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# Statistical Assessment of Heavy Metal Distribution and Contamination of Beach Sands of Antalya-Turkey: an Approach to the Multivariate Analysis Techniques

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**Abstract.** The distribution of heavy metal concentrations in the beach sand samples collected from 44 different locations along the Manavgat Alanya coastline of Antalya covering different coastal sandy beaches was studied. The average concentration level of these metals in the beach sand was calculated and compared to those of the Earth Crust, Sandstone, Ultrabasic Rock and the acceptable limit for Turkey in order to determine their anomalies. Heavy metal (Cr, Zn, Ni, As, Cu, Pb, Co, Mo, Sb and Cd; along with Al, Fe, Mg, Mn, Na, K, Ba, Ca and W) were determined. The elements occurred in abundance as Ca>Na>Mg>Fe>Al>K>Ti>Mn>Cr>Ba>V>Zn>Ni>As>Cu>Pb>Co>Mo>Sb>W>Cd. The sufficiency of the number of samples used from the study area is revealed by the high explanatory power $R^2$ = 96.9 % of the ANOVA Model. Using the box plot, it was also noted that some heavy metals such as As (in samples 1, 19, 25, 28 and 29); Mn (in Samples 23 and 39); Na (in samples 23, 24 and 45); Cr (in Sample 33) and Ti (in Sample 15) had very high anomalies. Heavy metal contents show high anomaly concentrations when compared to some background values (Earth Crust, Sandstone, Ultrabasic and Turkey acceptable limit).

## 1. Introduction

The considerable increase in the accumulation of heavy metals in the coastal environment in recent times attributed to anthropogenic activities has being of particular concern owing to their environmental persistence, biogeochemical recycling, and toxicity risks [25], [1], [8], [2], [29]. The contamination of soils and sediments by heavy metals is the most serious environmental problem and has significant implications on human health processes [7], [17].

Sediments act as traps for most heavy metals by forming stable complexes with sediment organic matter, carbonates, and iron (Fe) − manganese (Mn) oxides [9], [19]. Interestingly, these metal fractions may have different characteristics in terms of mobility, toxicity, and chemical behaviour patterns; therefore, knowledge of various geochemical forms of metals is highly essential to assess the extent of contamination and the fate of metals in the aquatic system [20].

Heavy metals also have different remobilization behaviors under changing environmental conditions [10] as well as based on their solubility, which directly influence their bioavailability [23]. It is also believed that metals in adsorbed carbonate, sulfide, and organic bonds are highly correlated to pollution and greater risk of bioavailability [11].

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At the beach, people can easily be affected by heavy metal through body contact with the beach sand and sipping of the sea water [18]. The Manavgat Alanya coastline of Antalya together with other Coastlines, especially the beach areas of not only Antalya, but all over the world are the main attraction center for many locals/tourists during the summer period, who swim and bask on these sandy beaches. In this light, in order to mitigate environmental pollution in coastal areas, it is very important to investigate the concentration their sources in the coastal areas, most especially the beach sand sediments. To determine these, the multivariate statistical analysis which is the most commonly used method to explain the geogenic and anthropogenic source of heavy metal in sediments [12], [3], [28] will be used; Among this method, factor analysis is often used [5], [15], [13].

Therefore, the aim of this work is to 1) assess the concentration and average distribution of heavy metals by chemical analysis and, 2) assess the contamination level and statistical analysis of heavy metals in the beach sand of this coastline, for monitoring purposes.

## 2. Method and Materials Used

In this project a total of 44 beaches sand samples of 1 kg each were systematically collected at depths of 10 cm from different stations along the 60 km coastline with the use of a shovel. The samples collected were all labeled and their GPS positions noted after which they were then transported to the laboratory. The initial laboratory work was carried out in the mineral deposit laboratory of the Akdeniz University, were the grain distribution of the sample was carried out. During this process, to prevent artificial contamination, glassware used for drying the samples were washed with 10% $HNO_3$ and rinsed with distilled water. The beach sand samples were then dried in an oven at a temperature of 105 °C for 24 hours. The samples were then passed through a 2.00 mm sieve and the <2.00 mm collected were then homogenized using an agate mortar and pestle. Before the homogenization of each sample the agate mortar was washed with 6M $HNO_3$, rinsed with distilled water and dried, in order to prevent artificial contamination of each sample. The Geochemical analyses of the samples with reference number ANK13000444 were determined at the ACME Analytical Laboratories Ltd. Chemical analysis of content made with 1EX method are given in ppm and % for a total of 41 elements. The data was then statistically analyzed using SPSS-21.0 software.

