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Sediment as a dynamic natural resource from catchment to open sea

Dating of marine sediments for historical trends of the heavy metal concentrations in the Candarlı Gulf of Turkey

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co-organised by: Ruđer Bošković Institute and University of Dubrovnik
with the participation of: IAEA




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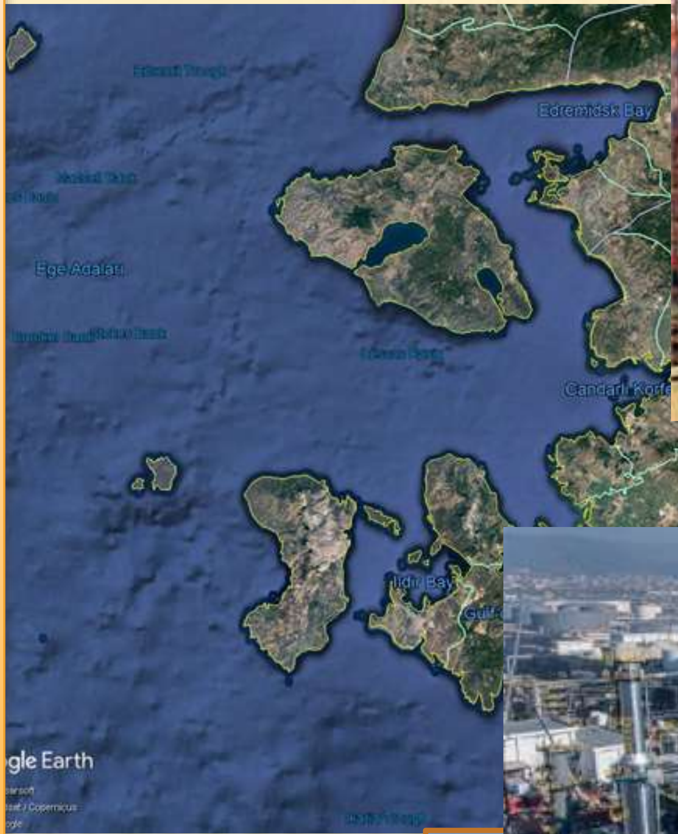
THE STUDY AREA

Characteristics of the study area

- Candarli Gulf (38.67◦–38.95◦N, 26.83◦–27.08◦E) is a semi-enclosed bay in the eastern Aegean Sea (Fig. 1). Bakırcay River is a highly contaminated stream passing through the most heavily industrialized area. The Bakırcay River water contains domestic and industrial wastewaters of three important plains such as Kirkagac, Bergama, and Kinik.
- In particularly, Aliaga city which is south of Çandarlı Gulf includes many heavy industries such as Turkish Petroleum Refinery (TUPRAS), Petrochemical Holding Company (PETKIM), shipbreaking facilities, phosphate fertilizer plant, paper factory, iron and steel plants and two thermal power plants and other medium and small establishments. All of them in the region cause heavy metal pollution (Pazi, 2011 ; Sponza and Karaoglu 2002).
- As a result, the rapid urbanization and industrialization in the region since the 1970s has resulted a significant environmental impact on the aquatic environment.



SAMPLING

- The sampling via a gravity corer have been performed by Koca Piri Reis research vessel. Sediment cores were collected systematically at 20 stations in ÇANDARLI GULF.
- Each core sample was taken in a PVC tube with inner diameter of 11 cm inside a metallic tube (length of 400 cm).
- The core lengths are ranged from 30 to 194 cm based on the ground floor. After collection, the core samples were secured in a vertical position at all times and immediately transferred to marine laboratory for preparation of the samples.

SAMPLING POINTS

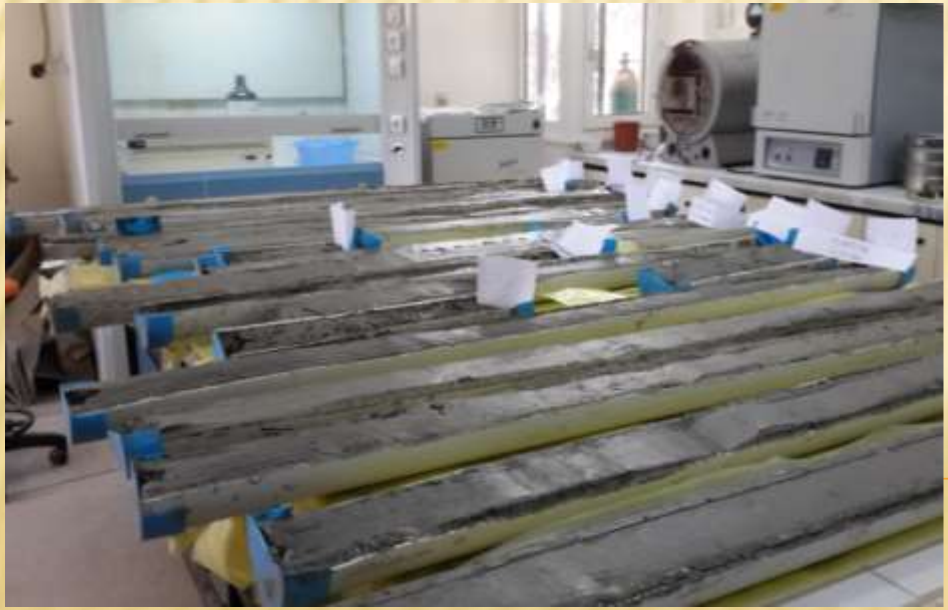
According to sampling plan, geographical grids that are about 3.5 X 3.5 km were established. However, the spaces of the grids in the near-shore areas knowing the heavily polluted were reduced by 2.5km X 2.5 km. Therefore, twenty core samples were taken from the center of grids within the 250 km^2 study area .The coordinates of the 20 stations were recorded to navigation system of the R/V Koca Piri Reis research vessel.

Station No.	coordinate		water depth (m)	core lengths (cm)
	Enlem	Boylam		
1	38°46'66"N	26°48'00"E	103	194
2	38°51'41"N	26°47'99"E	136	180
3	38°54'23"N	26°47'99"E	103	170-180
4	38°53'89"N	26°50'57"E	82	180-185
5	38°51'50"N	26°50'62"E	118	185
6	38°46'36"N	26°50'65"E	105	170
7	38°46'16"N	26°53'33"E	84	30
8	38°46'92"N	26°54'80"E	48	30
9	38°52'60"N	26°53'19"E	76	Empty(Rock surface)
10	38°54'31"N	26°53'65"E	67	160
11	38°54'30"N	26°55'84"E	57	190
12	38°52'40"N	26°55'60"E	60	100
13				Empty(Rock surface)
14	38°49'80"N	26°57'50"E	25	50
14/1	38°49'80"N	26°57'50"E	25	140
15	38°51'35"N	26°58'30"E	44	170
16	38°53'25"N	26°58'50"E	55	185
17	38°54'50"N	26°58'50"E	45	180
18	38°54'50"N	27°01'00"E	33	190
19	38°53'50"N	27°01'00"E	48	185
20	38°52'50"N	27°01'00"E	23	50

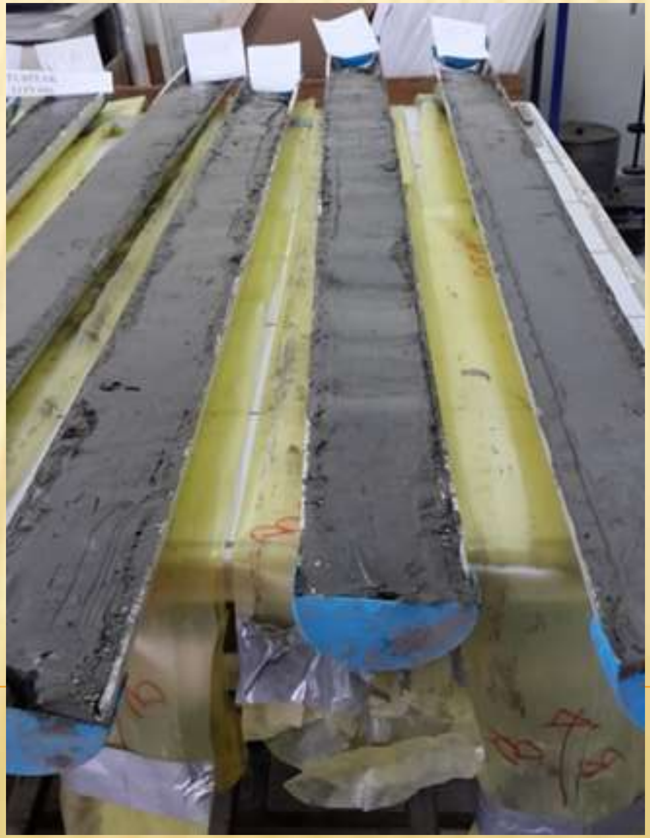
GENERAL ANALYSIS

CORES WERE IMMEDIATELY TRANSFERRED TO THE LABORATORY AND STORED. PLASTIC AND GLASS MATERIAL WERE USED TO AVOID METAL CONTAMINATION OF THE SAMPLES.

ACCORDING TO THE MAIN GOAL OF THE STUDY, THE SEDIMENT CORES WERE CUT LONGITUDINALLY AS A AND B-PARTS,OPENED WITH A NYLON STRING AND PHOTOGRAPHED BEFORE BEING SLICED FOR FURTHER ANALYSES. THE A-PARTS OF THE CORES WERE UTILIZED IN THE GAMMA SPECTROMETRIC AND TRACE METAL ANALYSES AND ALSO SOME CRITICAL SEDIMENT PARAMETERS FOR DATA INTERPRETATION.



A-PARTS OF THE CORES WERE SLICED AT ONE CM INTERVALS BY CAUSING ANY DISTURBANCE OF THE SEDIMENT COLUMN AND PUT IN THE SEALED PLASTIC COVERS. A SAMPLE ID CARD INCLUDING THE COORDINATES OF SEDIMENT SAMPLING POINT, WATER DEPTH AND CORE SIZE WAS FORMED FOR EACH SUB-SAMPLE (A TOTAL OF 1000 SAMPLES). IN THE LABORATORY, THE SEDIMENT SAMPLES WERE DRIED AT 40-60 0C TO CONSTANT WEIGHT. THE SUB-SAMPLES WERE HOMOGENIZED VIA PASSED THROUGH <0.08 MM SIEVE WITH A BALL-MILL FOR GEOCHEMICAL AND RADIONUCLIDE ANALYSIS.



In the case of B-parts, the cores were used to determine the grain-size distribution and the water content. Textural analyses were carried out on wet sediment samples. Grain size distributions were determined through standard sieving technique for the coarse part and hydrometer technique for the finer part of sediments.

GAMMA SPECTROMETRY

IN THIS STUDY, THE QUANTITATIVE DETERMINATION OF THE ^{210}Pb AND ^{137}Cs WERE CARRIED OUT BY GAMMA SPECTROMETRY

The dried samples were powdered in a ball-mill for geochemical and radionuclide analysis.

The samples and standards were pressed into pellets of 40.6 mm radius and 3-4 mm thickness under a pressure of 300 kg/cm^2 for providing an easily repeated geometry as well as avoiding for self absorption of the sample matrix. The samples were sealed and stored for at least 30 d to allow for secular equilibrium between ^{226}ra and its decay products

GAMMA-SPECTROMETRIC MEASUREMENTS

A 184 CC p-type coaxial HPGe detector with a relative efficiency of 25% and a resolution of 1.85 kev at 1.332 mev (with associated electronics procured from EG&G ORTEC) was employed for the measurement of 40K, 226RA, 232TH and 137CS activity in the sediment samples. the detector was shielded by 100 mm thick lead bricks internally lined with 1.5 mm copper foil. the spectrum was acquired and analyzed using a PC-based multichannel analyzer and the associated software. The detector efficiency calibration was performed by IAEA quality assurance reference materials of the radionuclide of interest in the same geometry as the sample.
(RGU-1, RGTH-1, IAEA-152/156)

GAMMA-SPECTROMETRIC MEASUREMENTS

The measurement of ^{210}Pb in the sediment samples were performed by planar HPGe low energy photon detectors (FWHM=0.585 keV at 122 keV) with a 0.25 mm Be window and related electronics. The detector was shielded by 100 mm thick lead bricks internally lined with 1.5 mm copper foil. The spectrum was acquired and analyzed using a PC-based multichannel analyzer and the associated software.

In the present study, the following studies were carried out;

Sediment samples were characterized by grain size, water content and inflammeble organic matter (IOM).

^{210}Pb and ^{137}Cs show a preferentially sorption to the organic rich, fine grained sediments.
Grain size variability is a main controlling factor on radionuclide content as well as abundance of the trace metal contents.

In the study, CRS and CIC Model were applied to date the sediment cores.
The validity of the proposed methodology is confirmed by records of ^{137}Cs distribution in the sediment sequence.

Capabilities and limitations of the ^{210}Pb and ^{137}Cs methods are complementary and combined use of both radiotracers is necessary for establishing reliable geochronologies in coastal environments.

The vertical distribution of metal concentrations in sediments were determined. The Pb isotopic composition allowed for evaluating the anthropogenic inputs of heavy metals.

The information is necessary to evaluate any change induced by man in the future.

Multivariate data analysis techniques were used.

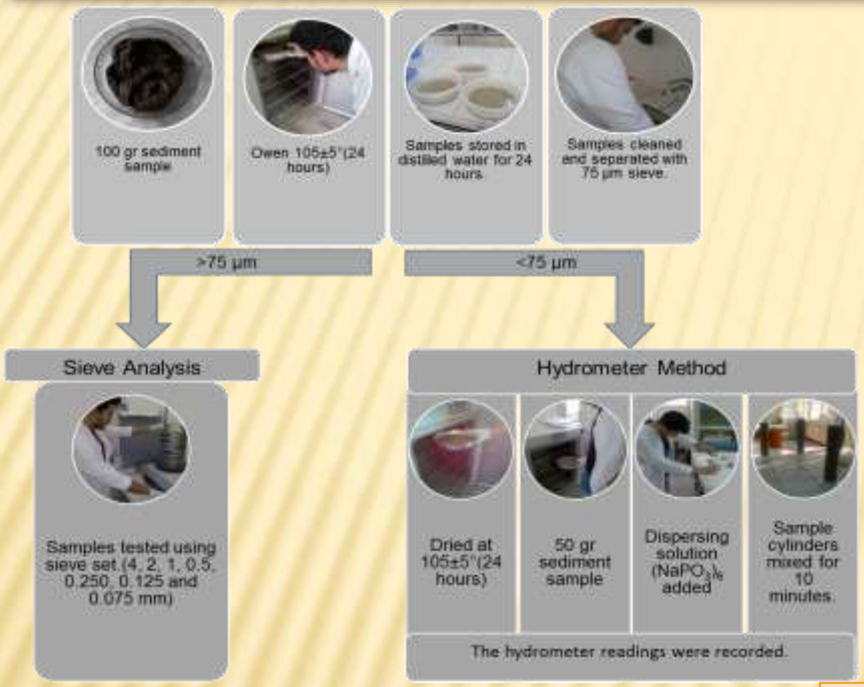
The statistical data are necassary to obtain general classification scenery of the pollution.

On the basis of the results, a radiological maps were also set up to illustrate the distribution of the ^{137}Cs and natural radionuclides in the ÇANDARLI GULF

GRAIN SIZE COMPOSITION

^{210}Pb and ^{137}Cs show a preferentially sorption to the organic rich, fine grained sediments.

Grain size variability is a main controlling factor on radionuclide content as well as abundance of the trace metal contents.

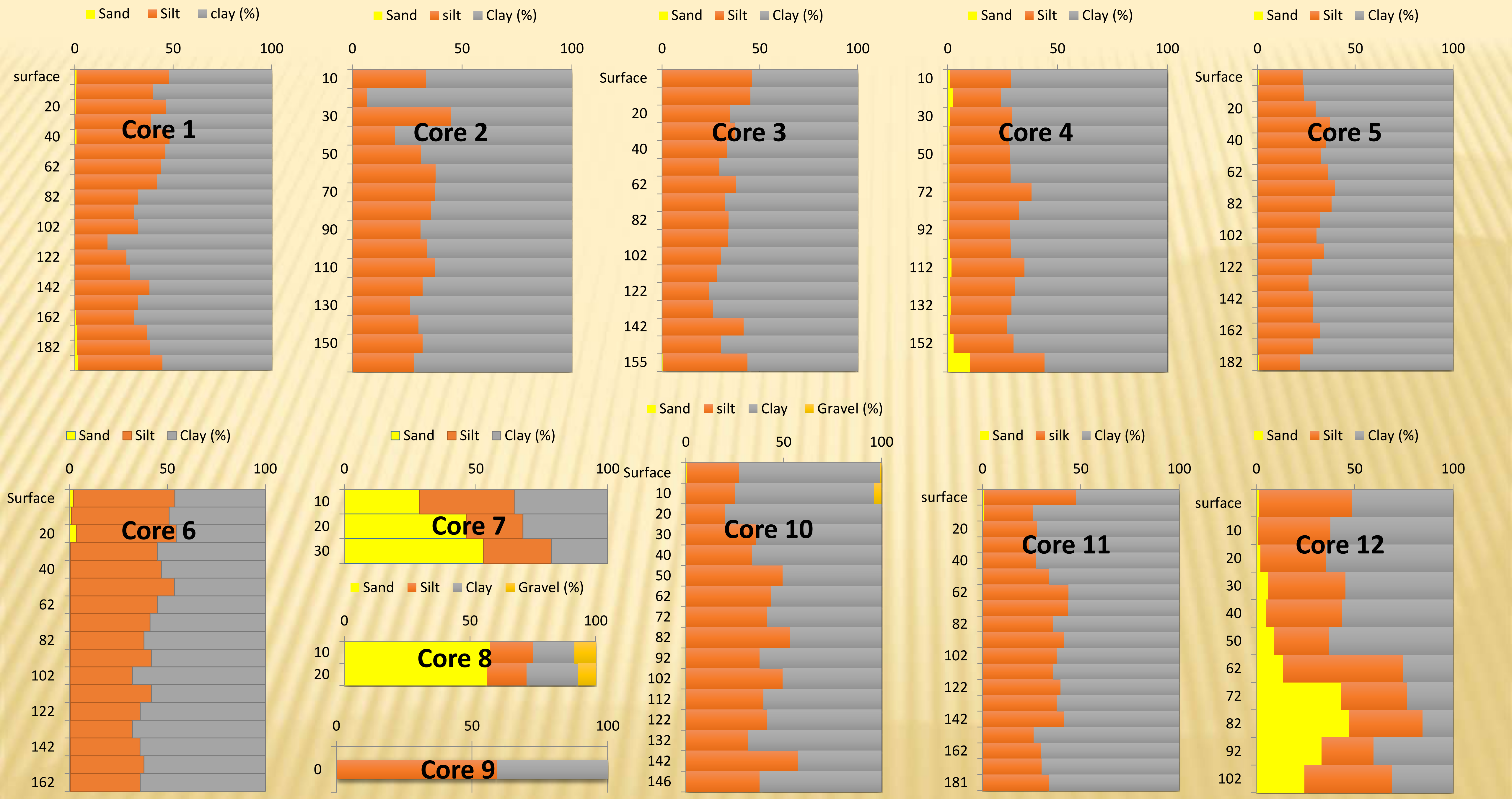


Grain size distributions were determined through standard sieving technique for the coarse part and hydrometer technique for the finer part of sediments.

