | 13.38 | 24.16 |
| **59** | 3.94 | 474 | 4.60 | 0.37 | 1.60 | 1.75 | 35.1 | 0.01 | 19.27 | 0.53 | 18.88 | 24.15 |
| **60** | 3.81 | 371 | 3.96 | 0.04 | 4.08 | 1.58 | 32.6 | 0.01 | 19.87 | 0.37 | 14.93 | 21.92 |
| **61** | 3.56 | 566 | 4.98 | 0.05 | 6.65 | 1.86 | 36.5 | 0.01 | 22.05 | 0.41 | 16.25 | 32.24 |
| **62** | 4.04 | 569 | 5.41 | 0.40 | 8.90 | 1.64 | 36.5 | 0.21 | 24.75 | 1.09 | 17.65 | 34.23 |
| **63** | 3.93 | 649 | 6.26 | 0.53 | 9.05 | 1.47 | 41.1 | 0.17 | 22.30 | 0.87 | 18.35 | 36.23 |
| **64** | 4.31 | 852 | 7.74 | 0.48 | 7.30 | 1.58 | 57.6 | 0.20 | 22.77 | 0.80 | 17.28 | 49.87 |
| **65** | 3.86 | 595 | 6.44 | 0.41 | 0.56 | 1.58 | 37.8 | 0.00 | 22.31 | 0.52 | 17.16 | 35.39 |
| **66** | 4.81 | 576 | 5.02 | 0.34 | 6.59 | 1.89 | 45.7 | 0.29 | 20.31 | 0.52 | 22.89 | 32.33 |
| **67** | 4.04 | 387 | 4.99 | 0.40 | 4.56 | 0.89 | 31.0 | 0.20 | 16.94 | 0.31 | 17.76 | 25.52 |
| **68** | 37.57 | 7104 | 62.40 | 0.65 | 87.10 | 14.47 | 420.0 | 2.11 | 198.90 | 8.45 | 162.50 | 419.10 |
| **69** | 3.98 | 843 | 6.88 | 0.42 | 3.46 | 1.32 | 51.2 | 0.25 | 23.49 | 0.42 | 17.03 | 53.22 |
| **70** | 5.29 | 1075 | 9.24 | 0.44 | 5.39 | 1.97 | 61.3 | 0.00 | 24.50 | 0.32 | 26.00 | 62.84 |
| **71** | 4.70 | 838 | 8.87 | 0.03 | 0.56 | 1.85 | 45.6 | 0.00 | 21.67 | 1.80 | 23.44 | 44.46 |
| **72** | 6.68 | 863 | 10.40 | 0.43 | 3.55 | 2.32 | 64.2 | 0.32 | 24.73 | 1.03 | 37.92 | 41.65 |
| **73** | 3.54 | 405 | 4.54 | 0.32 | 0.55 | 1.48 | 35.6 | 0.24 | 19.63 | 0.24 | 17.35 | 24.22 |
| **74** | 4.75 | 317 | 4.13 | 0.20 | 0.98 | 0.86 | 22.7 | 0.01 | 14.52 | 3.59 | 33.62 | 16.79 |
| **75** | 3.88 | 295 | 3.90 | 0.02 | 0.00 | 0.84 | 15.9 | 0.01 | 16.02 | 1.19 | 28.68 | 15.55 |
| **76** | 3.96 | 318 | 3.75 | 0.02 | 0.00 | 1.11 | 18.1 | 0.02 | 11.70 | 0.24 | 22.29 | 15.21 |
| **77** | 10.24 | 343 | 5.01 | 0.01 | 0.00 | 0.88 | 17.4 | 0.02 | 12.29 | 7.06 | 58.55 | 13.01 |
| **78** | 13.04 | 391 | 6.04 | 0.00 | 1.03 | 1.04 | 34.2 | 0.00 | 21.19 | 0.29 | 119.60 | 12.64 |
| **79** | 7.03 | 425 | 5.66 | 0.05 | 0.89 | 1.01 | 28.5 | 0.00 | 15.35 | 4.17 | 67.76 | 19.06 |