## 3. Results and Discussion

Heavy metals present in the samples in order of their abundance in ppm include the following with the minimum and maximum concentrations respectively: Cr (41 & 202), Zn (8 & 55), Ni (5.8 & 35), As (5 & 36), Cu (3.3 & 22.1), Pb (3.9 & 17.6), Co (1.5 & 15.4), Mo (0.6 & 2.7), Sb (0.1 & 2.3), and Cd (0.1 & 0.3). They all have mean values of Cr (112.8667), Zn (21.6), Ni (18.5356), As (10.5556), Cu (10.0511), Pb (7.4356), Co (5.5244), Mo (1.6311) Sb (0.5333) and Cd (0.1356). Other toxic and radioactive elements present in the sample with their minimum, maximum and mean values respectively include Mg (5000.00, 41900.00 & 19037.7778), Fe (6200.00, 35100.00 & 14784.4444), Al (3200.00, 34800.00 & 12746.6667), Ba (24.00, 158.00 & 74.5333), V (12.00, 47.00 & 23.1111), Ti (270.00, 1950.00 & 698.6667), Mn (129.00, 1021.00 & 387.2444), U (0.50, 1.90 & 1.0489) and Th (1.10, 7.20 & 2.0844).

Comparing the quantitative distribution of the concentration of the various elements in the samples as shown in the box plot, Fig 1 , some elements have anomalies of higher concentration in some samples such as: samples 19, 1, 28, 29, and 25, have higher concentration of **As**; Samples 23 has higher concentrations of **Mn** and **Na**; samples 24 and 45 also had higher concentration of Na; sample 33 **(Cr)** ; sample 39 (Mn); and sample 15 **(Ti)**. Note that in more than one sample these elements are also higher: Mn (higher in 23 & 39) and Na (higher in 24, 45 & 23) as presented on **Table 1**.

When compared to the earth crust values [14], concentrations of As in the samples 19 **(15.56 folds)**, 1 **(15.56 folds)**, 28 **(14.57 folds)**, 29 **(15 folds)** and 25 **(20 folds)**; Mn in samples 23 **(0.86 folds)** and 39 **(1.0 folds)**; Na in samples 23 **(5.54 folds)**, 24 **(3.42 folds)** and 45 **(3.625 folds)**; Cr in sample 33 **(2.02 folds)**; and Ti in sample 15 **(390 folds)** are higher.

When compared to the average value of Sandstone [21], As in the samples 19 **(28 folds)**, 1 **(28 folds)**, 28 **(26.22 folds)**, 29 **(27 folds)** and 25 **(36 folds)**; Mn in samples 23 **(9.51 folds)** and 39 **(11.34 folds)**; Na in

samples 24 **(24.84 folds)**, 45 **(26.36 folds)** and 23 **(40.30 folds)**; Cr in sample 33 **(5.77 folds)**; and Ti in sample 15 **(1.3 folds)** are higher. When compared to the average for Ultrabasic rocks [21], As in the samples 19 **(28 folds)**, 1 **(28 folds)**, 28 **(26.22 folds)**, 29 **(27 folds)** and 25 **(36 folds)**; Mn in samples 23 **(0.53 folds)** and 39 **(0.63 folds)**; Na in samples 24 **(19.52 folds)**, 45 **(20.71 folds)** and 23 **(31.67 folds)**; Cr in sample 33 **(0.13 folds)**; and Ti in sample 15 **(6.5 folds)** are higher. When compare to the average acceptable limit for Turkey [16], As in the samples 19 **(1.4 folds)**, 1 **(1.4 folds)**, 28 **(1.31 folds)**, 29 **(1.35 folds)** and 25 **(1.8 folds)**; Na in samples 24 **(656 folds)**, 45 **(696 folds)** and 23 **(1064 folds)**; and Cr in sample 33 **(2.02 folds)** are higher. Turkeys accepted values for Ti and Mn were not available.

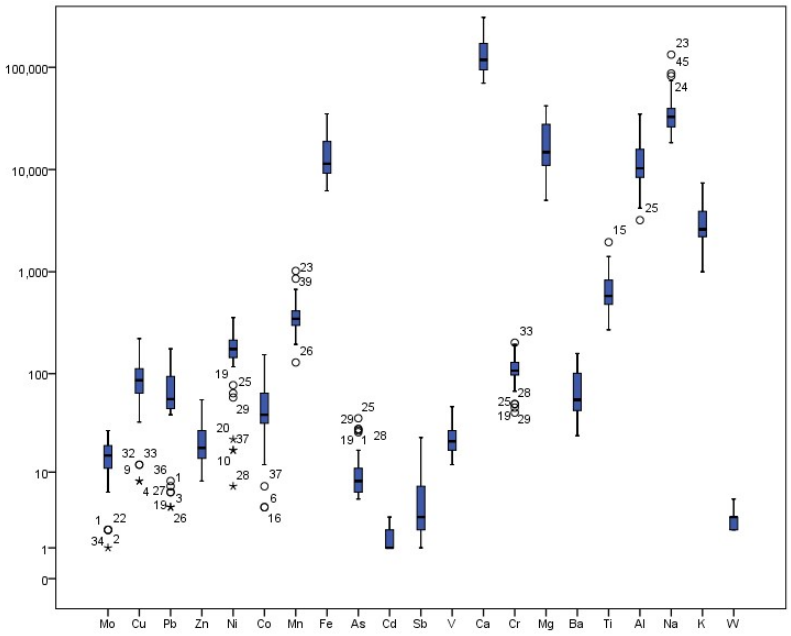


Figure 1: Concentration of Heavy Metals in the Manavgat Alanya Beach Sand Sediments.