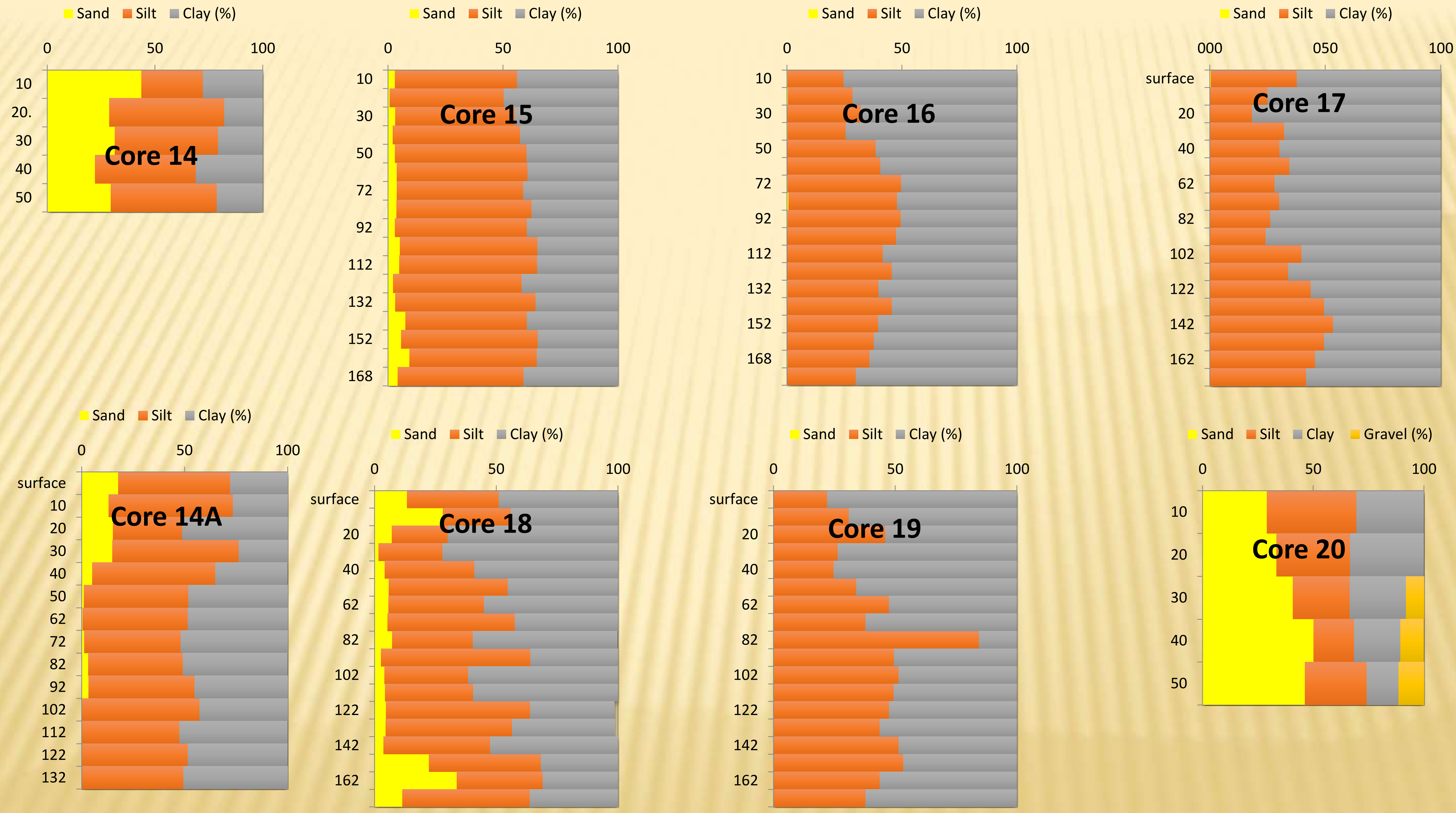
Generally, silty and clayey sediments are present in the northern part of the Gulf where the source is mainly Bakircay River.

Silty clay with 51–61% clay occurs along the northern part of the Candarli Gulf for the sediments, and clayey silts with 50–71% silt are essentially in the central part of Candarli Gulf.

The sand content decreases towards the eastern shelf. The sediments from Candarli Gulf are covered by sand at stations 7, 8, 9 and sandy clay at stations 20.



Sand Silt clay (%)
Core 1
surface 20 40 62 82 102 122 142 162 182
0 50 100
Sand silt Clay (%)
Core 2
10 30 50 70 90 110 130 150
0 50 100
Sand Silt Clay (%)
Core 3
Surface 20 40 62 82 102 122 142 155
0 50 100
Sand Silt Clay (%)
Core 4
10 30 50 72 92 112 132 152
0 50 100
Sand Silt Clay (%)
Core 5
Surface 20 40 62 82 102 122 142 162 182
0 50 100
Sand Silt Clay (%)
Core 6
Surface 20 40 62 82 102 122 142 162
0 50 100
Sand Silt Clay (%)
Core 7
10 20 30
0 50 100
Sand Silt Clay Gravel (%)
Core 8
10 20
0 50 100
Core 9
0
0 50 100
Sand silt Clay Gravel (%)
Core 10
Surface 10 20 30 40 50 62 72 82 92 102 112 122 132 142 146
0 50 100
Sand silk Clay (%)
Core 11
surface 20 40 62 82 102 122 142 162 181
0 50 100
Sand Silt Clay (%)
Core 12
surface 10 20 30 40 50 62 72 82 92 102
0 50 100

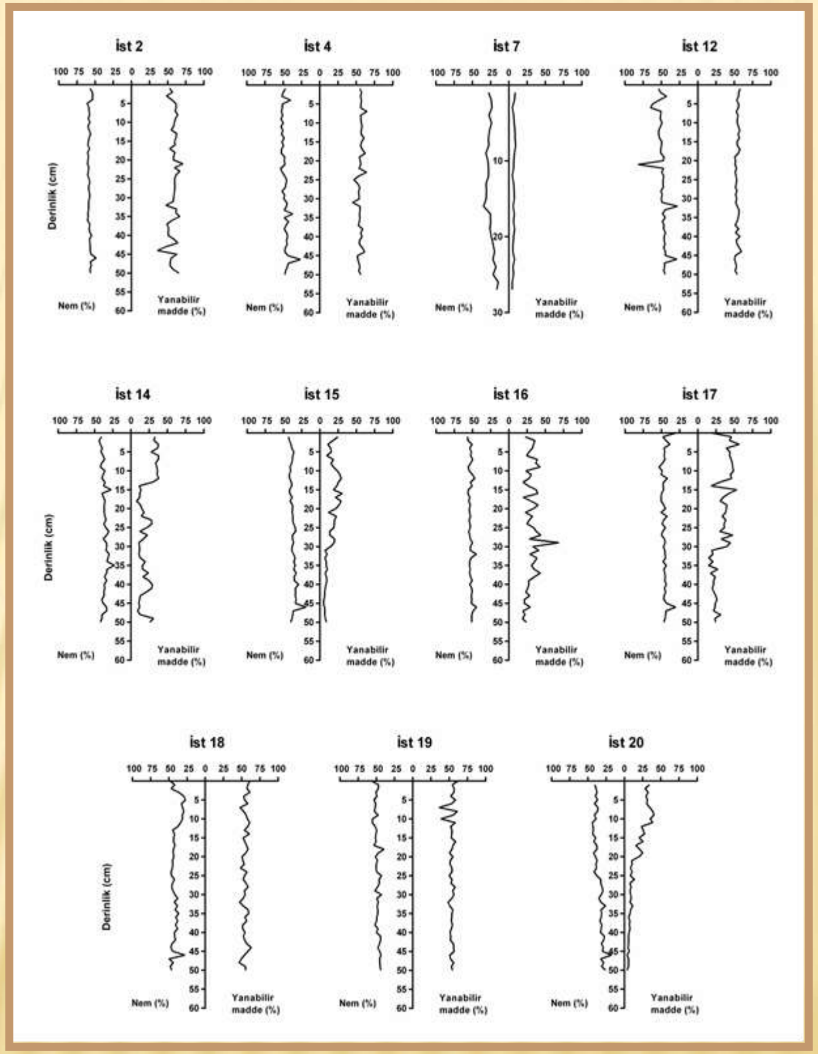

Sand Silt Clay (%)
Core 14
0 50 100
10 20. 30 40 50
Core 15
10 30 50 72 92 112 132 152 168
Core 16
10 30 50 72 92 112 132 152 168
Core 17
000 050 100
surface 20 40 62 82 102 122 142 162
Core 14A
surface 10 20 30 40 50 62 72 82 92 102 112 122 132
Core 18
surface 20 40 62 82 102 122 142 162
Core 19
surface 20 40 62 82 102 122 142 162
Sand Silt Clay Gravel (%)
Core 20
10 20 30 40 50

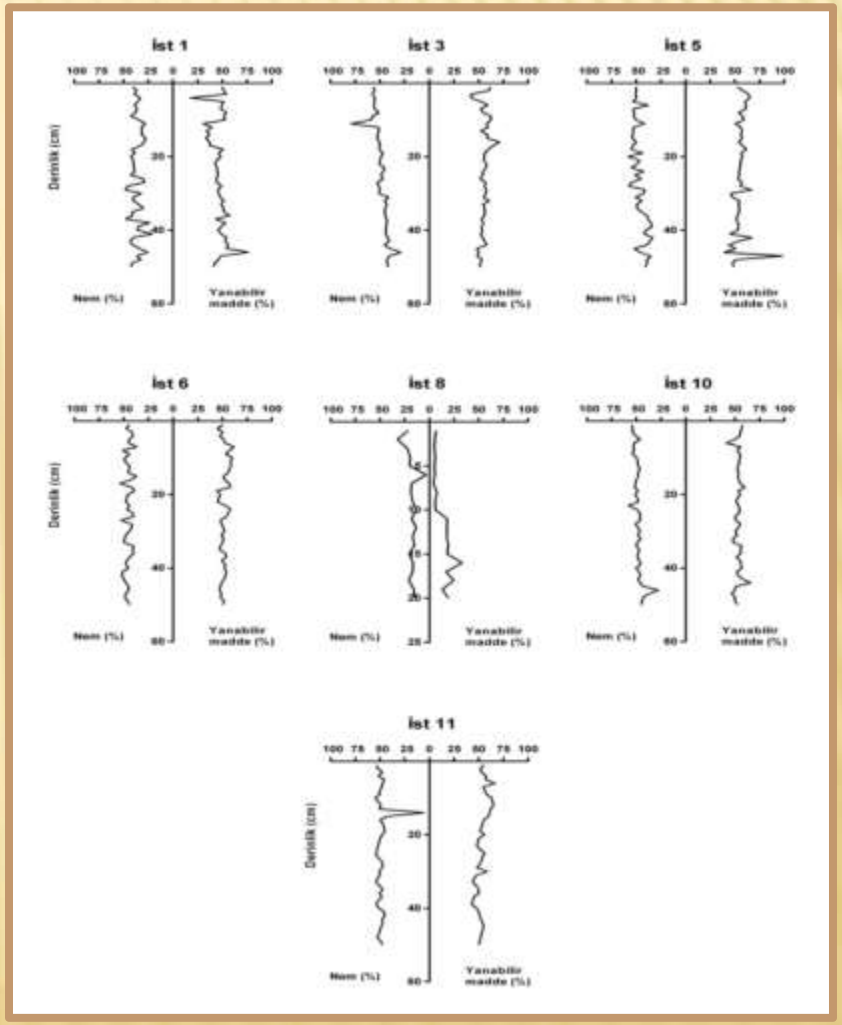
SEDIMENT SAMPLES WERE CHARACTERIZED BY WATER CONTENT AND INFLAMMABLE ORGANIC MATTER (IOM)

Generally, measured water contents were in the range 50-25%, decreasing with depth except stations 7,8 and 20 because of their higher contents of coarser sediments. This trend is similar that of IOM.

A majority of fine-grained deposits, a decreasing water content profile and high organic matter content at the top are characteristic of low-hydrodynamic-energy marine environments, where fine-grained sediments can be deposited (P. A-lvarez-Iglesias et al. 2007). These conditions favour radionuclide accumulation as well as heavy metals. From the knowledge of the water content profile, together with the organic matter profile and grain size as well, a classification of the stations can be derived, which provides useful information on the sedimentary environment for each sampling station(Ligero et.al., 2002).

In the studied area, fine grained core samples correspond to 60 % of samples and they represent the geologic features of working area in terms of statistical representation (IAEA-TECDOC-1360).





^{210}Pb and ^{137}Cs Dating

When assessing ^{210}Pb data it is useful to calculate dates using both models –any discrepancies between them highlight changes in the recent history of the studied marine environment.

Where there is a significant discrepancy between the CRS and CIC models, validation from records of fallout ^{137}Cs or ^{241} Am is essential (Appleby, 2008).

Model	Spesific Activity	Accumulation Rate	Flux of $^{210}Pb_{exs}$
CS-CF Costant Flux/Costant Sedimentation	Costant	Costant	Costant
CF or CRS Costant Flux Costant Rate of Supply	Variable	Variable	Costant
CIC Costant Initial Concentration	Costant	Variable	Variable

- In order to construct a credible ^{210}Pb chronology, a suitable model should be applied to process the ^{210}Pb accumulation data.
- In the CIC Model, the sediment core is dated by an average sedimentation rate and an average sedimentation flux (Appleby, 2008).
- The CRS model assumes a constant rate of supply of fallout ^{210}Pb irrespective of any changes in the sedimentation rate (Appleby and Oldfield, 1978; Appleby, 2008).

- In the study, CRS and CIC Model were applied to date the sediment cores.
- The both models give the same results since the sedimentation rate have remained relatively constant.
- Furthermore, the validity of the proposed methodology is confirmed by records of ^{137}Cs distribution in the sediment sequence.

^{210}Pb and ^{137}Cs Dating

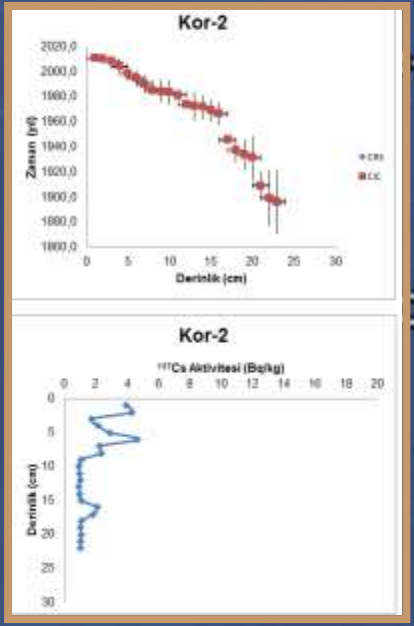
Pb and Cs dating for the cores (1,10,12,15 and 17) provides good pollution history of the Candarlı Gulf.

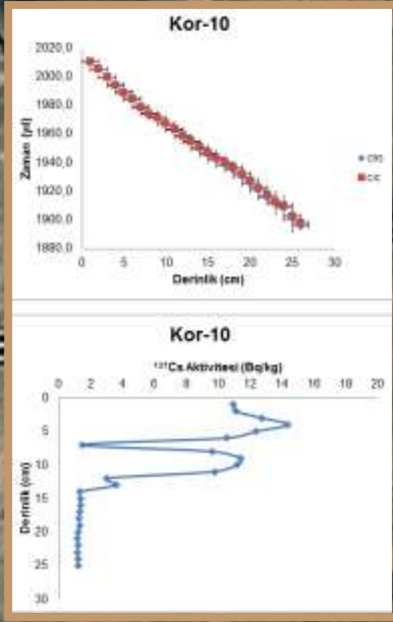
- Sedimentation rates obtained from ^{210}Pb dating were appeared in the range of 0,2 - 2,5 cmyr^{-1}.
- In the figures, when ^{210}Pb and ^{137}Cs dating results are compared, a good agreement between the obtained sedimentation rates is observed.
- Several well resolved maximum activity peaks are identified in the normalized ^{137}Cs profiles at 7-8 cm (1986 -Chernobyl peak) and 12-13cm (1963) .

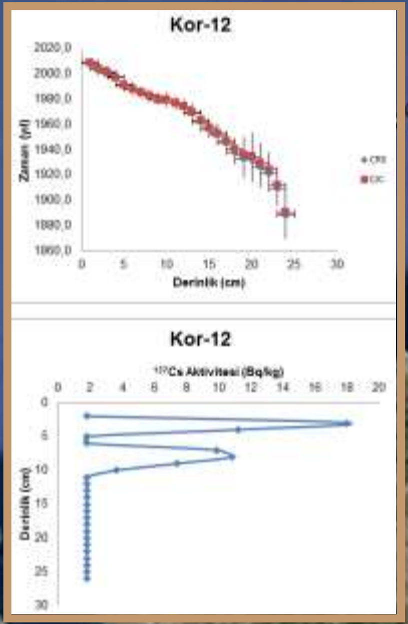
On other hand, three peaks are observed for the stations S-17. The maximum, corresponding to the layers of 16-17 cm is probably related to the ^{137}Cs first appearance in 1954.

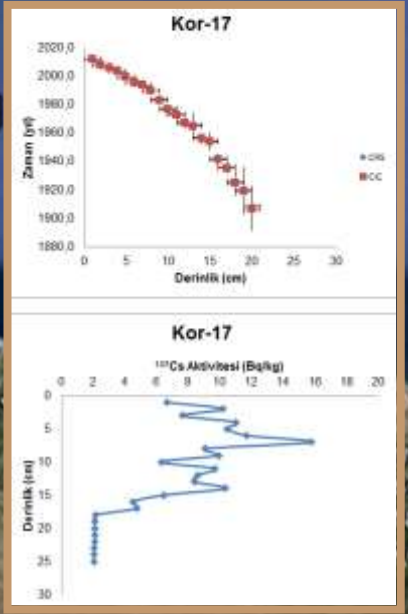
- Generally, ^{210}Pb dating supports the ^{137}Cs maximum in 1986 and confirms high sediment deposit in recent times.

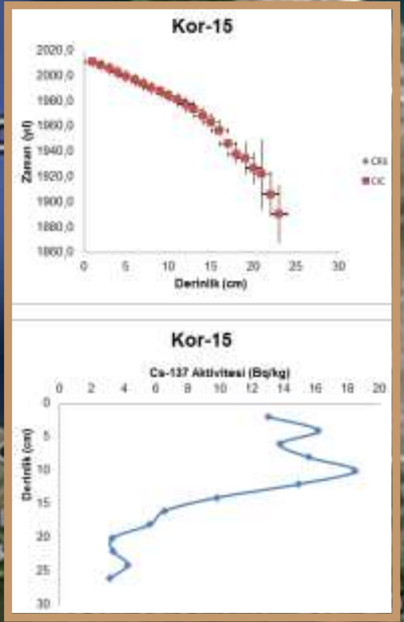
*Because of the superior sorption of $^{210}Pb_{ex}$ onto fine-grained, organic-rich sediments, a normalization of the specific activity profile is required to minimize grain–size effects and allow the assumption of relatively constant porosity. We selected normalization by Al because it is the usual grain-size proxy recommended in geochemical studies.