| **80** | 2.20 | 418 | 4.10 | 0.01 | 2.19 | 1.44 | 22.1 | 0.04 | 15.83 | 0.19 | 21.91 | 23.59 |

| Station No. | Ba | Cd | Co | Cr | Cu | Fe | Mn | Ni | Pb | Sn | Sr | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **81** | 2.51 | 375 | 3.98 | 0.06 | 0.70 | 1.03 | 18.8 | 0.22 | 16.25 | 0.88 | 13.39 | 21.76 |
| **82** | 3.04 | 416 | 3.87 | 0.25 | 0.41 | 1.35 | 21.4 | 0.00 | 14.60 | 0.96 | 15.87 | 22.08 |
| **83** | 2.41 | 533 | 3.94 | 0.01 | 0.42 | 1.53 | 20.6 | 0.00 | 14.21 | 0.48 | 14.26 | 31.07 |
| **84** | 2.77 | 502 | 4.68 | 0.03 | 0.42 | 1.76 | 20.0 | 0.05 | 15.83 | 0.60 | 16.25 | 25.96 |
| **85** | 2.94 | 506 | 4.47 | 0.20 | 2.27 | 1.76 | 29.8 | 0.23 | 16.18 | 0.34 | 16.90 | 25.45 |
| **86** | 2.85 | 464 | 4.43 | 0.26 | 0.73 | 1.35 | 34.6 | 0.05 | 16.52 | 0.50 | 11.77 | 25.91 |
| **87** | 2.67 | 396 | 3.60 | 0.03 | 1.75 | 1.60 | 22.9 | 0.01 | 13.24 | 0.02 | 13.74 | 19.72 |
| **88** | 3.09 | 379 | 4.00 | 0.04 | 0.79 | 1.07 | 22.0 | 0.27 | 16.63 | 0.43 | 14.54 | 20.31 |
| **89** | 5.14 | 461 | 5.31 | 0.03 | 0.00 | 1.41 | 39.3 | 0.02 | 8.29 | 2.80 | 45.39 | 20.37 |
| **90** | 5.02 | 400 | 3.99 | 0.04 | 0.00 | 1.42 | 39.3 | 0.08 | 16.00 | 2.65 | 35.12 | 17.65 |
| **92** | 3.12 | 395 | 3.77 | 0.01 | 0.00 | 1.24 | 26.4 | 0.22 | 17.31 | 0.55 | 16.32 | 19.47 |
| **93** | 2.98 | 374 | 4.01 | 0.22 | 0.65 | 1.08 | 36.0 | 0.24 | 16.89 | 0.43 | 22.63 | 20.06 |
| **94** | 3.33 | 305 | 3.51 | 0.19 | 2.86 | 0.98 | 36.7 | 0.21 | 16.14 | 0.18 | 14.92 | 18.04 |
| **95** | 3.25 | 360 | 3.78 | 0.01 | 2.24 | 0.90 | 36.2 | 0.21 | 17.51 | 0.63 | 13.60 | 20.26 |
| **96** | 3.48 | 365 | 3.71 | 0.24 | 0.45 | 0.86 | 32.0 | 0.02 | 16.41 | 0.57 | 13.25 | 21.56 |
| **97** | 3.40 | 419 | 4.69 | 0.03 | 0.54 | 1.18 | 29.3 | 0.21 | 18.88 | 0.33 | 14.51 | 24.91 |
| **98** | 3.63 | 394 | 3.82 | 0.26 | 0.60 | 1.36 | 30.7 | 0.30 | 17.23 | 0.49 | 14.88 | 21.18 |
| **99** | 3.03 | 398 | 3.84 | 0.21 | 0.24 | 1.47 | 31.2 | 0.23 | 16.01 | 0.49 | 14.65 | 21.47 |
| **100** | 3.98 | 424 | 3.89 | 0.19 | 0.38 | 1.63 | 31.1 | 0.29 | 15.69 | 1.06 | 23.27 | 19.41 |

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