Comparing the mean values of the heavy metal content of the Manavgat Alanya coastline of Antalya to the works of other studied areas as shown in **Table 2**; it shows that, compared to the **Earth Crust** there was a very strong positive anomaly for **Ti (139.74 fold)**, **As (5.86 folds)**, **Sb (2.67 folds)**, **Mo (1.09 folds)** and **Cr (1.13 folds)** showed moderate positive anomaly. Compared to **sandstone**, **Fe (1.51 folds)**, **Mg (2.72 folds)**, **Mn (4.30 folds)**, **Cr (3.22 folds)**, **Cu (1.12 folds)**, **Ni (9.27 folds)**, **Co (18.42 folds)**, **Pb (1.06 folds)**, **Zn (1.35 folds)**, **Cd (1.57 folds)**, **As (10.56 folds)**, **Mo (8.16 folds)** and **Sb (5.93 folds)** concentrations are higher. Comparing with **Ultrabasic Rock**, its concentrations of Ti **(2.33 folds)**, Cu **(1.01 folds)**, Pb **(7.44 folds)**, As **(10.56 folds)**, Mo **(5.44 folds)** and Sb **(5.33 folds)** are higher. Compared to the **heavy metal accepted limit for Turkey**, Cr **(1.13 folds)** is slightly higher. In comparison with **Kzlakale beachsand**, it shows that concentrations of Al **(1.54 folds)**, Cu **(1.01 folds)**, Pb **(1.86 folds)** and Zn **(1.14 folds)** are higher. Compared to **Susanoglu sediments**, concentrations for Al **(1.07 folds)**, Fe **(1.06 folds)**, Mg **(1.22 folds)**, Mn **(1.16 folds)**, Pb **(1.49 folds)** and Zn **(1.27 folds)** are high. When Compared to skenderun Bay Beach sediment concentrations for As **(1.09 folds)**, Mo **(2.33 folds)** and Sb **(1.33 folds)** were higher; and with the Mersin Bay Beach Sediments none of the elements had a higher concentration; while Silifke-Alanya Beach Sediments, concentrations of Mn **(1.09 folds)**, Cr **(6.87)**, Cu **(1.15 folds)**, Ni **(1.20 folds)**, Co **(1.03 folds)**, As **(1.17 folds)**, Mo **(3.09 folds)** and W **(1.27 folds)**are higher.

Besides the heavy metal content of the Manavgat Alanya coastline it is realized that: the average concentration of Na is higher than that of Earth Crust **(1.59 folds)**, Sandstone **(11.54 folds)**, Ultrabasic **(9.07 folds)**, Accepted limit for Turkey **(304.86 folds)**, and the Beach Sediments of Kizkalesisi**(11.26 folds)**, Susanoglu**(10.48 folds)**, Iskenderun Bay **(4.52 folds)**, Mersin Bay **(4.46 folds)** and Silifke-Alanya (6.3426542

folds), indicating very strong anomalies; The average concentration of K is higher than those of Ultrabasic **(81.45 folds)** and Kizkalesi beach sediments **(2.19 folds)**, and approximately same as that of Iskenderun Bay (1.05 folds), indicating a very strong anomalies for the Ultrabasic; The average concentration for Ca is higher than those of Earth Crust **(3.21 folds)**, Sandstone **(3.36 folds)**, Ultrabasic**(5.26 folds)** and Iskenderun Bay **(1.26 folds)**, with Ultrabasic having a very strong anomaly.

**Correlation Analysis:** Correlation among various metal contents of the beach sand samples as shown in Table 3. From the result of coefficient correlation existing between the metals, there are strong positive correlations between Zn and V, Ti, Al, Ba and K; between Co and Fe; between Sb and Fe and Mg; between V and Ti, Ba, Al and K. A moderate positive relationship does exist between Mo and Fe and Cr; between Cu and Co, Mn, Fe, V, and Al; between Pb and Zn, Fe, V, Ba, Al and K; between Zn and Ni, Co and Fe; between Ni and Mn, V and Ti; between Co and Mn, Sb, V and Al; between Mn and Fe, Sb and V; between Fe and V, Mg, Ba, Al and K; between V and Na; between Ba and Na; between Ti and Al and K; between Al and Na; and between Na and K. Also moderate negative relationship is found between Cr and Ca.

**Cluster Analysis:** Cluster analysis for the beach sand samples reveals that the 5 most similarly or homogeneously combining samples are 14 & 18 followed by: 16 & 20, 13 & 14, 28 & 29, 35 & 36, 7 & 8, 12 & 16, 27 & 33, 13 & 21 and 38 & 40. While the most dissimilarly combining samples are 1 & 25, followed by: 1 & 23, 1 & 23, 1 & 2, 1 & 34, 2 & 24, 1 & 26, 1 & 27, 2 & 3, 27 & 30, 1 & 15 and 2 & 4. Sample one 1 shows the highest number of most dissimilar combination with other samples, occurring 8 time among the 15 highly most dissimilar combining cluster samples; followed by 2 (5 times), 27 (4 times) and 34 (2 times). Sample 1 & 25 show no homogenous combination and Sample 25, 24, 23 and 26 doesnt show any direct homogenous combination with any other sample. The least of the indirect homogenous combination is 25 & 23, followed by 23 & 24, **Fig. 2.**