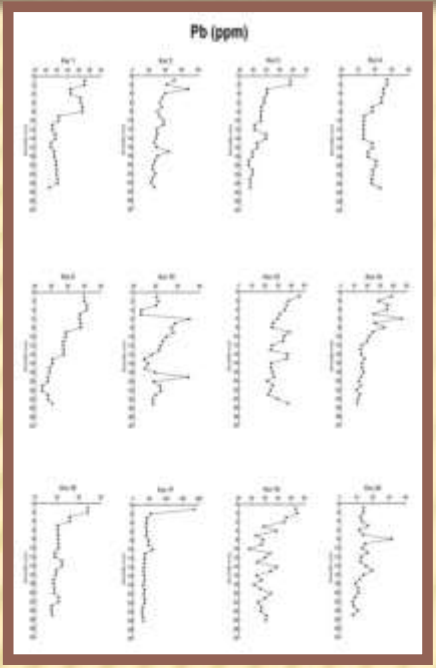


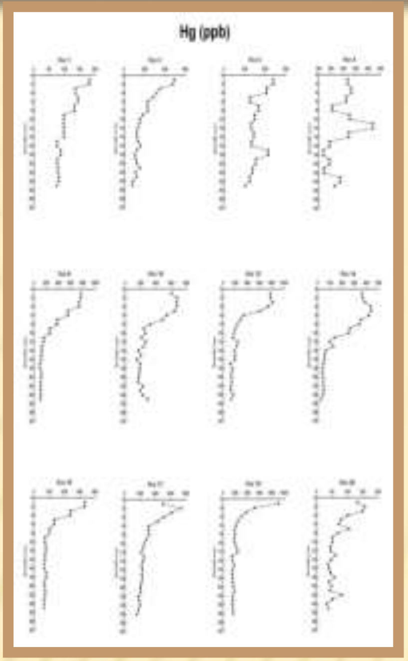


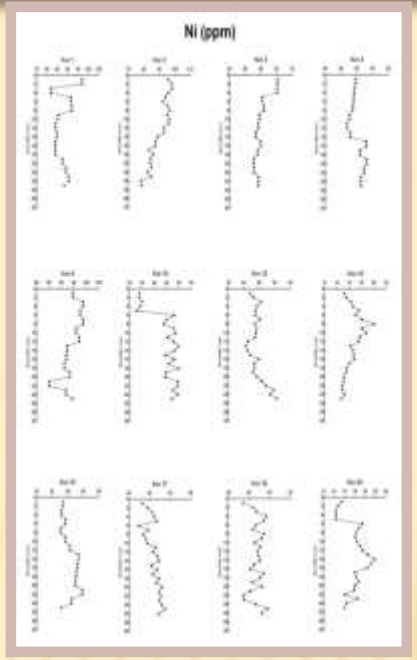


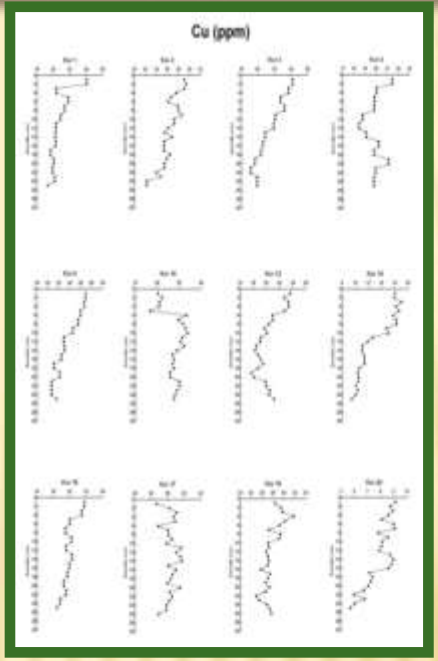
Station	$^{210}Pb_{ex}$ Inventory (mBq cm^{-2})
Core-17	791,52 ± 57
Core-15	1049,32 ± 71
Core-14	863,47 ± 74
Core-12	1116,87 ± 83
Core-10	1056,87 ± 86
Core-2	756,45 ± 66

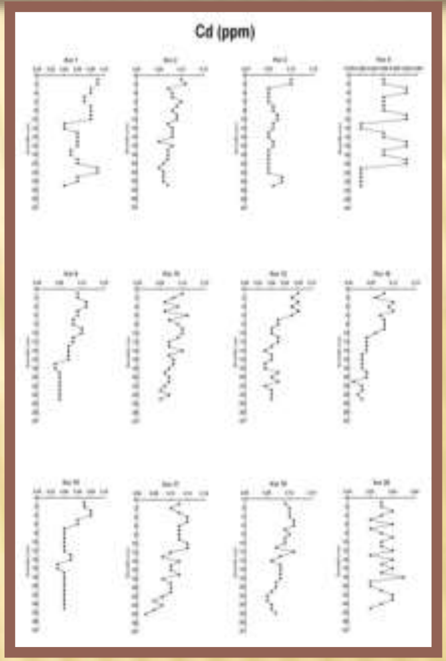
DATED SEDIMENT CORES WERE USED TO INVESTIGATE THE EVOLUTION OF HISTORICAL RECORDS OF CONTAMINANT INPUTS IN THE ÇANDARLı GULF





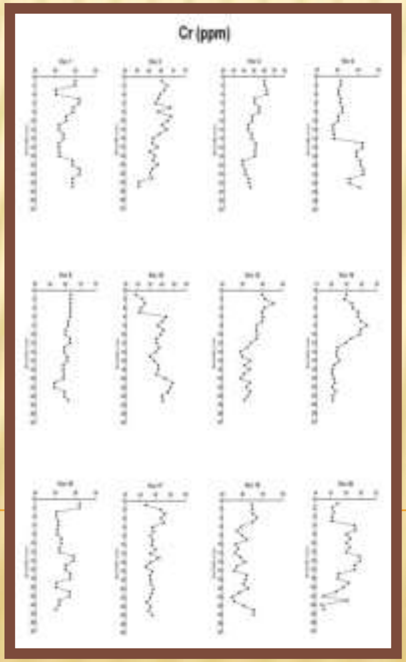


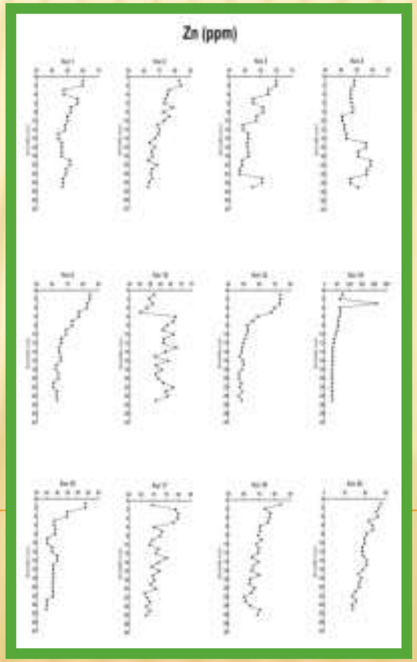


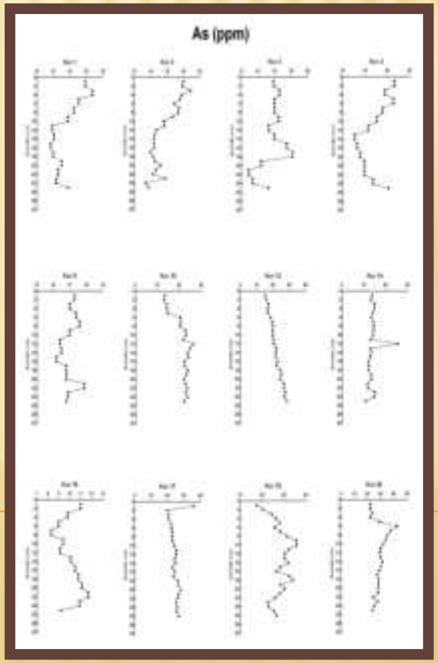


According to the established chronology

pollution by Cu, Zn, Cr, Ni, As, Cd, Hg and Pb has been detected in the recent sediment, mainly first 10cm, after 1980s, and decreases with respect to the depth all stations.





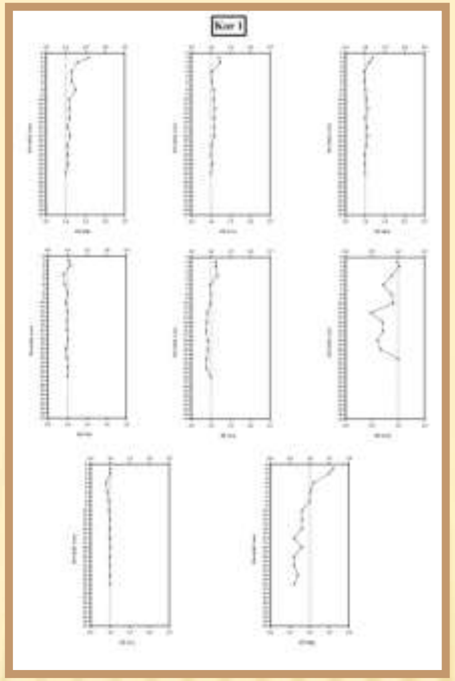


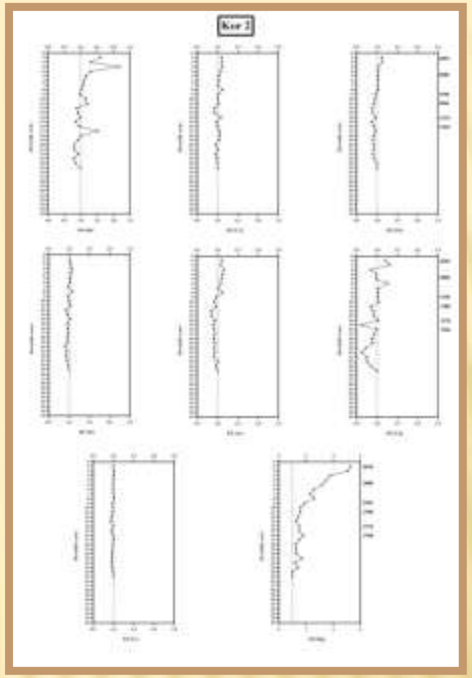
The most likely explanations for these profiles could be an increase of antropogenic inputs over time. In fact the purpose of our study is to understand the current environmental status and the extent of metal contamination with respect to natural environment.
Therefore, this explanation has been confirmed by calculation of enrichment factors (EF) as the sediment quality criteria.

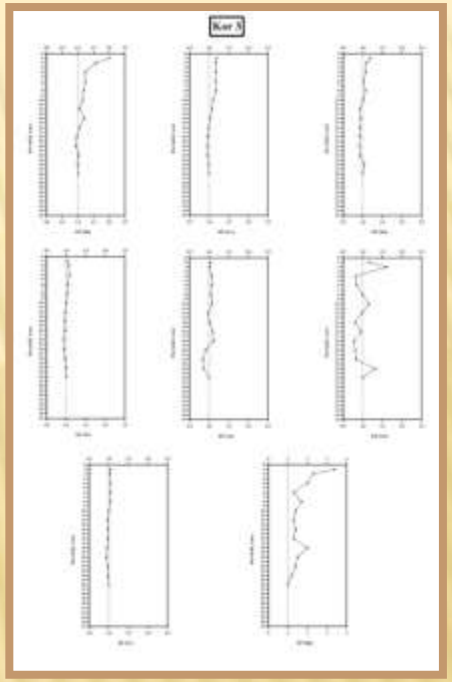
METAL ENRICHMENT FACTORS (EF)

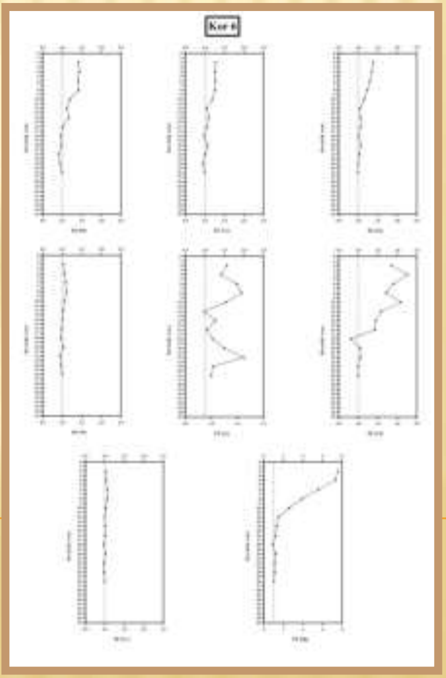
$$EF = \frac{(C_s/C_{Al})_{sample}}{(C_s/C_{Al})_{background}}$$

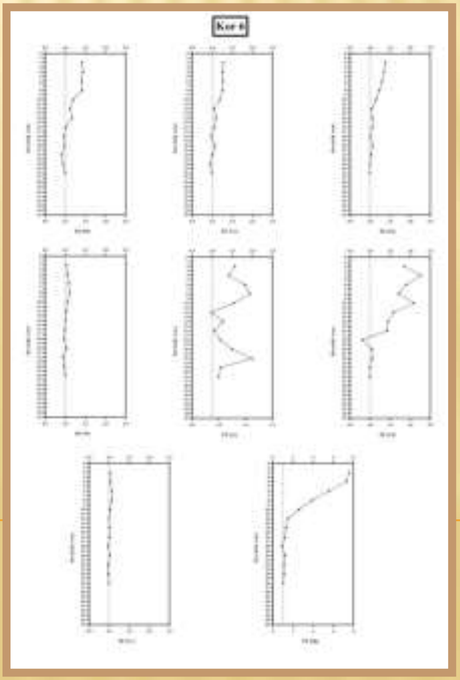
- Enrichment Factor (EF) is commonly defined as the observed metal to aluminum (Al) ratio in the sample of interest divided by the background metal/Al ratio.
- Al is one of the most abundant elements on the earth and usually has no contaminationconcern and has been widely used by many researchers to study the sources and contamination of trace metals in riverine, estuarine and coastal environment .
- It can indicate whether the metals are from natural weathering processes of rocks or from anthropogenic sources and reflect the status of environmental contamination. The assessment criteria are generally based on the EF values.
- If EF values is between 0.5 and 1.5 (i.e., 0.5 ≤EF≤1.5) it suggest that the trace metal may be entirely from crustal metals or natural weathering processes. On other hand, when a value of EF is grether than 1.5 (i.e., EF>1.5), it suggests that a significant portion of trace metals are provided by other sources (Zhang et al. 2007
- In this study, background or reference values are obtained from the deepest layers of the sediment cores (z≥25-30cm).

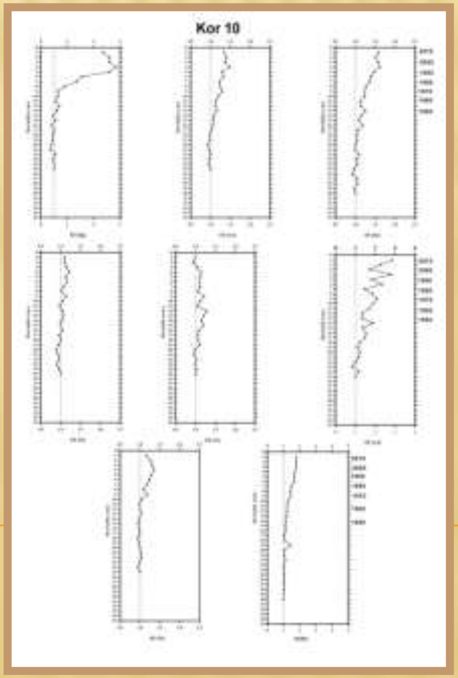




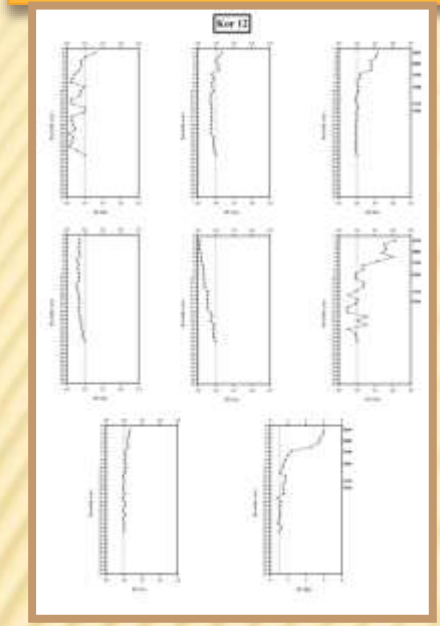


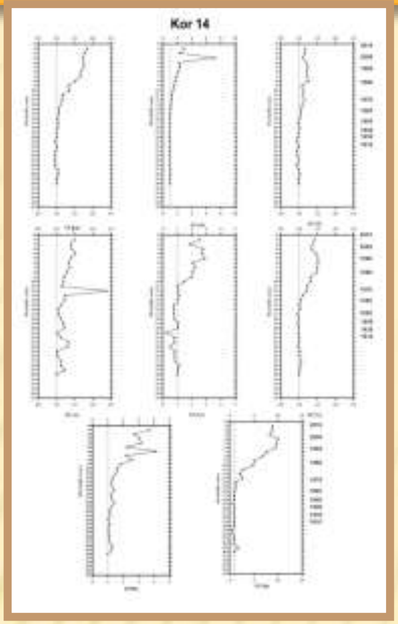


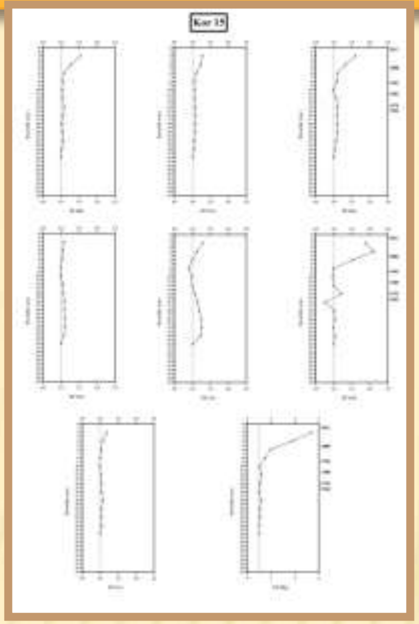


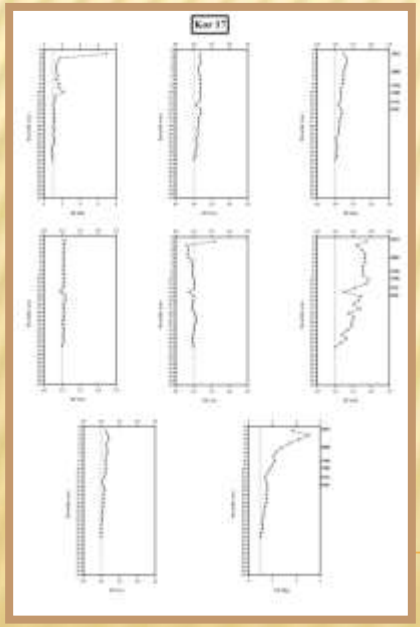


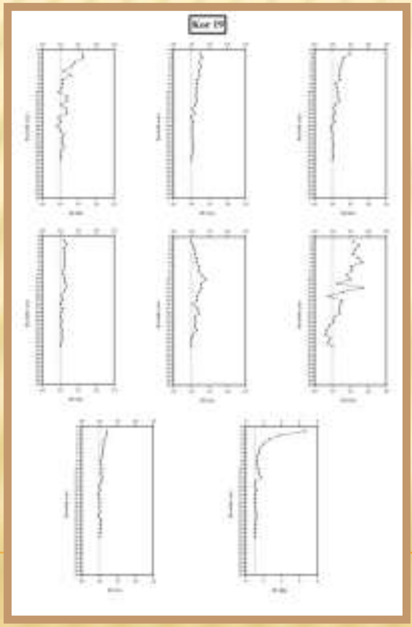
METAL ENRICHMENT FACTORS (EF)

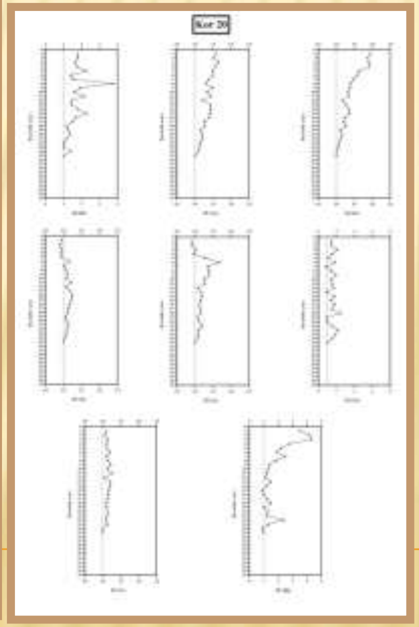












- The results from this study show that the enrichment factor of Hg is greater than 1.5 every station, except Station4 and Station2, in the superficial layers of the sediment cores.
- Most of the EF values of Cu, Cr, Zn, As and Cd for the sediment cores are generally less than 1.5, suggesting that these metal contaminations in most of the study area are not significant
- In Çandarlı Gulf , metal enrichment factors suggest that Station 14 in the Aliağa Bay, Station -17 near the estuary of Bakırçay River and station 20 which is located near an outlet of sewage discharge are contaminated by most of the metals, particularly Cd, Zn and Pb in addition to the Hg.
- As a result, metal contamination in the superficial layers of these sediment cores still exists in the GULF, suggesting recent contamination of these metals.