**Regression Analysis:** Calculations were done according to Model Summary and ANOVA and presented on Table 4. The chemical data of the elements where on Fe and the explanatory power of the Model Summary is $R^2$ = 96.9%, indicating a high degree of accuracy of the chemical analysis. According to ANOVA, 20 descriptive variables (Cr, Zn, Ni, As, Pb, Cu, Co, Mo, Sb, Cd, W, Al, V, Ti, Mg, Mn, Na, K and Ca) has a high explanatory power on Iron (Fe). From this result, it suggests that, the number of samples and heavy metals from the study area was sufficient [25], [28], [27].

**Pearsons nearest neighbor Cluster Analysis (CA)** for the elements within the samples reveals strong correlation existing between Al and K and Ba; between Zn and V, Ti and Mn; between V and Ba; between Sb and Mg; between Co and Zn, Fe and Sb; between Cu and Zn, Pb, Na, Ni and Mo; between Mo and Cu and Cr; and As and Ca. Whereas there is a moderate negative relationship between Mo and As, **Table 5 and Fig 3.** Cluster analysis CA is the most suitable method for determination of correlation between the variables [4]. Although CA is not significantly different from PCA, it is an alternative method used for the justification of results [12], [28].

**Factor Analysis: Table 6**, shows the results of the Principal Component Analysis (PCA) of the elements. In the retained 6 components, all the elements are well represented. The 6 components contributes for 85.168% of the 37 variables variance and they all have total Eigenvalues > 1. According to the initial component matrix indicator, V, Al, Zn, Cu, K, Ba, Pb, Ti, Fe, Co, Ni, Mn, Na, Cr, Mo and W, all with their highest value indicators are found within the first component, which explains 46.552% of the total variance with the highest Eigenvalue of 17.69. The second component (Factor 2) explains 15.661% of the total variance with Eigenvalue of 5.951, where the value of only Ca is highest. The 3rd component (factor 3) with high values of Sb, As and Mg explains 10.55% of the total variance with Eigenvalue of 4.009. The 4th component (Factor 4) with high value of Cd explains 5.228% of the total variance with Eigenvalue of 1.987. The 5th component (Factor 5) with high value of Y explains 4.272% of the total variance and an Eigenvalue of 1.623. The 6th component (Factor 6) with high value of Sn explains 2.904 of the total variance with an eigenvalue of 1.104.

## 4. Conclusion

From the results and discussion above, it can be concluded that the elements are in abundance as Ca> Na>Mg>Fe>Al>K>Ti>Mn>Cr>Ba>V>Zn>Ni>As>Cu>Pb>Co>Mo>Sb>W>Cd. The Model Summary

and ANOVA of 20 descriptive elements (Cr, Zn, Ni, As, Pb, Cu, Co, Mo, Sb, Cd, W, Al, V, Ti, Mg, Mn, Na, K and Ca) on Fe has a high explanatory power $R^2$ = 96.9% which indicates the sufficiency of the number of samples and heavy metals from the study area. From the factor analysis 6 factors where retained. The first factor retained a very high ratio, 85.168%, of all the elements in the sample that were analyzed. Heavy metal contents show high anomaly concentrations when compared to some background values (Earth Crust, Sandstone, Ultrabasic and Turkey acceptable limit). From the Boxplot analysis, the concentration of some elements is anomalously high in some samples when compared to Earth crust, Sandstone, Ultrabasic and Accepted Turkey limit, such as As (samples 1, 19, 25, 28 and 29); Mn (Samples 23 and 39); Cr (Sample 33) and Ti (Sample 15). The locations of these samples should be further invested for its contamination content of these elements within close proximity because heavy metals with anomaly values have toxic effects. As stated earlier on, in this study area, average concentration of Ti, As, Sb, Mo, Cr, Na and Ca are higher than those of Earth Crust; average concentration of As, Sb, Mo, Cr, Fe, Mg, Mn, Cu, Ni, Co, Ni, Co, Pb, Zn, Cd, Na and Ca are higher than those of Sandstone; average concentrations of Ti, As, Sb, Mo, Cu, Pb, Na, K and Ca are higher than those of Ultrabasic; and average concentration of Cr and Na are higher than Turkeys acceptable limit. Considering the high concentration of Na and K that is shown by the samples, it is recommended that further investigation be carried out to determine the pH of the beach of this study area. Both the Correlation and Pearson nearest neighbor element analysis indicates strong positive correlation between **Co** and Zn, Fe and Sb; between **Cu** and Zn, Pb, Na, Ni and Mo; between **Zn** and V, Ti and Mn; between **Al** and K and Ba; between **Sb** and **Mg**; between **V** and Ba; between **Mo** and Cr; and As and Ca. and the moderate negative relationship between Mo and As. From this analysis, metals that have strong positive correlation are thought to be of the same source, while those of strong negative correlations are thought to be of a different origin. The Cluster analysis for the beach sand samples reveals that similarly or homogeneously combining samples (14 & 18, 16 & 20, 13 & 14, 28 & 29, 35 & 36, 7 & 8, 12 & 16, 27 & 33, 13 & 21 and 38 & 40) are thought to have their element content from the same origin; While the element content of the dissimilarly combining samples (1 & 25, 1 & 23, 1 & 23, 1 & 2, 1 & 34, 2 & 24, 1 & 26, 1 & 27, 2 & 3, 27 & 30, 1 & 15 and 2 & 4), are thought to be of a different origin.

## 5. Acknowledgement

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## 6. Appendix

Table 1: Comparison between high anomaly concentration of some elements in the sample with Earth Crust, Sandstone, Ultrabasic Rock and Acceptable limit for Turkey

| SN | EUT | CE | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|---|
| **15** | **Ti** | **1950** | 5 | **390** | 1500 | **1.3** | 300 | **6.5** | - | **-** |
| **23** | **Mn** | **856** | 1000 | **0.86** | 90 | **9.51** | 1620 | **0.53** | - | **-** |
| **39** | **Mn** | **1021** | 1000 | **1.02** | 90 | **11.34** | 1620 | **0.63** | - | **-** |
| **33** | **Cr** | **202** | 100 | **2.02** | 35 | **5.78** | 1600 | **0.13** | 100 | **2.02** |
| **1** | **As** | **28** | 1.8 | **15.56** | 1 | **28** | 1 | **28** | 20 | **1.4** |
| **19** | **As** | **28** | 1.8 | **15.56** | 1 | **28** | 1 | **28** | 20 | **1.4** |
| **25** | **As** | **36** | 1.8 | **20** | 1 | **36** | 1 | **36** | 20 | **1.8** |
| **28** | **As** | **26.22** | 1.8 | **14.57** | 1 | **26.22** | 1 | **26.22** | 20 | **1.311** |
| **29** | **As** | **27** | 1.8 | **15** | 1 | **27** | 1 | **27** | 20 | **1.35** |
| **23** | **Na** | **133000** | 24000 | **5.54** | 3300 | **40.3** | 4200 | **31.67** | 125 | **1064** |
| **24** | **Na** | **82000** | 24000 | **3.42** | 3300 | **24.85** | 4200 | **19.52** | 125 | **656** |
| **45** | **Na** | **87000** | 24000 | **3.63** | 3300 | **26.36** | 4200 | **20.71** | 125 | **696** |

SN: Sample no
EUT: Elements under test
CE: Concentration of Elements / ppm
A: Earth crust (mg/kg) [21] (B)
B: Variation with average concentration in Earth crust (fold) (A/B)
C: Sanstone [21] ( C )
D: Variation with average concentration in Sanstone (fold) (A/C)
E: Ultrabasic [21] (D)
F: Variation with average concentration in Ultrabasic (fold) (A/D)
G: Acceptable limit for Turkey (mg/kg) [16] ( E )
H: Variation with average concentration in [16] (fold) (A/E)

Table 2: Comparison of the average concentration of heavy metal content in the Manavgat-Alanya beach sand to those of the Earth Crust, Sandstone, Ultrabasic Rock, their acceptable limit in Turkey and to the beach sand sediments of Kizkalesi , Susanoglu, skenderun Bay, Mersin Bay and Silifke.