GEOACCUMULATION INDEX(I_{geo})

THE USEPA NORMATIVE DO NOT CONSIDER NATURAL BACKGROUND LEVELS OF THE METALS WHICH MAY OCCUR NATURALLY AT GREATER CONCENTRATIONS IN SOME AREAS OF THE WORLD. THEREFORE, A MULTIPLE APPROACHES SHOULD BE CONSIDERED FOR SEDIMENT QUALITY ASSESSMENT .

ANOTHER CRITERION TO EVALUATE THE HEAVY METAL POLLUTION IN THE ÇANDARLı GULF SEDIMENTS IS THE GEOACCUMULATION INDEX (IGEO).

Geoaccumulation Index was originally defined by Müller (1979) in order to determine and define the metal contamination in sediments by comparing current concentrations with pre-industrial levels (Zhang et al. 2007).

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

C_n : the measured concentration of the examined metal (n) in the sediment

B_n : geochemical background concentration of the metal (n)

Müller's classification for geochmical index (Zang,2007)

I_{geo} value	Class	Quality of sediment
≤0	0	Unpolluted
0–1	1	From unpolluted to moderately polluted
1–2	2	Moderately polluted
2–3	3	From moderately to strongly polluted
3–4	4	Strongly polluted
4–5	5	From strongly to extremely polluted
>5	6	Extremely polluted

The index of geoaccumulation indicates that **Hg values** are falling into **the moderately - polluted to strongly polluted classes** in most of the stations. Recently, the facilities producing mercury lambs was colosed.

The Gulf shows **a moderate pollution with Cd (Igeo < 1) in all the study areas.**

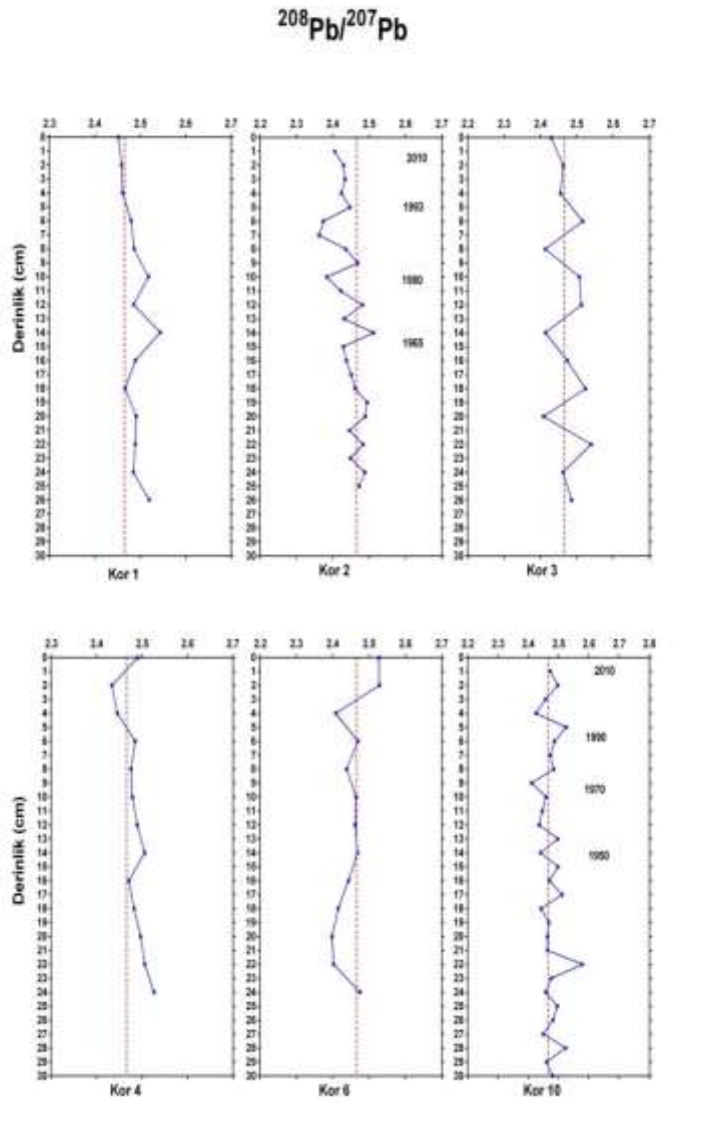
Cr, Cu, Ni , As (exceept Station 14 and 20) in the sediment samples exhibit Igeo values corresponding to **an unpolluted situation**.

Since the Station 14 in the Aliağa Bay receives wastewater discharge from the surrounding industrial area, Station 17 receives debris with unfiltered discharge by Bakırçay River and Station 20 receives sewage discharge, respectively, metal contaminations including Pb in these areas or stations were in **the range of a moderate pollution.**

All of the metals in the bottom sediments (z>10cm) exhibit Igeo values corresponding to an unpolluted situation , except Station 20.

The source of the contaminants in the station can be attributed to the sewage input in the area which was uncontrolled in the past.

Pb ISOTOPIC COMPOSITION DATA INDICATED THAT THE INCREASED PB IN THE RECENT SEDIMENTS ARE OF ANTHROPOGENIC ORIGIN.



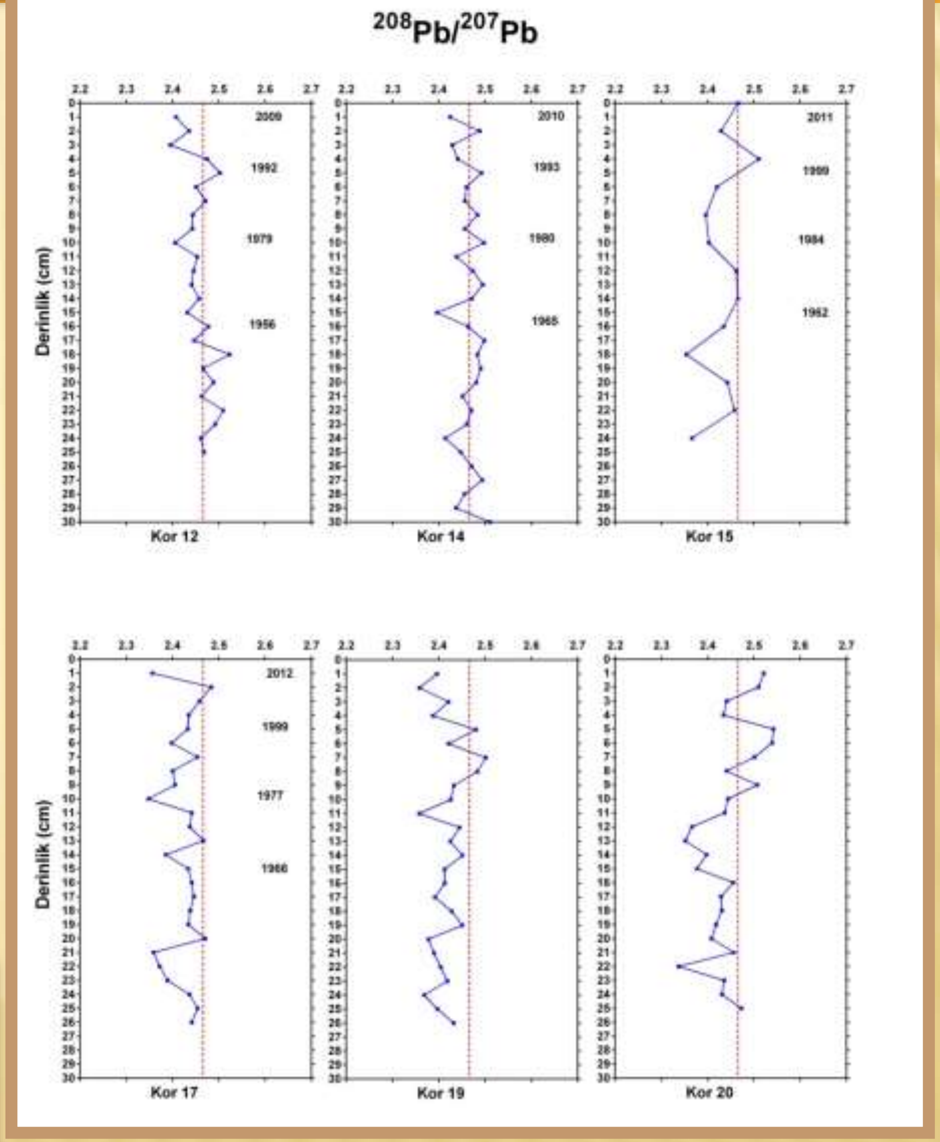
All materials of natural origin, such as sediment, soil, and water, should have background Pb isotopic signature.The natural Pb isotopic composition of sediments depends on the natural inputs.

Before the 1970s, the studied area was mainly an agricultural region. At that time, the Çandarlı Gulf mainly received inputs from the natural environment. Then the Pb isotopic ratios of the sediments before the 1950s can be considered as the natural background.

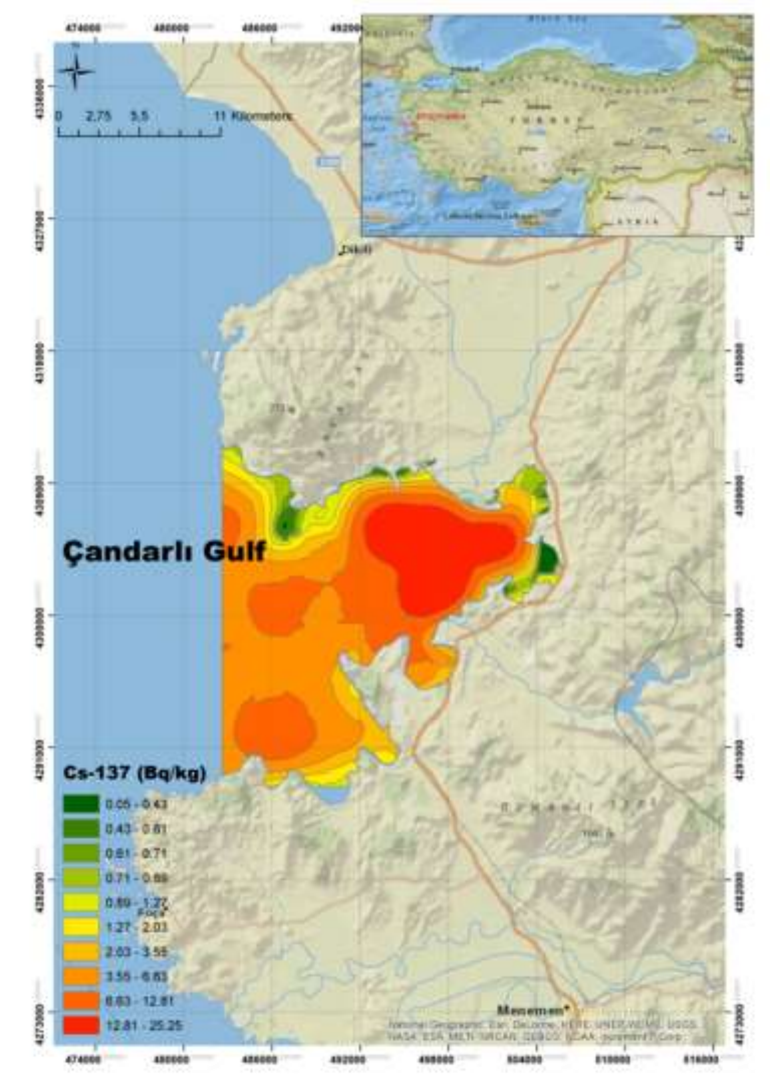
The average measured ratios of $^{206}Pb/^{207}Pb$, $^{208}Pb/^{207}Pb$ in the deepest sediment layers(z=20-25cm) were 1.190±0.004 and 2.466±0.005, respectively.

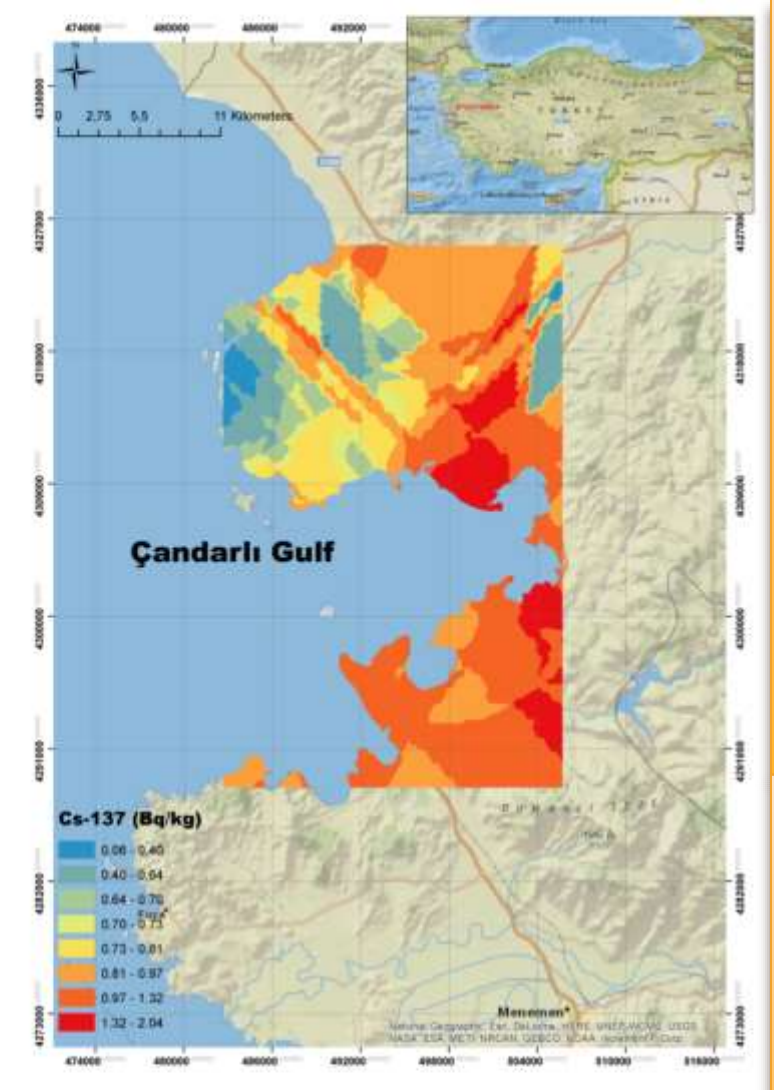
The ratios were indicated as the dotted line in the figures.

Inputs from industrial emissions, metallurgical activities, vehicles and marine traffic are thought to have an impact on these isotopic ratios.



^{137}Cs Mapping



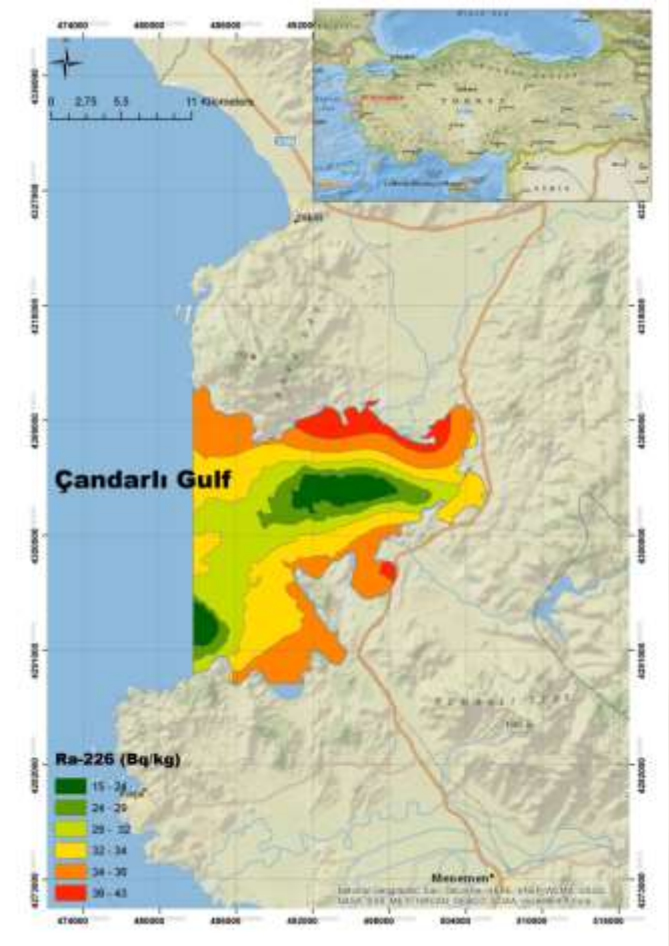


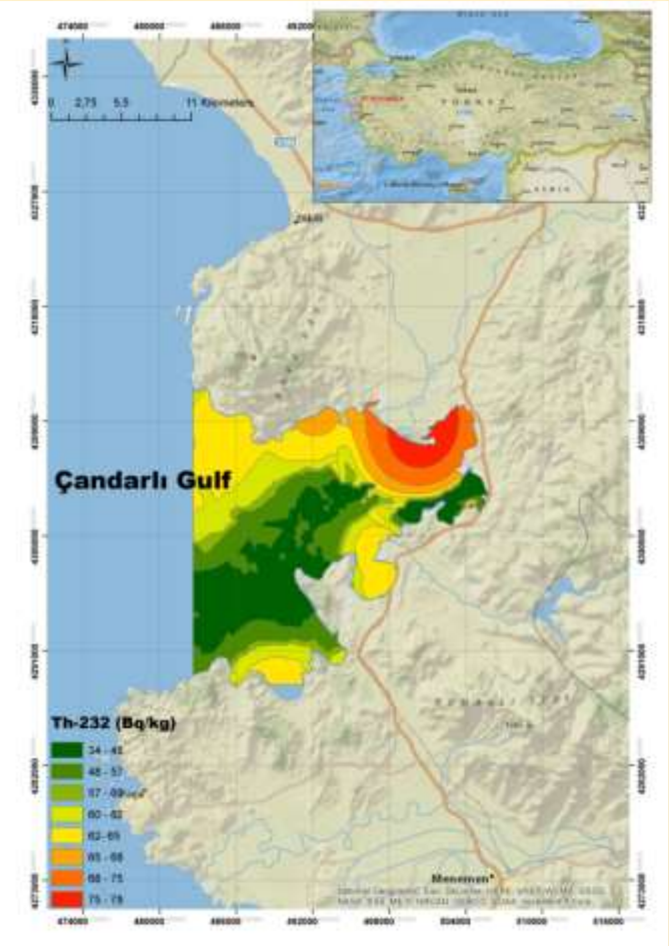
Distribution of ^{137}Cs in the marine and beach sediment samples

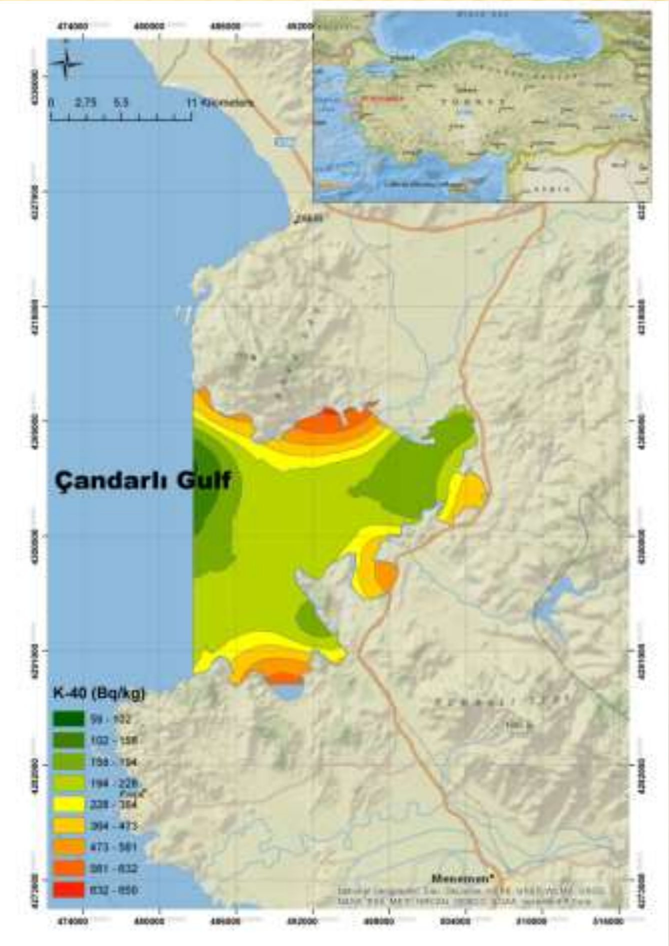
The mapped activity concentrations of ^{137}Cs in the sediment samples were appeared in the range of 1 to 25 Bq/kg. On the other hand, radiocesium activities in the beach sands were lower than the marine sediments as expected. In the beach sands, maximum value of ^{137}Cs is about 2 Bq/kg. It is clearly that the Marine sediments is a major sink for radionuclides and trace/heavy metals as well in the surrounding ecosystem.

THE APPLYING SAMPLING PROCEDURE FOR BEACH SAND IS SIMILAR TO THE RER/2/003 METHODOLOGICAL GUIDELINES.
THE samples were collected throughout of ÇANDARLI GULF coastal line including the public beaches at every three km, as the topography would permit.
Sampling sites were selected to be open and close to the water edge, in a place where the sand is dry down to a depth of 10 cm.
THE samples were taken with a plastic shovel.
In each site, the surface sample was obtained from five positions, one central and four close to the corners of a square of about 5 m length. The sub-samples were homogenized in situ.

THE MAPS OF NATURAL RADIONUCLIDES







Distribution of ^{226}Ra, ^{232}Th and ^{40}K in the marine sediments using geographic information systems (GIS).

The activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in the marine sediments ranged from 15 to 45 Bq/kg, 30-80 Bq/ kg and 60-650 Bq/ kg ,respectively.

Statistical Analysis

In the present study, we performed statistical analysis on the data. In this respect, Pearson's correlation coefficient matrix among Al, As, Cu, Pb, Zn, Cd, Ni, Cr, and other metals in the sediments are presented in the figures.

Core-1

	Al	Cu	Zn	Ni	Co	Mn	Fe	As	U	Th	Sr	Cd	Sb	Ca	P	Cr	Mg	Na	K	Sc	S	Hg	Se	Cs	Sn	Zr	Pb
Al	1,0	,4	,5	,5	,6*	,5	,6*	,7**	-,1	,2	,0	,5*	,4	,0	,6*	,7*	,2	,7*	,9**	,4	,2	,5	,0	,2	,5*	,1	,5*
Cu	,4	1,0	,9**	,8**	,2	,8**	,7**	,7**	-,3	-,2	-,5	,7*	,8**	-,5*	,8**	,5	,0	,7**	,4	,3	-,4	,9**	-,3	,4	,9**	-,6*	,9**
Zn	,5	,9**	1,0	,7**	,2	,8**	,7**	,6*	-,4	-,1	-,4	,6*	,8**	-,5	,8**	,7*	,1	,7**	,4	,1	-,4	,9**	-,3	,6*	,8**	-,6*	,9**
Ni	,5	,8**	,7**	1,0	,0	1,0**	,9**	,5	-,6*	,4	-,6*	,5	,4	-,5*	,9**	,9**	,6*	,6*	,6*	,5	-,3	,6*	-,2	,7*	,7*	-,2	,7*
Co	,6*	,2	,2	,0	1,0	,1	,0	,8**	,6*	-,4	,6*	,4	,5	,5	,2	-,1	-,5	,6*	,4	-,2	,7**	,5	,1	-,4	,3	-,1	,4
Mn	,5	,8**	,8**	1,0**	,1	1,0	,9**	,6*	-,5	,3	-,5	,5*	,6*	-,5	,9**	,8**	,4	,6*	,6*	,4	-,3	,8**	-,3	,6*	,7*	-,4	,8**
Fe	,6*	,7**	,7**	,9**	,0	,9**	1,0	,4	-,6*	,5	-,6*	,5	,4	-,5	,9**	,9**	,6*	,5*	,7**	,6*	-,3	,5*	-,1	,7*	,6*	-,1	,6*
As	,7**	,7**	,6*	,5	,8**	,6*	,4	1,0	,2	-,3	,2	,6*	,8**	,1	,6*	,3	-,2	,8**	,5	-,1	,3	,8**	,0	,1	,6*	-,3	,8**
U	-,1	-,3	-,4	-,6*	,6*	-,5	-,6*	,2	1,0	-,4	,9**	,1	,0	,8**	-,4	-,6*	-,6*	-,1	-,2	-,4	,7**	-,1	,2	-,7*	-,3	,2	-,2
Th	,2	-,2	-,1	,4	-,4	,3	,5	-,3	-,4	1,0	-,3	-,2	-,5	-,1	,2	,6*	,9**	-,1	,5	,5	,0	-,3	,2	,4	-,2	,6*	-,3
Sr	,0	-,5	-,4	-,6*	,6*	-,5	-,6*	,2	,9**	-,3	1,0	,0	-,1	1,0**	-,5	-,5	-,4	,0	-,2	-,5	,9**	-,2	,4	-,6*	-,4	,3	-,3
Cd	,5*	,7*	,6*	,5	,4	,5*	,5	,6*	,1	-,2	,0	1,0	,5	-,1	,7**	,5	,0	,7**	,4	,3	,0	,6*	-,2	,1	,6*	-,2	,7**
Sb	,4	,8**	,8**	,4	,5	,6*	,4	,8**	,0	-,5	-,1	,5	1,0	-,2	,6*	,2	-,4	,7**	,2	-,1	-,1	1,0**	-,1	,3	,7*	-,7*	,9**
Ca	,0	-,5*	-,5	-,5*	,5	-,5	-,5	,1	,8**	-,1	1,0**	-,1	-,2	1,0	-,5	-,4	-,3	,0	-,1	-,5	,9**	-,3	,5*	-,6*	-,5	,4	-,3
P	,6*	,8**	,8**	,9**	,2	,9**	,9**	,6*	-,4	,2	-,5	,7**	,6*	-,5	1,0	,8**	,3	,7**	,6*	,4	-,3	,7**	-,3	,5	,7*	-,4	,8**
Cr	,7*	,5	,7*	,9**	-,1	,8**	,9**	,3	-,6*	,6*	-,5	,5	,2	-,4	,8**	1,0	,7*	,5	,7**	,5	-,3	,4	-,2	,8**	,5	,0	,6*
Mg	,2	,0	,1	,6*	-,5	,4	,6*	-,2	-,6*	,9**	-,4	,0	-,4	-,3	,3	,7*	1,0	,0	,4	,5	-,2	-,2	,1	,6*	-,1	,4	-,1
Na	,7*	,7**	,7**	,6*	,6*	,6*	,5*	,8**	-,1	-,1	,0	,7**	,7**	,0	,7**	,5	,0	1,0	,5*	,1	,1	,8**	,0	,3	,7*	-,5	,9**
K	,9**	,4	,4	,6*	,4	,6*	,7**	,5	-,2	,5	-,2	,4	,2	-,1	,6*	,7**	,4	,5*	1,0	,6*	,1	,4	,0	,2	,4	,2	,4
Sc	,4	,3	,1	,5	-,2	,4	,6*	-,1	-,4	,5	-,5	,3	-,1	-,5	,4	,5	,5	,1	,6*	1,0	-,4	,1	-,1	,2	,4	,3	,1
S	,2	-,4	-,4	-,3	,7**	-,3	-,3	,3	,7*	,0	,9**	,0	-,1	,9**	-,3	-,3	-,2	,1	,1	-,4	1,0	-,1	,6*	-,5	-,3	,3	-,2
Hg	,5	,9**	,9**	,6*	,5	,8**	,5*	,8**	-,1	-,3	-,2	,6*	1,0**	-,3	,7**	,4	-,2	,8**	,4	,1	-,1	1,0	-,3	,3	,8*	-,7*	,9**
Se	,0	-,3	-,3	-,2	,1	-,3	-,1	,0	,2	,2	,4	-,2	-,1	,5*	-,3	-,2	,1	,0	,0	-,1	,6*	-,3	1,0	-,1	-,4	,4	-,3
Cs	,2	,4	,6*	,7**	-,4	,6*	,7**	,1	-,7*	,4	-,6*	,1	,3	-,6*	,5	,8**	,6*	,3	,2	,2	-,5	,3	-,1	1,0	,3	-,2	,5
Sn	,5*	,9**	,8**	,7**	,3	,7*	,6*	,6*	-,3	-,2	-,4	,6*	,7**	-,5	,7**	,5	-,1	,7*	,4	,4	-,3	,8*	-,4	,3	1,0	-,5	,9**
Zr	,1	-,6*	-,6*	-,2	-,1	-,4	-,1	-,3	,2	,6*	,3	-,2	-,7*	,4	-,4	,0	,4	-,5	,2	,3	,3	-,7*	,4	-,2	-,5	1,0	-,6*
Pb	,5*	,9**	,9**	,7**	,4	,8**	,6*	,8**	-,2	-,3	-,3	,7**	,9**	-,3	,8**	,6*	-,1	,9**	,4	,1	-,2	,9**	-,3	,5	,9*	-,6*	1,0

**Korelasyonlar 0.01 seviyesinde anlamlıdır (2-tailed).

*Korelasyonlar 0.05 seviyesinde anlamlıdır (2-ta ~1,0 0,9 0,8 0,7 0,6

Core-2

	Al	Cu	Zn	Ni	Co	Mn	Fe	As	U	Th	Sr	Cd	Sb	Ca	P	Cr	Mg	Na	K	Sc	S	Hg	Se	Cs	Sn	Zr	Pb
Al	1,0	,7**	,6**	,7**	,6**	,6**	,8**	,4	,4*	,8**	-,2	,4*	-,2	,2	,6**	,9**	,9**	,5**	1,0**	,8**	-,1	,3	-,1	,8**	,7**	,5**	,3
Cu	,7**	1,0	,8**	,9**	,1	,9**	,9**	,8**	,2	,6**	-,1	,6**	,3	,2	,8**	,8**	,8**	,7**	,7**	,4	,1	,8**	-,2	,7**	,9**	-,1	,7**
Zn	,6**	,8**	1,0	,8**	,1	,8**	,8**	,9**	,3	,4*	-,1	,8**	,4	,2	,7**	,8**	,7**	,5*	,6**	,2	,2	,9**	-,1	,7**	,9**	-,1	,6**
Ni	,7**	,9**	,8**	1,0	,2	,9**	,9**	,8**	,4	,6**	-,2	,7**	,4	,1	,7**	,9**	,8**	,6**	,7**	,4*	-,1	,7**	-,1	,8**	,9**	-,1	,6**
Co	,6**	,1	,1	,2	1,0	,1	,3	-,2	,0	,1	-,1	,1	-,5**	-,1	,1	,4*	,3	,0	,4*	,4*	-,4*	-,2	,0	,2	,1	,5**	-,1
Mn	,6**	,9**	,8**	,9**	,1	1,0	,8**	,8**	,0	,4	-,3	,7**	,4*	-,1	,8**	,8**	,7**	,7**	,7**	,3	,0	,8**	-,2	,6**	,9**	-,3	,6**
Fe	,8**	,9**	,8**	,9**	,3	,8**	1,0	,7**	,6**	,8**	,0	,5**	,1	,4	,8**	,9**	,9**	,5**	,8**	,6**	,0	,6**	-,2	,8**	,8**	,2	,5*
As	,4*	,8**	,9**	,8**	-,2	,8**	,7**	1,0	,2	,4	-,1	,6**	,5*	,2	,7**	,6**	,6**	,5*	,5*	,2	,4	,9**	-,1	,6**	,8**	-,3	,7**
U	,4*	,2	,3	,4	,0	,0	,6**	,2	1,0	,6**	,3	,1	-,2	,4*	,3	,4	,5**	-,1	,3	,5**	-,2	,1	-,2	,6**	,2	,4*	,1
Th	,8**	,6**	,4*	,6**	,1	,4	,8**	,4	,6**	1,0	,1	,1	-,2	,5*	,6**	,7**	,8**	,3	,8**	,8**	-,1	,3	-,1	,6**	,5**	,4*	,3
Sr	-,2	-,1	-,1	-,2	-,1	-,3	,0	-,1	,3	,1	1,0	-,3	-,2	,6**	,0	-,2	,0	-,2	-,2	,1	-,1	,0	,0	-,3	-,2	,1	,1
Cd	,4*	,6**	,8**	,7**	,1	,7**	,5**	,6**	,1	,1	-,3	1,0	,4*	,0	,4*	,6**	,4*	,4	,4	,0	,0	,6**	,1	,5**	,6**	-,2	,4*
Sb	-,2	,3	,4	,4	-,5**	,4*	,1	,5*	-,2	-,2	-,2	,4*	1,0	-,4	,0	,0	-,1	,0	-,2	-,4*	,1	,5*	,0	,2	,4	-,8**	,3
Ca	,2	,2	,2	,1	-,1	-,1	,4	,2	,4*	,5*	,6**	,0	-,4	1,0	,4*	,2	,4*	,1	,2	,4	,2	,2	,0	,1	,1	,3	,4
P	,6**	,8**	,7**	,7**	,1	,8**	,8**	,7**	,3	,6**	,0	,4*	,0	,4*	1,0	,8**	,8**	,8**	,8**	,5*	,2	,7**	-,2	,6**	,7**	,1	,6**
Cr	,9**	,8**	,8**	,9**	,4*	,8**	,9**	,6**	,4	,7**	-,2	,6**	,0	,2	,8**	1,0	,9**	,6**	,9**	,7**	-,1	,5*	-,1	,8**	,8**	,3	,5*
Mg	,9**	,8**	,7**	,8**	,3	,7**	,9**	,6**	,5**	,8**	,0	,4*	-,1	,4*	,8**	,9**	1,0	,6**	,9**	,8**	,0	,5*	,0	,8**	,7**	,3	,4*
Na	,5**	,7**	,5*	,6**	,0	,7**	,5**	,5	-,1	,3	-,2	,4	,0	,1	,8**	,6**	,6**	1,0	,7**	,3	,3	,4	,1	,5*	,6**	,0	,3
K	1,0**	,7**	,6**	,7**	,4*	,7**	,8**	,5	,3	,8**	-,2	,4	-,2	,2	,8**	,9**	,9**	,7**	1,0	,7**	,0	,4	,0	,7**	,7**	,4*	,3
Sc	,8**	,4	,2	,4*	,4*	,3	,8**	,2	,5**	,8**	,1	,0	-,4*	,4	,5*	,7**	,8**	,3	,7**	1,0	-,2	,0	,0	,5*	,3	,5**	,1
S	-,1	,1	,2	-,1	-,4*	,0	,0	,4	-,2	-,1	-,1	,0	,1	,2	,2	-,1	,0	,3	,0	-,2	1,0	,3	,0	-,1	,1	-,1	,1
Hg	,3	,8**	,9**	,7**	-,2	,8**	,6**	,9**	,1	,3	,0	,6**	,5*	,2	,7**	,5**	,5*	,4	,4	,0	,3	1,0	-,3	,4*	,8**	-,3	,7**
Se	-,1	-,2	-,1	-,1	,0	-,2	-,2	-,1	-,2	-,1	,0	,1	,0	,0	-,2	-,1	,0	,1	,0	,0	,0	-,3	1,0	-,1	-,2	-,1	-,3
Cs	,8**	,7**	,7**	,8**	,2	,6**	,8**	,6**	,6**	,6**	-,3	,5**	,2	,1	,6**	,8**	,8**	,5*	,7**	,5*	-,1	,4*	-,1	1,0	,7**	,2	,3
Sn	,7**	,9**	,9**	,9**	,1	,9**	,8**	,8**	,2	,5*	-,2	,6**	,4	,1	,7**	,8**	,7**	,6**	,7**	,3	,1	,8**	-,2	,7**	1,0	-,1	,7**
Zr	,5**	-,1	-,1	-,1	,5**	-,3	,2	-,3	,4*	,4*	,1	-,2	-,8**	,3	,1	,3	,3	,0	,4*	,5**	-,1	-,3	-,1	,2	-,1	1,0	-,3
Pb	,3	,7**	,6**	,6**	-,1	,6**	,5**	,7**	,1	,3	,1	,4*	,3	,4	,6**	,5*	,4*	,3	,3	,1	,1	,7**	-,3	,3	,7**	-,3	1,0

**Korelasyonlar 0.01 seviyesinde anlamlıdır (2-tailed).

*Korelasyonlar 0.05 seviyesinde anlamlıdır (2-tailed). ~1,0 0,9 0,8 0,7 0,6

- ** Correlation is significant at the 0.01 level (2-tailed).
- * Correlation is significant at the 0.05 level (2-tailed).
- Significance coefficients were customized by using the color spectrum for correlation in the related chart.

$r^2 \geq 1$ $r^2 \geq 0.9$ $r^2 \geq 0.8$ $r^2 \geq 7$ $r^2 \geq 0.6$

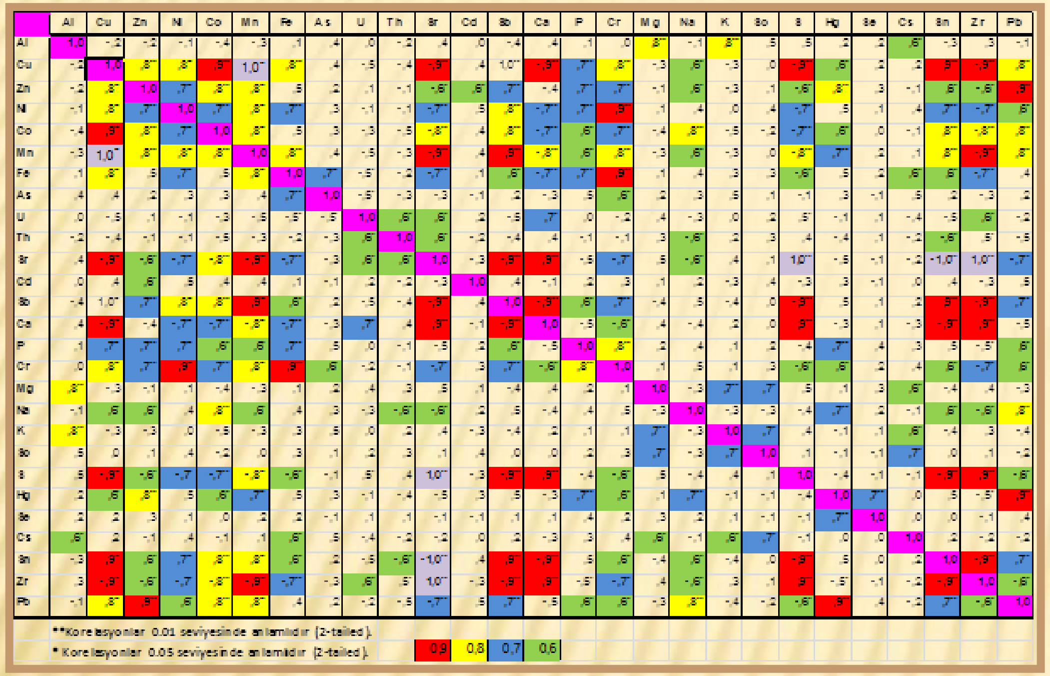
- All statistical evaluations were carried out with SPSS 20 program.

Basically, the difference of heavy metals with Al indicates that they are anthropogenic origine(Alvarez-Iglesias, 2007).