| | Alanya-Manavgat, Mean (A) | Earth crust (mg/kg) [21] (B) | Variation of average concentration in Earth crust (fold) (A/B) | Sanstone [22] (C) | Variation of average concentration in Sanstone (fold) (A/C) | Ultrabasic [22] (D) | Variation of average concentration in Ultrabasic (fold) (A/D) | Acceptable limit for Turkey (mg/kg) [23] (E) | Variation of average concentration in [23] (fold) (A/E) | Kizkalesi Beach sediman mean [1] (F) | Variation of average concentration in Kizkalesi Beach dune (A/F) | Susanoglu Beach sediman mean [26] (G) | Variation of average concentration in Susanoglu Beach dune (A/G) | Iskenderun Bay Beach sediman Mean [27] (H) | Variation of average concentration in İskenderun Bay (A/H) | Mersin Bay Beach sediman Mean [28] (I) | Variation of average concentration in Mersin Bay (A/I) | Silifke-Alanya Beach sediman Mean [29] (J) | Variation of average concentr ation in Silifke-Alanya Beach (A/J) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Al | 12746,67 | 81000 | 0,16 | 25000 | 0,51 | 20000 | 0,64 | -- | - | 8267 | 1,54 | 11924 | 1,07 | 26648 | 0,48 | 30485 | 0,42 | 20908 | 0,61 |
| Fe | 14784,44 | 54000 | 0,27 | 9800 | 1,51 | 94300 | 0,16 | -- | - | 18803 | 0,79 | 13909 | 1,06 | 45312 | 0,33 | 34078 | 0,43 | 15751 | 0,94 |
| Mg | 19037,78 | 23000 | 0,83 | 7000 | 2,72 | 204000 | 0,09 | -- | - | 34993 | 0,54 | 15624 | 1,22 | 93500 | 0,2 | 42370 | 0,45 | 19998 | 0,95 |
| Ti | 698,67 | 5 | 139,73 | 1500 | 0,47 | 300 | 2,33 | -- | - | 813 | 0,86 | 736 | 0,95 | 2414 | 0,29 | 2773 | 0,25 | 947 | 0,74 |
| Mn | 387,24 | 1000 | 0,39 | 90 | 4,3 | 1620 | 0,24 | -- | - | 585 | 0,66 | 333 | 1,16 | 1166 | 0,33 | 7666000 | 0 | 355,12 | 1,09 |
| Cr | 112,87 | 100 | 1,13 | 35 | 3,22 | 1600 | 0,07 | 100 | 1,13 | 553 | 0,2 | 428 | 0,26 | 1187 | 0,1 | 15124138 | 0 | 16,42 | 6,87 |
| Cu | 10,05 | 50 | 0,2 | 9 | 1,12 | 10 | 1,01 | 50-140 | - | 10 | 1,01 | 12 | 0,84 | 16 | 0,63 | 158517 | 0 | 8,7 | 1,15 |
| Ni | 18,54 | 75 | 0,25 | 2 | 9,27 | 2000 | 0,01 | 30-75 | - | 186 | 0,1 | 145 | 0,13 | 646 | 0,03 | 2790917 | 0 | 15,48 | 1,2 |
| Co | 5,52 | 20 | 0,28 | 0,3 | 18,41 | 150 | 0,04 | 20 | 0,28 | 28 | 0,2 | 21 | 0,26 | 43 | 0,13 | 281217 | 0 | 5,39 | 1,03 |
| Pb | 7,44 | 12,5 | 0,59 | 7 | 1,06 | 1 | 7,44 | 50-300 | - | 4 | 1,86 | 5 | 1,49 | 15 | 0,5 | 102300 | 0 | 9,06 | 0,82 |
| Zn | 21,6 | 70 | 0,31 | 16 | 1,35 | 50 | 0,43 | 150-300 | - | 19 | 1,14 | 17 | 1,27 | 89 | 0,24 | 525500 | 0 | 30,12 | 0,72 |
| Cd | 0,14 | 0,15 | 0,9 | 0,09 | 1,51 | 0,9 | 0,15 | 42007 | 0 | 4 | 0,03 | 4 | 0,03 | 0,3 | 0,45 | 2127 | 0 | 0,14 | 0,97 |
| As | 10,56 | 1,8 | 5,86 | 1 | 10,56 | 1 | 10,56 | 20 | 0,53 | 24 | 0,44 | 19 | 0,56 | 9,7 | 1,09 | 88833 | 0 | 9,05 | 1,17 |
| Ag | ---- | 0,07 | - | 0,09 | - | 0,06 | - | - | - | 4 | - | 4 | - | 0,1 | - | - | - | 0,1 | - |
| Mo | 1,63 | 1,5 | 1,09 | 0,2 | 8,16 | 0,3 | 5,44 | 10 | 0,16 | 25 | 0,07 | 27 | 0,06 | 0,7 | 2,33 | - | - | 0,53 | 3,09 |
| Sb | 0,53 | 0,2 | 2,67 | 0,09 | 5,93 | 0,1 | 5,33 | - | - | 5 | 0,11 | 5 | 0,11 | 0,4 | 1,33 | - | - | 1,54 | 0,35 |
| Sn | 0,48 | 2,5 | 0,19 | 0,9 | 0,53 | 0,5 | 0,95 | 20 | 0,02 | 8 | 0,06 | 7 | 0,07 | 1,2 | 0,4 | - | - | 0,59 | 0,8 |
| V | 23,11 | 110 | 0,21 | 20 | 1,16 | 40 | 0,58 | - | - | 63 | 0,37 | 38 | 0,61 | 122 | 0,19 | - | - | 28,02 | 0,82 |
| W | 0,29 | 1,2 | 0,24 | 1,6 | 0,18 | 0,77 | 0,38 | - | - | 7 | 0,04 | 6 | 0,05 | 1,4 | 0,21 | - | - | 0,23 | 1,27 |
| Na | 38106,67 | 24000 | 1,59 | 3300 | 11,55 | 4200 | 9,07 | 125 | 304,85 | 3385,59 | 11,26 | 3636,36 | 10,48 | 8430 | 4,52 | 8544 | 4,46 | 6008 | 6,34 |
| K | 3257,78 | 21000 | 0,16 | 10700 | 0,3 | 40 | 81,44 | -- | - | 1486,73 | 2,19 | 6560,61 | 0,5 | 3110 | 1,05 | 6177 | 0,53 | 5749 | 0,57 |
| Ca | 131428,9 | 41000 | 3,21 | 39100 | 3,36 | 25000 | 5,26 | -- | - | 233648 | 0,56 | 174745,45 | 0,75 | 104392 | 1,26 | 136343 | 0,96 | 141030 | 0,93 |

Table 3: Coefficient correlation between the 21 elements in the Manavgat-Alanya beach sand sediments.