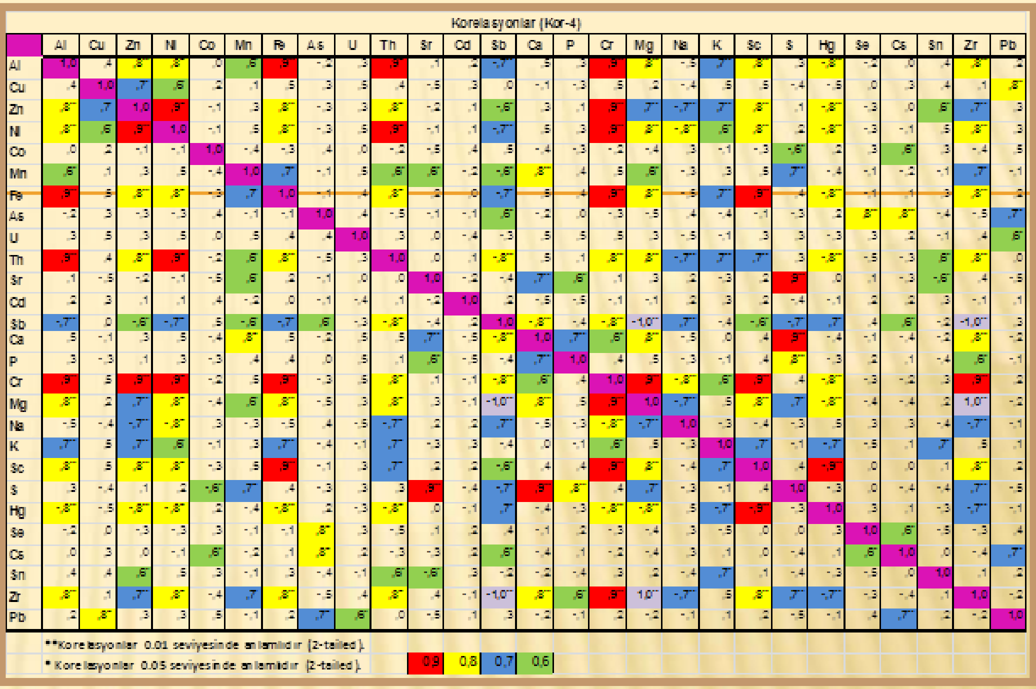
$r^2 \geq 1$ $r^2 \geq 0.9$ $r^2 \geq 0.8$ $r^2 \geq 7$ $r^2 \geq 0.6$

Pearson's correlation coefficients among the metals and Al in the bottom sediments

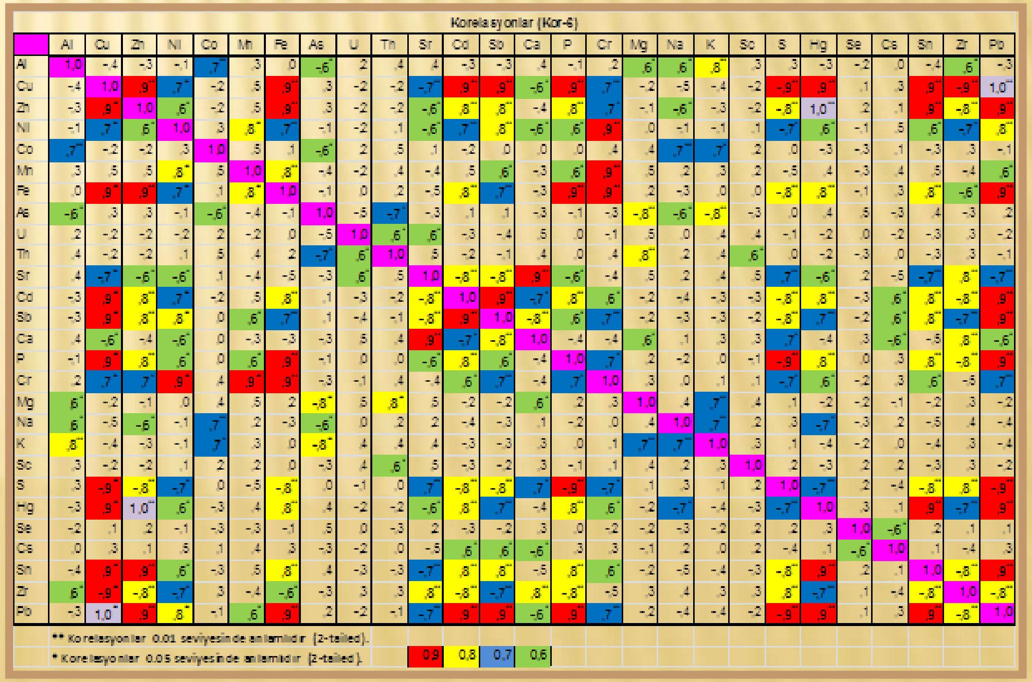
Core-3



Core-4



Core-6



$r^2 \geq 1$ | $r^2 \geq 0.9$ | $r^2 \geq 0.8$ | $r^2 \geq 7$ | $r^2 \geq 0.6$

The correlation with Al can indicate whether the metals are from natural weathering processes of rocks or from anthropogenic sources and reflect the status of environmental contamination.

Pearson' s correlation coefficients among the metals and Al in the bottom sediments

Core-10

Korelasyonlar (Kor-10)

	Al	Cu	Zn	Ni	Co	Mn	Fe	As	U	Th	Sr	Cd	Sb	Ca	P	Cr	Mg	Na	K	Sc	S	Hg	Se	Cs	Sn	Zr	Pb
Al	1,0	,7	,5	,9	,8	,6	1,0	,9	,5	,9	,8	-,3	-1,0	,4	-,8	,9	1,0	,8	1,0	1,0	,9	-,9	,2	,9	,8	-,9	,0
Cu	,7	1,0	,8	,9	,9	1,0	,7	,8	,8	,8	,7	,2	-,7	,7	-,3	,8	,7	,7	,7	,7	,5	-,6	,1	,7	,5	-,8	,5
Zn	,5	,8	1,0	,7	,7	,8	,5	,6	,7	,6	,6	,3	-,6	,6	-,1	,6	,5	,6	,5	,5	,2	-,4	,1	,6	,5	-,6	,5
Ni	,9	,9	,7	1,0	,9	,8	,9	,9	,7	1,0	,8	-,1	-,9	,6	-,6	,9	,9	,8	,9	,9	,7	-,8	,2	,9	,7	-,9	,2
Co	,8	,9	,7	,9	1,0	,9	,9	,9	,7	,9	,8	,0	-,8	,7	-,5	,9	,9	,8	,8	,8	,7	-,8	,2	,8	,6	-,9	,3
Mn	,6	1,0	,8	,8	,9	1,0	,7	,8	,8	,8	,7	,2	-,7	,7	-,3	,7	,7	,7	,7	,7	,4	-,6	,2	,7	,4	-,8	,5
Fe	1,0	,7	,5	,9	,9	,7	1,0	,9	,6	1,0	,8	-,3	-1,0	,5	-,7	,9	1,0	,8	1,0	1,0	,9	-,9	,2	,9	,7	-,9	,1
As	,9	,8	,6	,9	,9	,8	,9	1,0	,5	,9	,8	-,2	-,9	,6	-,6	,8	,9	,8	,9	,9	,7	-,9	,2	,9	,7	-,9	,2
U	,5	,8	,7	,7	,7	,8	,6	,5	1,0	,7	,6	,1	-,6	,4	-,2	,8	,6	,7	,5	,6	,4	-,4	,2	,5	,5	-,5	,6
Th	,9	,8	,6	1,0	,9	,8	1,0	,9	,7	1,0	,8	-,1	-,9	,6	-,7	,9	1,0	,8	1,0	,9	,8	-,9	,2	,9	,8	-,9	,3
Sr	,8	,7	,6	,8	,8	,7	,8	,8	,6	,8	1,0	-,1	-,9	,8	-,5	,8	,8	,9	,8	,8	,7	-,7	,2	,7	,8	-,8	,3
Cd	-,3	,2	,3	-,1	,0	,2	-,3	-,2	,1	-,1	-,1	1,0	,2	,2	,3	-,2	-,3	,0	-,3	-,3	-,5	,2	,1	-,2	-,3	,0	,3
Sb	-1,0	-,7	-,6	-,9	-,8	-,7	-1,0	-,9	-,6	-,9	-,9	,2	1,0	-,6	,8	-,8	-1,0	-,9	-1,0	-,9	-,9	,9	-,2	-,9	-,8	,9	-,2
Ca	,4	,7	,6	,6	,7	,7	,5	,6	,4	,6	,8	,2	-,6	1,0	-,2	,4	,6	,6	,5	,5	,3	-,5	,2	,5	,4	-,7	,3
P	-,8	-,3	-,1	-,6	-,5	-,3	-,7	-,6	-,2	-,7	-,5	,3	,8	-,2	1,0	-,5	-,7	-,6	-,8	-,7	-,8	,8	-,1	-,6	-,5	,7	,2
Cr	,9	,8	,6	,9	,9	,7	,9	,8	,8	,9	,8	-,2	-,8	,4	-,5	1,0	,9	,8	,8	,9	,8	-,7	,1	,7	,7	-,7	,3
Mg	1,0	,7	,5	,9	,9	,7	1,0	,9	,6	1,0	,8	-,3	-1,0	,6	-,7	,9	1,0	,9	1,0	1,0	,9	-,9	,2	,9	,8	-,9	,1
Na	,8	,7	,6	,8	,8	,7	,8	,8	,7	,8	,9	,0	-,9	,6	-,6	,8	,9	1,0	,8	,8	,7	-,8	,3	,7	,8	-,9	,4
K	1,0	,7	,5	,9	,8	,7	1,0	,9	,5	1,0	,8	-,3	-1,0	,5	-,8	,8	1,0	,8	1,0	1,0	,9	-,9	,2	,9	,8	-,9	,1
Sc	1,0	,7	,5	,9	,8	,7	1,0	,9	,6	,9	,8	-,3	-,9	,5	-,7	,9	1,0	,8	1,0	1,0	,9	-,9	,2	,9	,7	-,8	,1
S	,9	,5	,2	,7	,7	,4	,9	,7	,4	,8	,7	-,5	-,9	,3	-,8	,8	,9	,7	,9	,9	1,0	-,8	,2	,7	,7	-,7	-,1
Hg	-,9	-,6	-,4	-,8	-,8	-,6	-,9	-,9	-,4	-,9	-,7	,2	,9	-,5	,8	-,7	-,9	-,8	-,9	-,9	-,8	1,0	-,2	-,9	-,7	,9	,0
Se	,2	,1	,1	,2	,2	,2	,2	,2	,2	,2	,2	,1	-,2	,2	-,1	,1	,2	,3	,2	,2	,2	-,2	1,0	,2	,0	-,2	-,1
Cs	,9	,7	,6	,9	,8	,7	,9	,9	,5	,9	,7	-,2	-,9	,5	-,6	,7	,9	,7	,9	,9	,7	-,9	,2	1,0	,7	-,8	,1
Sn	,8	,5	,5	,7	,6	,4	,7	,7	,5	,8	,8	-,3	-,8	,4	-,5	,7	,8	,8	,8	,7	,7	-,7	,0	,7	1,0	-,6	,3
Zr	-,9	-,8	-,6	-,9	-,9	-,8	-,9	-,9	-,5	-,9	-,8	,0	,9	-,7	,7	-,7	-,9	-,9	-,9	-,8	-,7	,9	-,2	-,8	-,6	1,0	-,2
Pb	,0	,5	,5	,2	,3	,5	,1	,2	,6	,3	,3	,3	-,2	,3	,2	,3	,1	,4	,1	,1	-,1	,0	-,1	,1	,3	-,2	1,0

**Korelasyonlar 0.01 seviyesinde anlamlıdır (2-tailed).
*Korelasyonlar 0.05 seviyesinde anlamlıdır (2-tailed). -1,0 0,9 0,8 0,7 0,6

Core-12

	Al	Cu	Zn	Ni	Co	Mn	Fe	As	U	Th	Sr	Cd	Sb	Ca	P	Cr	Mg	Na	K	Sc	S	Hg	Se	Cs	Sn	Zr	Pb
Al	1,0	,2	,1	,1	,4	-,1	,8	-,2	-,3	-,3	-,4	,2	-,1	-,5	,3	,5	,2	,1	,8	,6	-,3	,1	-,2	,6	,3	-,2	-,2
Cu	,2	1,0	,9	,2	,4	,1	,0	-,6	,5	,3	-,2	,8	,9	-,5	,7	,8	-,1	,5	,3	,6	-,6	,9	,3	,3	,8	-,6	,5
Zn	,1	,9	1,0	-,2	,4	-,3	-,1	-,8	,4	,0	,1	,9	,9	-,5	,8	,9	-,5	,6	,1	,5	-,8	1,0	,4	,0	,9	-,8	,6
Ni	,1	,2	-,2	1,0	,1	,9	,2	,6	,5	,7	-,4	-,1	-,1	,2	-,4	,0	,8	-,2	,3	,3	,5	-,2	,1	,6	-,3	,5	-,1
Co	,4	,4	,4	,1	1,0	,0	,1	-,2	,1	,0	,1	,4	,3	-,2	,2	,5	-,1	,0	,1	,3	-,3	,5	,1	,0	,3	-,2	,2
Mn	-,1	,1	-,3	,9	,0	1,0	,0	,7	,6	,8	-,2	-,2	-,2	,4	-,5	-,3	,8	-,2	,1	,1	,7	-,3	,0	,4	-,5	,7	-,3
Fe	,8	,0	-,1	,2	,1	,0	1,0	,0	-,3	-,3	-,5	,0	-,3	-,4	,2	,3	,4	,1	,9	,5	-,2	-,2	-,1	,7	,1	,0	-,3
As	-,2	-,6	-,8	,6	-,2	,7	,0	1,0	,1	,5	,0	-,7	-,7	,7	-,9	-,8	,8	-,5	-,1	-,3	1,0	-,8	-,2	,1	-,9	1,0	-,5
U	-,3	,5	,4	,5	,1	,6	-,3	,1	1,0	,9	,1	,4	,5	,2	,1	,2	,3	,2	-,1	,3	,2	,4	,2	,2	,1	,1	,0
Th	-,3	,3	,0	,7	,0	,8	-,3	,5	,9	1,0	,1	,0	,2	,4	-,3	-,1	,6	,1	-,1	,2	,5	,0	,2	,2	-,3	,5	-,2
Sr	-,4	-,2	,1	-,4	,1	-,2	-,5	,0	,1	,1	1,0	-,1	,1	,6	,0	-,2	-,4	,3	-,6	-,2	,1	,1	,0	-,6	-,1	,0	,0
Cd	,2	,8	,9	-,1	,4	-,2	,0	-,7	,4	,0	-,1	1,0	,8	-,6	,8	,8	-,4	,5	,2	,4	-,7	,9	,3	,1	,8	-,7	,5
Sb	-,1	,9	,9	-,1	,3	-,2	-,3	-,7	,5	,2	,1	,8	1,0	-,4	,7	,7	-,5	,5	,0	,3	-,7	1,0	,4	-,1	,8	-,7	,6
Ca	-,5	-,5	-,5	,2	-,2	,4	-,4	,7	,2	,4	,6	-,6	-,4	1,0	-,6	-,7	,3	-,2	-,6	-,4	,7	-,4	-,2	-,4	-,7	,6	-,3
P	,3	,7	,8	-,4	,2	-,5	,2	-,9	,1	-,3	,0	,8	,7	-,6	1,0	,9	-,5	,6	,2	,4	-,9	,8	,2	,0	,9	-,9	,5
Cr	,5	,8	,9	,0	,5	-,3	,3	-,8	,2	-,1	-,2	,8	,7	-,7	,9	1,0	-,3	,5	,5	,6	-,8	,8	,1	,3	,9	-,8	,4
Mg	,2	-,1	-,5	,8	-,1	,8	,4	,8	,3	,6	-,4	-,4	-,5	,3	-,5	-,3	1,0	-,2	,4	,2	,7	-,5	-,1	,7	-,6	,8	-,5
Na	,1	,5	,6	-,2	,0	-,2	,1	-,5	,2	,1	,3	,5	,5	-,2	,6	,5	-,2	1,0	,2	,4	-,4	,5	,2	,0	,5	-,4	,1
K	,8	,3	,1	,3	,1	,1	,9	-,1	-,1	-,1	-,6	,2	,0	-,6	,2	,5	,4	,2	1,0	,6	-,3	,0	,0	,8	,3	-,1	-,2
Sc	,6	,6	,5	,3	,3	,1	,5	-,3	,3	,2	-,2	,4	,3	-,4	,4	,6	,2	,4	,6	1,0	-,4	,4	,2	,5	,5	-,3	,0
S	-,3	-,6	-,8	,5	-,3	,7	-,2	1,0	,2	,5	,1	-,7	-,7	,7	-,9	-,8	,7	-,4	-,3	-,4	1,0	-,7	-,1	,0	-,9	1,0	-,6
Hg	,1	,9	1,0	-,2	,5	-,3	-,2	-,8	,4	,0	,1	,9	1,0	-,4	,8	,8	-,5	,5	,0	,4	-,7	1,0	,3	-,1	,8	-,8	,6
Se	-,2	,3	,4	,1	,1	,0	-,1	-,2	,2	,2	,0	,3	,4	-,2	,2	,1	-,1	,2	,0	,2	-,1	,3	1,0	-,1	,2	-,2	,4
Cs	,6	,3	,0	,6	,0	,4	,7	,1	,2	,2	-,6	,1	-,1	-,4	,0	,3	,7	,0	,8	,5	,0	-,1	-,1	1,0	,1	,2	-,2
Sn	,3	,8	,9	-,3	,3	-,5	,1	-,9	,1	-,3	-,1	,8	,8	-,7	,9	,9	-,6	,5	,3	,5	-,9	,8	,2	,1	1,0	-,9	,5
Zr	-,2	-,6	-,8	,5	-,2	,7	,0	1,0	,1	,5	,0	-,7	-,7	,6	-,9	-,8	,8	-,4	-,1	-,3	1,0	-,8	-,2	,2	-,9	1,0	-,6
Pb	-,2	,5	,6	-,1	,2	-,3	-,3	-,5	,0	-,2	,0	,5	,6	-,3	,5	,4	-,5	,1	-,2	,0	-,6	,6	,4	-,2	,5	-,6	1,0

**Korelasyonlar 0.01 seviyesinde anlamlıdır (2-tailed).
*Korelasyonlar 0.05 seviyesinde anlamlıdır (2-tailed). 0,9 0,8 0,7 0,6

Core-14

Korelasyonlar (Kor-14)

	Al	Cu	Zn	Ni	Co	Mn	Fe	As	U	Th	Sr	Cd	Sb	Ca	P	Cr	Mg	Na	K	Sc	S	Hg	Se	Cs	Sn	Zr	Pb
Al	1	-,4	-0,3	0,26	,8	,5	,8	,0	,6	,8	-,2	-,5	-,5	-,2	-,1	-0,1	,4	-0,3	,8	,8	,5	-,5	-,1	,7	-,4	,5	-,5
Cu	-,4	1,0	,7	,6	-,3	-,4	-,2	,3	-,6	-,4	,0	,9	,8	-,1	,6	,9	,6	,9	-,1	-,4	-,5	1,0	,4	,1	,9	-,8	,9
Zn	-,3	,7	1,0	,2	-,3	-,2	-,4	,2	-,4	-,4	,2	,7	,6	,2	,4	,4	,2	,7	-,3	-,4	-,5	,6	,3	-,2	,5	-,6	,6
Ni	,3	,6	,2	1,0	,0	,0	,3	,4	-,1	,3	-,2	,6	,5	-,2	,5	,9	1,0	,7	,6	,3	-,1	,5	,3	,7	,7	-,5	,4
Co	,8	-,3	-,3	,0	1,0	,2	,6	-,1	,2	,4	-,3	-,5	-,5	-,3	-,3	-,2	,2	-,3	,6	,5	,2	-,4	-,1	,5	-,2	,3	-,4
Mn	,5	-,4	-,2	,0	,2	1,0	,5	-,1	,6	,6	,4	-,3	-,4	,4	,2	-,3	,0	-,4	,3	,4	,5	-,5	,1	,3	-,5	,7	-,5
Fe	,8	-,2	-,4	,3	,6	,5	1,0	-,1	,5	,8	-,3	-,3	-,3	-,3	,1	,0	,4	-,2	,8	,7	,5	-,3	,1	,7	-,2	,4	-,4
As	,0	,3	,2	,4	-,1	-,1	-,1	1,0	-,1	,1	,0	,2	,2	,0	,0	,3	,3	,5	,1	-,1	-,2	,2	,0	,2	,3	-,2	,2
U	,6	-,6	-,4	-,1	,2	,6	,5	-,1	1,0	,6	,2	-,5	-,4	,3	-,2	-,3	,0	-,5	,5	,6	,9	-,6	-,1	,3	-,6	,8	-,6
Th	,8	-,4	-,4	,3	,4	,6	,8	,1	,6	1,0	-,2	-,4	-,4	-,2	,0	-,1	,3	-,3	,7	,8	,4	-,5	,1	,7	-,3	,5	-,6
Sr	-,2	,0	,2	-,2	-,3	,4	-,3	,0	,2	-,2	1,0	,1	,0	,9	,2	-,1	-,2	,0	-,3	-,3	,2	,0	,1	-,3	-,2	,3	,0
Cd	-,5	,9	,7	,6	-,5	-,3	-,3	,2	-,5	-,4	,1	1,0	,8	,0	,6	,8	,5	,9	-,1	-,4	-,4	,9	,3	,0	,8	-,7	,8
Sb	-,5	,8	,6	,5	-,5	-,4	-,3	,2	-,4	-,4	,0	,8	1,0	-,1	,5	,7	,4	,8	-,2	-,3	-,5	,8	,4	,0	,8	-,8	,7
Ca	-,2	-,1	,2	-,2	-,3	,4	-,3	,0	,3	-,2	,9	,0	-,1	1,0	,1	-,2	-,3	-,1	-,3	-,3	,2	-,1	,0	-,3	-,3	,3	-,1
P	-,1	,6	,4	,5	-,3	,2	,1	,0	-,2	,0	,2	,6	,5	,1	1,0	,6	,5	,5	,0	-,2	-,1	,6	,7	,2	,4	-,3	,5
Cr	-,1	,9	,4	,9	-,2	-,3	,0	,3	-,3	-,1	-,1	,8	,7	-,2	,6	1,0	,8	,8	,3	-,1	-,3	,9	,5	,4	,9	-,7	,7
Mg	,4	,6	,2	1,0	,2	,0	,4	,3	,0	,3	-,2	,5	,4	-,3	,5	,8	1,0	,6	,7	,4	-,1	,5	,3	,8	,7	-,4	,4
Na	-,3	,9	,7	,7	-,3	-,4	-,2	,5	-,5	-,3	,0	,9	,8	-,1	,5	,8	,6	1,0	,0	-,3	-,5	,9	,4	,1	,9	-,8	,8
K	,8	-,1	-,3	,6	,6	,3	,8	,1	,5	,7	-,3	-,1	-,2	-,3	,0	,3	,7	,0	1,0	,8	,4	-,2	,0	,9	,0	,2	-,2
Sc	,8	-,4	-,4	,3	,5	,4	,7	-,1	,6	,8	-,3	-,4	-,3	-,3	-,2	-,1	,4	-,3	,8	1,0	,5	-,5	,1	,8	-,3	,4	-,4
S	,5	-,5	-,5	-,1	,2	,5	,5	-,2	,9	,4	,2	-,4	-,5	,2	-,1	-,3	-,1	-,5	,4	,5	1,0	-,5	-,1	,2	-,6	,8	-,5
Hg	-,5	1,0	,6	,5	-,4	-,5	-,3	,2	-,6	-,5	,0	,9	,8	-,1	,6	,9	,5	,9	-,2	-,5	-,5	1,0	,4	-,1	,9	-,8	,9
Se	-,1	,4	,3	,3	-,1	,1	,1	,0	-,1	,1	,1	,3	,4	,0	,7	,5	,3	,4	,0	,1	-,1	,4	1,0	,1	,3	-,2	,5
Cs	,7	,1	-,2	,7	,5	,3	,7	,2	,3	,7	-,3	,0	,0	-,3	,2	,4	,8	,1	,9	,8	,2	-,1	,1	1,0	,2	,1	-,1
Sn	-,4	,9	,5	,7	-,2	-,5	-,2	,3	-,6	-,3	-,2	,8	,8	-,3	,4	,9	,7	,9	,0	-,3	-,6	,9	,3	,2	1,0	-,9	,8
Zr	,5	-,8	-,6	-,5	,3	,7	,4	-,2	,8	,5	,3	-,7	-,8	,3	-,3	-,7	-,4	-,8	,2	,4	,8	-,8	-,2	,1	-,9	1,0	-,8
Pb	-,5	,9	,6	,4	-,4	-,5	-,4	,2	-,6	-,6	,0	,8	,7	-,1	,5	,7	,4	,8	-,2	-,4	-,5	,9	,5	-,1	,8	-,8	1,0

**Korelasyonlar 0.01 seviyesinde anlamlıdır (2-tailed).
*Korelasyonlar 0.05 seviyesinde anlamlıdır (2-tailed). 0,9 0,8 0,7 0,6

$r^2 \geq 1$ $r^2 \geq 0.9$ $r^2 \geq 0.8$ $r^2 \geq 7$ $r^2 \geq 0.6$

there are no significant correlations between Pb and Al
The anthropogenic Pb probably comes from non-point sources, such as wastewater discharges and also atmospheric deposition.

Pearson' s correlation coefficients among the metals and Al in the bottom sediments

Core-15

Korelasyonlar (Kor-15)

	Al	Cu	Zn	Ni	Co	Mn	Fe	As	U	Th	Sr	Cd	Sb	Ca	P	Cr	Mg	Na	K	Sc	S	Hg	Se	Cs	Sn	Zr	Pb
Al	1,0	-,5	-,7**	,3	-,3	-,5	,9**	-,3	-,5	,5	-,5	-,7*	-,7*	-,5	,0	-,1	,5	-,1	,8**	,8**	,8**	-,8**	-,5	-,1	-,4	,8**	-,6*
Cu	-,5	1,0	,9**	-,2	,4	,6*	-,3	,1	-,2	-,4	,7*	,8*	,7*	,6*	,5	,5	,1	,6*	-,4	-,5	-,5	,8*	,3	,2	,7*	-,7*	,9**
Zn	-,7**	,9**	1,0	-,3	,4	,7*	-,5	,2	,1	-,5	,9**	,8**	,7*	,7**	,5	,6*	,0	,5	-,5	-,6*	-,7*	,9**	,4	,2	,7*	-,7**	1,0**
Ni	,3	-,2	-,3	1,0	-,3	-,1	,4	,7*	,3	,6*	-,2	-,5	,1	,2	-,2	,4	,6*	-,4	,7*	,5	,6*	-,5	-,2	,5	-,1	,2	-,3
Co	-,3	,4	,4	-,3	1,0	,1	-,2	,0	-,1	-,7*	,5	,5	,2	,2	,3	,2	-,3	,8**	-,5	-,4	-,6*	,5	-,2	-,2	,0	,0	,5
Mn	-,5	,6*	,7*	-,1	,1	1,0	-,4	,2	,2	,0	,4	,6*	,4	,4	,0	,4	,1	,1	-,1	-,3	-,4	,6*	,5	,2	,3	-,6*	,6*
Fe	,9**	-,3	-,5	,4	-,2	-,4	1,0	-,1	-,4	,5	-,2	-,6*	-,5	-,2	,2	,2	,7**	,0	,8**	,8**	,8**	-,6*	-,5	,1	-,2	,7**	-,4
As	-,3	,1	,2	,7*	,0	,2	-,1	1,0	,7*	,3	,3	,0	,3	,6*	-,2	,5	,2	-,3	,0	,1	,0	,1	,2	,6*	,2	-,2	,2
U	-,5	-,2	,1	,3	-,1	,2	-,4	,7*	1,0	,3	,0	,0	,1	,2	-,6*	,1	-,3	-,5	-,2	-,1	-,2	,1	,2	,3	,0	-,1	,1
Th	,5	-,4	-,5	,6*	-,7**	,0	,5	,3	,3	1,0	-,5	-,7*	-,4	-,3	-,4	,0	,4	-,7*	,6*	,7**	,7**	-,6*	,1	,5	-,1	,4	-,4
Sr	-,5	,7*	,9**	-,2	,5	,4	-,2	,3	,0	-,5	1,0	,5	,5	,8**	,7**	,7**	,2	,6*	-,4	-,3	-,6*	,8**	,4	,4	,5	-,5	,8**
Cd	-,7*	,8**	,8**	-,5	,5	,6*	-,6*	,0	,0	-,7*	,5	1,0	,6*	,4	,2	,1	-,3	,4	-,6*	-,7**	-,8**	,9**	,3	-,2	,4	-,7*	,8**
Sb	-,7*	,7*	,7**	,1	,2	,4	-,5	,3	,1	-,4	,5	,6*	1,0	,7**	,3	,5	,0	,0	-,2	-,7*	-,3	,6*	,2	,1	,7*	-,8**	,6*
Ca	-,5	,6*	,7**	,2	,2	,4	-,2	,6*	,2	-,3	,8**	,4	,7**	1,0	,5	,7**	,3	,2	-,1	-,3	-,3	,6*	,2	,4	,5	-,6*	,6*
P	,0	,5	,5	-,2	,3	,0	,2	-,2	-,6*	-,4	,7**	,2	,3	,5	1,0	,5	,5	,7*	,1	-,1	-,1	,4	-,1	,1	,4	-,2	,5
Cr	-,1	,5	,6*	,4	,2	,4	,2	,5	,1	,0	,7**	,1	,5	,7**	,5	1,0	,6*	,2	,2	,1	,0	,4	,2	,6*	,4	-,2	,6*
Mg	,5	,1	,0	,6*	-,3	,1	,7**	,2	-,3	,4	,2	-,3	,0	,3	,5	,6*	1,0	,1	,8**	,5	,6*	-,2	-,1	,4	,3	,1	,0
Na	-,1	,6*	,5	-,4	,8**	,1	,0	-,3	-,5	-,7*	,6*	,4	,0	,2	,7*	,2	,1	1,0	-,3	-,2	-,5	,5	-,2	-,2	,3	-,2	,6*
K	,8**	-,4	-,5	,7*	-,5	-,1	,8**	,0	-,2	,6*	-,4	-,6*	-,2	-,1	,1	,2	,8**	-,3	1,0	,7**	,9**	-,7*	-,4	,1	-,1	,5	-,4
Sc	,8**	-,5	-,6*	,5	-,4	-,3	,8**	,1	-,1	,7*	-,3	-,7**	-,7*	-,3	-,1	,1	,5	-,2	,7**	1,0	,7**	-,7**	-,2	,3	-,3	,7*	-,5
S	,8**	-,5	-,7*	,6*	-,6*	-,4	,8**	,0	-,2	,7*	-,6*	-,8**	-,3	-,3	-,1	,0	,6*	-,5	,9**	,7**	1,0	-,8**	-,4	,2	-,2	,6*	-,6*
Hg	-,8**	,8*	,9**	-,5	,5	,6*	-,6*	,1	,1	-,6*	,8*	,9**	,6*	,6*	,4	,4	-,2	,5	-,7*	-,7**	-,8**	1,0	,4	,1	,6*	-,7**	,9**
Se	-,5	,3	,4	-,2	-,2	,5	-,5	,2	,2	,1	,4	,3	,2	,2	-,1	,2	-,1	-,2	-,4	-,2	-,4	,4	1,0	,6*	,2	-,6*	,3
Cs	-,1	,2	,2	,5	-,2	,2	,1	,6*	,3	,5	,4	-,2	,1	,4	,1	,6*	,4	-,2	,1	,3	,2	,1	,6*	1,0	,3	-,1	,2
Sn	-,4	,7*	,7*	-,1	,0	,3	-,2	,2	,0	-,1	,5	,4	,7*	,5	,4	,4	,3	,3	-,1	-,3	-,2	,6*	,2	,3	1,0	-,6*	,7**
Zr	,8**	-,7*	-,7**	,2	,0	-,6*	,7**	-,2	-,1	,4	-,5	-,7*	-,8**	-,6*	-,2	-,2	,1	-,2	,5	,7*	,6*	-,7**	-,6*	-,1	-,6*	1,0	-,6*
Pb	-,6*	,9**	1,0**	-,3	,5	,6*	-,4	,2	,1	-,4	,8**	,8**	,6*	,6*	,5	,6*	,0	,6*	-,4	-,5	-,6*	,9**	,3	,2	,7*	-,6*	1,0

**Korelasyonlar 0.01 seviyesinde anlamlıdır (2-tailed).

* Korelasyonlar 0.05 seviyesinde anlamlıdır (2-tailed).

0,9 0,8 0,7 0,6

Core-17

Korelasyonlar (Kor-17)

	Al	Cu	Zn	Ni	Co	Mn	Fe	As	U	Th	Sr	Cd	Sb	Ca	P	Cr	Mg	Na	K	Sc	S	Hg	Se	Cs	Sn	Zr	Pb
Al	1,0	-,4*	-,3	,3	,8**	,5**	,8**	,0	,6**	,8*	-,2	-,5*	-,5**	-,2	-,1	-,1	,4*	-,3	,8**	,8**	,5**	-,5**	-,1	,7**	-,4*	,5**	-,5**
Cu	-,4*	1,0	,7**	,6**	-,3	-,4*	-,2	,3	-,6**	-,4*	,0	,9**	,8*	-,1	,6**	,9**	,6**	,9**	-,1	-,4*	-,5**	1,0**	,4*	,1	,9**	-,8**	,9**
Zn	-,3	,7**	1,0	,2	-,3	-,2	-,4*	,2	-,4*	-,4*	,2	,7**	,6**	,2	,4*	,4*	,2	,7**	-,3	-,4*	-,5**	,6**	,3	-,2	,5**	-,6**	,6**
Ni	,3	,6**	,2	1,0	,0	,0	,3	,4*	-,1	,3	-,2	,6**	,5*	-,2	,5*	,9**	1,0**	,7**	,6**	,3	-,1	,5**	,3	,7**	,7**	-,5**	,4*
Co	,8**	-,3	-,3	,0	1,0	,2	,6**	-,1	,2	,4*	-,3	-,5*	-,5*	-,3	-,3	-,2	,2	-,3	,6**	,5**	,2	-,4*	-,1	,5**	-,2	,3	-,4
Mn	,5**	-,4*	-,2	,0	,2	1,0	,5**	-,1	,6**	,6**	,4*	-,3	-,4*	,4*	,2	-,3	,0	-,4*	,3	,4*	,5**	-,5**	,1	,3	-,5**	,7**	-,5**
Fe	,8**	-,2	-,4*	,3	,6**	,5**	1,0	-,1	,5*	,8**	-,3	-,3	-,3	-,3	,1	,0	,4*	-,2	,8**	,7**	,5**	-,3	,1	,7**	-,2	,4*	-,4*
As	,0	,3	,2	,4*	-,1	-,1	-,1	1,0	-,1	,1	,0	,2	,2	,0	,0	,3	,3	,5**	,1	-,1	-,2	,2	,0	,2	,3	-,2	,2
U	,6**	-,6**	-,4*	-,1	,2	,6**	,5*	-,1	1,0	,6**	,2	-,5*	-,4*	,3	-,2	-,3	,0	-,5**	,5**	,6**	,9**	-,6**	-,1	,3	-,6**	,8**	-,6**
Th	,8**	-,4*	-,4*	,3	,4*	,6**	,8**	,1	,6**	1,0	-,2	-,4*	-,4	-,2	,0	-,1	,3	-,3	,7**	,8**	,4*	-,5**	,1	,7**	-,3	,5**	-,6**
Sr	-,2	,0	,2	-,2	-,3	,4*	-,3	,0	,2	-,2	1,0	,1	,0	,9**	,2	-,1	-,2	,0	-,3	-,3	,2	,0	,1	-,3	-,2	,3	,0
Cd	-,5*	,9**	,7**	,6**	-,5*	-,3	-,3	,2	-,5**	-,4*	,1	1,0	,8**	,0	,6**	,8**	,5**	,9**	-,1	-,4*	-,4*	,9**	,3	,0	,8**	-,7**	,8**
Sb	-,5**	,8**	,6**	,5*	-,5*	-,4*	-,3	,2	-,4*	-,4	,0	,8**	1,0	-,1	,5**	,7**	,4*	,8**	-,2	-,3	-,5**	,8**	,4*	,0	,8**	-,8**	,7**
Ca	-,2	-,1	,2	-,2	-,3	,4*	-,3	,0	,3	-,2	,9**	,0	-,1	1,0	,1	-,2	-,3	-,1	-,3	-,3	,2	-,1	,0	-,3	-,3	,3	-,1
P	-,1	,6**	,4*	,5*	-,3	,2	,1	,0	-,2	,0	,2	,6**	,5**	,1	1,0	,6**	,5**	,5**	,0	-,2	-,1	,6**	,7**	,2	,4*	-,3	,5**
Cr	-,1	,9**	,4*	,9**	-,2	-,3	,0	,3	-,3	-,1	-,1	,8**	,7**	-,2	,6**	1,0	,8**	,8**	,3	-,1	-,3	,9**	,5*	,4*	,9**	-,7**	,7**
Mg	,4*	,6**	,2	1,0**	,2	,0	,4*	,3	,0	,3	-,2	,5**	,4*	-,3	,5**	,8**	1,0	,6**	,7**	,4	-,1	,5**	,3	,8**	,7**	-,4*	,4*
Na	-,3	,9**	,7**	,7**	-,3	-,4*	-,2	,5*	-,5**	-,3	,0	,9**	,8**	-,1	,5**	,8**	,6**	1,0	,0	-,3	-,5**	,9**	,4	,1	,9**	-,8**	,8**
K	,8**	-,1	-,3	,6**	,6**	,3	,8**	,1	,5*	,7**	-,3	-,1	-,2	-,3	,0	,3	,7**	,0	1,0	,8**	,4*	-,2	,0	,9**	,0	,2	-,2
Sc	,8**	-,4*	-,4*	,3	,5**	,4*	,7**	-,1	,6**	,8**	-,3	-,4*	-,3	-,3	-,2	-,1	,4	-,3	,8**	1,0	,5*	-,5**	,1	,8**	-,3	,4*	-,4*
S	,5**	-,5**	-,5**	-,1	,2	,5**	,5**	-,2	,9**	,4*	,2	-,4*	-,5**	,2	-,1	-,3	-,1	-,5**	,4*	,5*	1,0	-,5**	-,1	,2	-,6**	,8**	-,5**
Hg	-,5**	1,0**	,6**	,5*	-,4*	-,5**	-,3	,2	-,6**	-,5**	,0	,9**	,8**	-,1	,6**	,9**	,5**	,9**	-,2	-,5**	-,5**	1,0	,4*	-,1	,9**	-,8**	,9**
Se	-,1	,4*	,3	,3	-,1	,1	,1	,0	-,1	,1	,1	,3	,4*	,0	,7**	,5*	,3	,4	,0	,1	-,1	,4*	1,0	,1	,3	-,2	,5*
Cs	,7**	,1	-,2	,7**	,5**	,3	,7**	,2	,3	,7**	-,3	,0	,0	-,3	,2	,4*	,8**	,1	,9**	,8**	,2	-,1	,1	1,0	,2	,1	-,1
Sn	-,4*	,9**	,5**	,7**	-,2	-,5**	-,2	,3	-,6**	-,3	-,2	,8**	,8**	-,3	,4*	,9**	,7**	,9**	,0	-,3	-,6**	,9**	,3	,2	1,0	-,9**	,8**
Zr	,5**	-,8**	-,6**	-,5**	,3	,7**	,4*	-,2	,8**	,5*	,3	-,7**	-,8**	,3	-,3	-,7**	-,4*	-,8**	,2	,4*	,8**	-,8**	-,2	,1	-,9**	1,0	-,8**
Pb	-,5**	,9**	,6**	,4*	-,4	-,5**	-,4*	,2	-,6**	-,6**	,0	,8**	,7**	-,1	,5**	,7**	,4*	,8**	-,2	-,4*	-,5**	,9**	,5**	-,1	,8**	-,8**	1,0

**Korelasyonlar 0.01 seviyesinde anlamlıdır (2-tailed).

* Korelasyonlar 0.05 seviyesinde anlamlıdır (2-tailed).