| | Mo | Cu | Pb | Zn | Ni | Co | Mn | Fe | As | Cd | Sb | V | Ca | Cr | Mg | Ba | Ti | Al | Na | K | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mo | 1 | | | | | | | | | | | | | | | | | | | | |
| Cu | .485** | 1 | | | | | | | | | | | | | | | | | | | |
| Pb | .443** | .538** | 1 | | | | | | | | | | | | | | | | | | |
| Zn | .459** | .566** | .716** | 1 | | | | | | | | | | | | | | | | | |
| Ni | 0,206 | .527** | .346* | .606** | 1 | | | | | | | | | | | | | | | | |
| Co | .458** | .628** | .516** | .603** | .574** | 1 | | | | | | | | | | | | | | | |
| Mn | .329* | .608** | .563** | .468** | .622** | .709** | 1 | | | | | | | | | | | | | | |
| Fe | .628** | .745** | .689** | .697** | .551** | .828** | .747** | 1 | | | | | | | | | | | | | |
| As | -.375* | -0,16 | -0,08 | -.348* | -.302* | -0,1 | 0,052 | -0,15 | 1 | | | | | | | | | | | | |
| Cd | -0,2 | 0,207 | 0,129 | .349* | .358* | 0,229 | 0,243 | 0,126 | -0,07 | 1 | | | | | | | | | | | |
| Sb | .540** | .545** | .487** | .368* | 0,294 | .718** | .645** | .817** | 0,034 | -0,06 | 1 | | | | | | | | | | |
| V | .453** | .660** | .715** | .877** | .652** | .609** | .609** | .722** | -0,18 | .340* | .370* | 1 | | | | | | | | | |
| Ca | -.536** | -.437** | -0,22 | -.360* | -0,14 | -.346* | -0,11 | -.521** | .497** | .313* | -.413** | -0,25 | 1 | | | | | | | | |
| Cr | .633** | .408** | 0,242 | .448** | 0,278 | .341* | 0,149 | .480** | -.556** | -0,01 | 0,245 | .348* | -.680** | 1 | | | | | | | |
| Mg | .483** | .363* | .434** | .357* | 0,119 | .577** | .456** | .703** | -0,01 | -0,06 | .844** | .311* | -.347* | 0,212 | 1 | | | | | | |
| Ba | .508** | .574** | .674** | .820** | .489** | .523** | .476** | .724** | -0,29 | 0,062 | .445** | .816** | -.548** | .556** | .458** | 1 | | | | | |
| Ti | 0,207 | .429** | .582** | .828** | .677** | .480** | .489** | .485** | -.300* | .521** | 0,134 | .813** | 0,008 | 0,211 | 0,054 | .552** | 1 | | | | |
| Al | .474** | .615** | .685** | .875** | .575** | .604** | .509** | .767** | -.324* | 0,168 | .394** | .888** | -.529** | .538** | .403** | .944** | .688** | 1 | | | |
| Na | 0,258 | .483** | .435** | .513** | .454** | .348* | .498** | .407** | -0,08 | 0,1 | 0,163 | .686** | -0,18 | 0,198 | 0,179 | .648** | .446** | .677** | 1 | | |
| K | .387** | .526** | .663** | .872** | .582** | .488** | .420** | .648** | -.308* | 0,153 | 0,29 | .856** | -.455** | .489** | 0,284 | .954** | .705** | .957** | .654** | 1 | |
| W | 0,214 | 0,271 | .305* | .462** | .383** | 0,276 | 0,262 | 0,222 | -0,07 | 0,003 | -0,01 | .489** | -0,09 | .296* | -0,14 | .498** | .495** | .484** | .487** | .591** | 1 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4: Data Regression of samples content of the Manavgat-Alanya beach sand sediments using Model Summary (a) and ANOVA (b).

**Model Summary (a)**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .985a | **.969** | .944 | 178,196,084 |

**ANOVA (b)**

| Model | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Regression | 2404529885 | 20 | 120226494.3 | 37,862 | **.000b** |
| Residual | 76209226.05 | 24 | 3175384.419 | | |
| Total | 2480739111 | 44 | | | |

a. Dependent Varianle : Fe

b. Predictors: (Constant), W, Cd, Sb, As, Na, Pb, Cr, Ni, Cu, Mo, Co, Mn, Ca, Ti, Mg, Ba, Zn V, Al, K