0,9 0,8 0,7 0,6

Core-19

Korelasyonlar (Kor-19)

	Al	Cu	Zn	Ni	Co	Mn	Fe	As	U	Th	Sr	Cd	Sb	Ca	P	Cr	Mg	Na	K	Sc	S	Hg	Se	Cs	Sn	Zr	Pb
Al	1,0	-,1	-,3	,5**	,4	,1	,8**	,3	-,1	,7**	-,1	-,4*	-,7**	-,5*	-,2	,3	,8**	-,1	,9**	,7**	,5**	-,5**	,1	,1	,2	,8**	-,3
Cu	-,1	1,0	,8**	,5*	,4*	,9**	,2	-,1	,7**	,1	,2	,7**	,3	,5*	,7**	,7**	,0	,2	-,4	,3	-,7**	,4	-,1	,6**	,3	-,4*	,6**
Zn	-,3	,8**	1,0	,2	,4	,6**	-,1	-,3	,6**	-,2	,6**	,6**	,3	,8**	,6**	,7**	,0	,5*	-,5**	-,1	-,5**	,8**	,2	,3	,5*	-,4*	,7**
Ni	,5**	,5*	,2	1,0	,4	,7*	,7**	,5*	,2	,6**	,0	,3	-,1	,1	,4*	,5**	,6**	-,1	,3	,7**	-,2	-,3	,0	,6**	,2	,1	,0
Co	,4	,4*	,4	,4	1,0	,3	,3	,1	,0	,0	,2	,2	-,4*	,2	,0	,3	,2	,2	,1	,3	-,2	,0	-,1	,5**	,2	,0	,1
Mn	,1	,9**	,6**	,7*	,3	1,0	,4*	,1	,6**	,3	,0	,6**	,2	,3	,7**	,7**	,1	,1	-,2	,5*	-,6**	,1	-,1	,6**	,2	-,4	,4
Fe	,8**	,2	-,1	,7*	,3	,4*	1,0	,3	,2	,8**	,0	-,2	-,5**	-,4	,2	,6**	,8**	-,1	,7**	,8**	,3	-,4*	,1	,2	,3	,6**	-,1
As	,3	-,1	-,3	,5*	,1	,1	,3	1,0	-,5**	,3	-,2	,1	-,1	,0	-,1	-,2	,3	-,1	,2	,3	,0	-,6**	-,2	,5*	-,1	,0	-,6**
U	-,1	,7**	,6**	,2	,0	,6**	,2	-,5**	1,0	,3	,3	,4	,3	,2	,7**	,8**	,1	,2	-,2	,1	-,3	,5**	,1	,0	,4*	-,2	,8**
Th	,7**	,1	-,2	,6**	,0	,3	,8**	,3	,3	1,0	-,2	-,3	-,3	-,5**	,2	,4	,7**	-,2	,7**	,7**	,3	-,5**	,0	,1	,2	,5**	-,1
Sr	-,1	,2	,6**	,0	,2	,0	,0	-,2	,3	-,2	1,0	,0	-,2	,6**	,2	,4*	,3	,7**	,0	-,1	,2	,7**	,6**	-,3	,6**	,1	,5*
Cd	-,4*	,7**	,6**	,3	,2	,6**	-,2	,1	,4	-,3	,0	1,0	,5**	,6**	,5**	,3	-,3	,3	-,6**	-,1	-,7**	,4	-,3	,4*	,0	-,6**	,3
Sb	-,7**	,3	,3	-,1	-,4*	,2	-,5**	-,1	,3	-,3	-,2	,5**	1,0	,4*	,5*	-,1	-,6**	-,2	-,8**	-,3	-,7**	,3	-,2	,3	-,3	-,8**	,3
Ca	-,5*	,5*	,8**	,1	,2	,3	-,4	,0	,2	-,5*	,6**	,6**	,4*	1,0	,5*	,2	-,2	,4	-,6**	-,3	-,6**	,6**	,1	,3	,2	-,6**	,5*
P	-,2	,7**	,6**	,4*	,0	,7**	,2	-,1	,7**	,2	,2	,5**	,5*	,5*	1,0	,6**	,1	,0	-,4*	,2	-,5*	,4*	,2	,3	,3	-,4	,6**
Cr	,3	,7**	,7**	,5**	,3	,7**	,6**	-,2	,8**	,4	,4*	,3	-,1	,2	,6**	1,0	,5**	,3	,1	,5*	-,1	,4*	,3	,2	,5*	,1	,6**
Mg	,8**	,0	,0	,6**	,2	,1	,8**	,3	,1	,7**	,3	-,3	-,6**	-,2	,1	,5**	1,0	,2	,8**	,5**	,6**	-,2	,4*	,0	,5*	,7**	,0
Na	-,1	,2	,5*	-,1	,2	,1	-,1	-,1	,2	-,2	,7**	,3	-,2	,4	,0	,3	,2	1,0	,0	-,2	,2	,5**	,4*	-,1	,4*	,0	,2
K	,9**	-,4	-,5*	,3	,1	-,2	,7**	,2	-,2	,7**	,0	-,6**	-,8**	-,6**	-,4*	,1	,8**	,0	1,0	,4*	,8**	-,5**	,1	-,3	,2	,9**	-,4
Sc	,7**	,3	-,1	,7**	,3	,5*	,8**	,3	,1	,7**	-,1	-,1	-,3	-,3	,2	,5*	,5**	-,2	,4*	1,0	,1	-,4*	-,1	,5*	,0	,3	-,1
S	,5**	-,7**	-,5**	-,2	-,2	-,6**	,3	,0	-,3	,3	,2	-,7**	-,7**	-,6**	-,5*	-,1	,6**	,2	,8**	,1	1,0	-,2	,4*	-,6**	,2	,9**	-,3
Hg	-,5**	,4	,8**	-,3	,0	,1	-,4*	-,6**	,5**	-,5*	,7**	,4	,3	,6**	,4*	,4*	-,2	,5**	-,5**	-,4*	-,2	1,0	,4	-,2	,4*	-,3	,8**
Se	,1	-,1	,2	,0	-,1	-,1	,1	-,2	,1	,0	,6**	-,3	-,2	,1	,2	,3	,4*	,4*	,1	-,1	,4*	,4	1,0	-,3	,5*	,3	,2
Cs	,1	,6**	,3	,6**	,5**	,6**	,2	,5*	,0	,1	-,3	,4*	,3	,3	,3	,2	,0	-,1	-,3	,5*	-,6**	-,2	-,3	1,0	-,1	-,4*	-,1
Sn	,2	,3	,5*	,2	,2	,2	,3	-,1	,4*	,2	,6**	,0	-,3	,2	,3	,5*	,5**	,4*	,2	,0	,2	,4*	,5*	-,1	1,0	,3	,5*
Zr	,8**	-,4*	-,4*	,1	,0	-,4	,6**	,0	-,2	,5*	,1	-,6**	-,8**	-,6**	-,4	,1	,7**	,0	,9**	,3	,9**	-,3	,3	-,4*	,3	1,0	-,3
Pb	-,3	,6**	,7**	,0	,1	,4	-,1	-,6**	,8**	-,1	,5**	,3	,3	,5*	,6**	,6**	,0	,2	-,4	-,1	-,3	,8**	,2	-,1	,5	-,3	1,0

**Korelasyonlar 0.01 seviyesinde anlamlıdır (2-tailed).

* Korelasyonlar 0.05 seviyesinde anlamlıdır (2-tailed).

0,9 0,8 0,7 0,6

$r^2 \geq 1$ | $r^2 \geq 0.9$ | $r^2 \geq 0.8$ | $r^2 \geq 7$ | $r^2 \geq 0.6$

It is found that the there is no any correlation with the metals in many core samples. These patterns may also reflect the anthropogenic discharges to the çandarlı Gulf comes from many different sources for several heavy metals .

Pearson' s correlation coefficients among the metals and Al in the bottom sediments

Core-20

Korelasyonlar (Kor-20)

	Al	Cu	Zn	Ni	Co	Mn	Fe	As	U	Th	Sr	Cd	Sb	Ca	P	Cr	Mg	Na	K	Sc	S	Hg	Se	Cs	Sn	Zr	Pb
Al	1,0	,4	,1	,7**	,1	,0	,4*	,5**	,4*	,5**	,3	-,1	,3	-,6**	,1	,8**	,6**	,9**	,4*	,5*	,6**	-,2	,4*	,0	,2	,7**	,2
Cu	,4	1,0	,9**	,2	,8**	,3	,8**	,3	-,4*	,9**	,0	,1	-,6**	-,1	,6**	,6**	,1	,4	-,6**	,9**	,4	,5*	-,3	,7**	,8**	,3	,4*
Zn	,1	,9**	1,0	-,3	1,0**	,3	,7**	,0	-,8**	,7**	-,2	,0	-,9**	,2	,7**	,2	-,3	,0	-,8**	,7**	,0	,8**	-,6**	,9**	,8**	-,2	,4
Ni	,7**	,2	-,3	1,0	-,3	-,1	,3	,6**	,8**	,3	,5*	,2	,7**	-,6**	-,2	,8**	,7**	,9**	,5**	,3	,7**	-,6**	,6**	-,4*	-,1	,9**	,2
Co	,1	,8**	1,0**	-,3	1,0	,4	,8**	,2	-,8**	,8**	-,2	-,1	-,8**	,1	,7**	,2	-,2	,0	-,8**	,7**	,1	,8**	-,5**	,9**	,8**	-,1	,4*
Mn	,0	,3	,3	-,1	,4	1,0	,4	,2	-,3	,2	,0	,0	-,3	,0	,2	,0	,4*	,0	-,4	,3	,2	,2	,0	,3	,1	,0	,5*
Fe	,4*	,8**	,7**	,3	,8**	,4	1,0	,7**	-,4	,9**	,0	,0	-,4*	-,3	,5*	,7**	,2	,4	-,5**	,9**	,7**	,3	-,2	,6**	,6**	,5*	,6**
As	,5**	,3	,0	,6**	,2	,2	,7**	1,0	,2	,6**	,3	,1	,2	-,5**	,1	,7**	,4*	,5*	,0	,5**	1,0**	-,3	,4	,0	,0	,8**	,4
U	,4*	-,4*	-,8**	,8**	-,8**	-,3	-,4	,2	1,0	-,3	,4*	,1	1,0**	-,5*	-,5**	,4	,6**	,6**	,9**	-,3	,3	-,9**	,8**	-,9**	-,6**	,6**	-,2
Th	,5**	,9**	,7**	,3	,8**	,2	,9**	,6**	-,3	1,0	,1	,1	-,4	-,2	,6**	,7**	,1	,4*	-,4*	,9**	,6**	,3	-,2	,6**	,7**	,5*	,5*
Sr	,3	,0	-,2	,5*	-,2	,0	,0	,3	,4*	,1	1,0	,2	,3	,2	,1	,3	,3	,4*	,2	,2	,4	-,4*	,1	-,3	-,3	,5*	,1
Cd	-,1	,1	,0	,2	-,1	,0	,0	,1	,1	,1	,2	1,0	,1	-,2	,2	,0	,1	,1	,0	,0	,0	,0	,1	-,1	,1	,1	-,1
Sb	,3	-,6**	-,9**	,7**	-,8**	-,3	-,4*	,2	1,0**	-,4	,3	,1	1,0	-,5*	-,6**	,2	,5**	,4*	,9**	-,4*	,3	-,9**	,8**	-,9**	-,6**	,5**	-,2
Ca	-,6**	-,1	,2	-,6**	,1	,0	-,3	-,5*	-,5*	-,2	,2	-,2	-,5*	1,0	,1	-,5**	-,5*	-,5**	-,5*	-,1	-,5**	,4	-,6**	,3	-,1	-,6**	,0
P	,1	,6**	,7**	-,2	,7**	,2	,5*	,1	-,5**	,6**	,1	,2	-,6**	,1	1,0	,1	-,3	-,1	-,6**	,5**	,0	,5**	-,5*	,6**	,5*	-,1	,2
Cr	,8**	,6**	,2	,8**	,2	,0	,7**	,7**	,4	,7**	,3	,0	,2	-,5**	,1	1,0	,5**	,8**	,1	,7**	,8**	-,2	,3	,0	,3	,9**	,3
Mg	,6**	,1	-,3	,7**	-,2	,4*	,2	,4*	,6**	,1	,3	,1	,5**	-,5*	-,3	,5**	1,0	,7**	,4*	,1	,5**	-,5*	,6**	-,4	-,2	,6**	,2
Na	,9**	,4	,0	,9**	,0	,0	,4	,5*	,6**	,4*	,4*	,1	,4*	-,5**	-,1	,8**	,7**	1,0	,4	,4*	,6**	-,4	,5*	-,2	,1	,8**	,3
K	,4*	-,6**	-,8**	,5*	-,8**	-,4	-,5**	,0	,9**	-,4*	,2	,0	,9**	-,5*	-,6**	,1	,4*	,4	1,0	-,5**	,1	-,7**	,8**	-,8**	-,5**	,4	-,4
Sc	,5*	,9**	,7**	,3	,7**	,3	,9**	,5*	-,3	,9**	,2	,0	-,4*	-,1	,5**	,7**	,1	,4*	-,5**	1,0	,6**	,2	-,2	,6**	,6**	,5*	,6**
S	,6**	,4	,0	,7**	,1	,2	,7**	1,0**	,3	,6**	,4	,0	,3	-,5**	,0	,8**	,5**	,6**	,1	,6**	1,0	-,4	,4*	-,1	,0	,9**	,4*
Hg	-,2	,5*	,8**	-,6**	,8**	,2	,3	-,3	-,9**	,3	-,4*	,0	-,9**	,4	,5**	-,2	-,5*	-,4	-,7**	,2	-,4	1,0	-,6**	,8**	,7**	-,6**	,1
Se	,4*	-,3	-,6**	,6**	-,5**	,0	-,2	,4	,8**	-,2	,1	,1	,8**	-,6**	-,5*	,3	,6**	,5*	,8**	-,2	,4*	-,6**	1,0	-,7**	-,4*	,5**	-,2
Cs	,0	,7**	,9**	-,4*	,9**	,3	,6**	,0	-,9**	,6**	-,3	-,1	-,9**	,3	,6**	,0	-,4	-,2	-,8**	,6**	-,1	,8**	-,7**	1,0	,7**	-,3	,4
Sn	,2	,8**	,8**	-,1	,8**	,1	,6**	,0	-,6**	,7**	-,3	,1	-,6**	-,1	,5*	,3	-,2	,1	-,5**	,6**	,0	,7**	-,4*	,7**	1,0	-,1	,2
Zr	,7**	,3	-,2	,9**	-,1	,0	,5*	,8**	,6**	,5*	,5*	,1	,5**	-,6**	-,1	,9**	,6**	,8**	,4	,5*	,9**	-,6**	,5**	-,3	-,1	1,0	,3
Pb	,2	,4*	,4	,2	,4*	,5*	,6**	,4	-,2	,5*	,1	-,1	-,2	,0	,2	,3	,2	,3	-,4	,6**	,4*	,1	-,2	,4	,2	,3	1,0

**Korelasyonlar 0.01 seviyesinde anlamlıdır (2-tailed).

* Korelasyonlar 0.05 seviyesinde anlamlıdır (2-tailed). 0,9 0,8 0,7 0,6

$r^2 \geq 1$ $r^2 \geq 0.9$ $r^2 \geq 0.8$ $r^2 \geq 7$ $r^2 \geq 0.6$

As shown in the figures, apart from Al, in most cases, there are no significant correlations among the heavy metals, suggesting that these metals are not associated with each other and the relationship doest not exist between them. Furthermore, these metals could have different anthropogenic and natural sources in the sediments of Çandarlı Gulf.

CONCLUSIONS

According to the established chronology showed clearly that the increase in the concentrations of the Hg, Cd, Pb and Zn in the recent sediments since 1980's were caused by human- induced changes. The results also showed that different sampling locations in received slightly different types of inputs. Pb isotopic composition data indicated that the increased Pb in the recent sediments was of anthropogenic origin. The combination of trace metal analysis, Pb isotopic composition and ^{210}Pb and ^{137}Cs dating as well as statistical data in the Gulf can provide vital information on the long-term accumulation of metals in sediments.

The results provide a realistic picture of the environmental changes of the ÇANDARLI Gulf throughout the last 100 years and a reference database for the future studies.

Our poster presentation

The Use of ^{7}Be, ^{137}Cs and ^{210}Pb in the Evaluation of the Short and Medium Term Sediment Deposition on the Meric River Floodplains''. The investigation is supported by The Scientific and Technical Research Council of Turkey (TUBITAK), No: 117Y 093 (2017-)

TEŞEKKÜRLER….

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COMING EVENT

Regional Training Course on Methodological Advances of Liquid Scintillation Counting and Alpha-particle Spectrometry for the Measurement of Marine Radioactivity (RER7009)

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We are glad to host this training course.

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THANKS FOR YOUR ATTENTıON

TC PROJECT RER7009 - EVT1900298

- Venue of the Workshop: The Regional Workshop will be held in Turkey, Ege University, Institute of Nuclear Sciences.
- Address: Ege University Campus, Institute of Nuclear Sciences 35100 Bornova - IZMIR, TURKEY within the period April 15th-19th, 2019.
- The following web sites can be accessed for more detailed information on Izmir:
- https://hometurkey.com/en/destinations/izmir
- https://hometurkey.com/en
- http://www.visitizmir.org/en/page/oegrenin/-518204
- https://ebys.ege.edu.tr/ogrenci/ebp/turkey-izmir.htm
- http://www.izmirturizm.gov.tr/
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- Workshop Host Organizer:
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- Accomodation: Hotel Anemon Ege Saglik, which is located in Ege University, Bornova (At 10 minutes walking distance to the Venue of the Workshop. At 5 minutes walking distance to metro station. You will be in the city center in 8 minutes by metro. At 2 minutes walking to shopping mall).
- https://tr.hotels.com/ho321230/?pa=1&q-check-out=2019-04-20&tab=description&q-room-0-adults=2&YGF=14&q-check-in=2019-04-14&MGT=6&WOE=6&WOD=7&ZSX=0&SYE=3&q-room-0-children=0
- Travel to İzmir (public bus/taxi):
- Adnan Menderes Airport (http://www.adnanmenderesairport.com/en-EN/Pages/Main.aspx) is located 15 km from the City Center of Izmir.
- http://www.visitizmir.org/en/how-come/-910915/-279321
- http://www.visitizmir.org/en/how-come/-907329/-631467
- By Public Transport: Bus services from the Adnan Menderes Airport are provided by ESHOT via the buses numbered 200, 202 and 204.
- Line route number 200; Mavişehir district, airport.
- Line route number 202; Alsancak district Cumhuriyet Square, airport
- Line route number 204; İzotaş (Bornova - subway - bus station) airport
- In addition to the ESHOT buses, HAVAŞ bus services also operate along the routes of Mavişehir - Airport and Cumhuriyet Square - Airport.
- Thanks to the bus lines operating 24/7, transportation is provided also after midnight for the people of İzmir. For further information visit: www.eshot.gov.tr
- By taxi: In Izmir, taxi fares are calculated by adding price per kilometer to the starting price.
- Opening fee: 3.00 TL, Price per kilometer: 2:40 TL
- Payments at taxi are made in cash, in local currency only.

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