Table 5: Result of Factor Analysis of Heavy Elements in the Manavgat-Alanya beach sand sediments

| Component Matrix | | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| V | .927 | .112 | .088 | .057 | .104 | -.199 |
| Al | .925 | -.133 | -.095 | -.126 | .098 | -.226 |
| Zn | .925 | .056 | -.085 | .018 | -.104 | -.139 |
| K | .919 | .010 | -.187 | -.223 | .081 | -.151 |
| Ba | .887 | -.188 | -.079 | -.274 | .063 | -.205 |
| Cu | .846 | -.389 | .061 | .088 | .209 | .087 |
| Pb | .826 | -.023 | .325 | -.256 | -.113 | .148 |
| Ti | .811 | .404 | -.115 | .292 | -.074 | -.003 |
| Fe | .803 | -.443 | .300 | .096 | -.085 | .005 |
| Co | .790 | -.410 | .317 | .196 | -.082 | .072 |
| Ni | .766 | -.006 | -.191 | .432 | .116 | .166 |
| Mn | .654 | -.119 | .411 | .337 | .051 | .144 |
| Na | .645 | .075 | .041 | -.076 | .481 | -.256 |
| U | .614 | .092 | .529 | -.153 | -.403 | .042 |
| W | .568 | .246 | -.210 | -.220 | .409 | .321 |
| Ca | -.392 | .726 | .364 | .218 | .092 | .023 |
| Mo | .560 | -.661 | -.150 | -.165 | .120 | .155 |
| Cr | .462 | -.594 | -.379 | .009 | .177 | .026 |
| Sb | .492 | -.519 | .509 | .010 | -.346 | .111 |
| As | -.276 | .304 | .728 | -.312 | .217 | .169 |
| Mg | .396 | -.522 | .524 | -.097 | -.362 | -.175 |
| Cd | .257 | .337 | .106 | .673 | .061 | -.214 |
| Sn | .336 | .252 | .359 | -.337 | .309 | .427 |

Extraction Method: Principal Component Analysis.
a. 6 components extracted.

Table 6: Explanation of total Variance on elements in Manavgat-Alanya beach sand sediments

| Component | Initial Eigenvalues | | |
|---|---|---|---|
| | Total | % of Variance | Cumulative % |
| 1 | 17.69 | 46.552 | 46.552 |
| 2 | 5.951 | 15.661 | 62.213 |
| 3 | 4.009 | 10.55 | 72.763 |
| 4 | 1.987 | 5.228 | 77.992 |
| 5 | 1.623 | 4.272 | 82.264 |
| 6 | 1.104 | 2.904 | 85.168 |

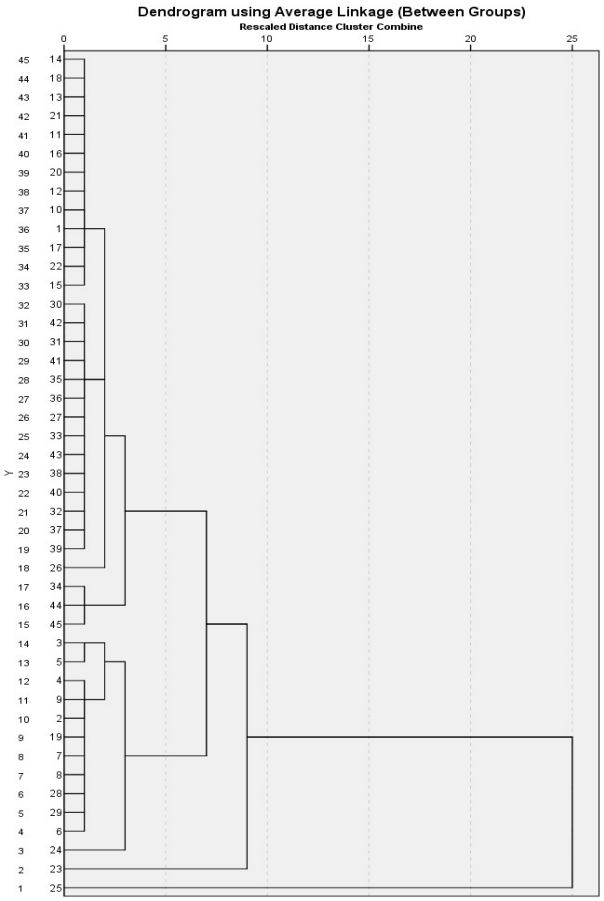


Table 7: Hierarchical Cluster analysis dendrogram of samples in the Manavgat-Alanya beach sand.

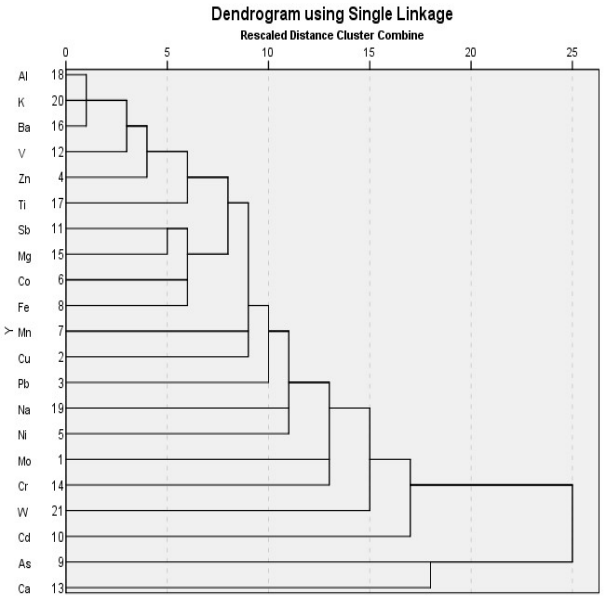


Table 8: Elements dendrogram of the Manavgat-Alanya beach sand.

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