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GEOCHEMICAL MODEL AND NORMALIZATION FOR HEAVY METALS IN THE BOTTOM SEDIMENTS, DUBAI, UAE.

By
Amr El-Sammak*
Present address : United Arab Emirates University, Faculty of Science, Geology Department, Al-Ain, P.O.Box 17551. UAE.
* Alexandria University, Faculty of Science, Oceanography Department, EGYPT

النمذجة الجيوكميائية وتسوية النتائج للعناصر الثقيلة في رواسب القاع دبي- الإمارات العربية المتحدة

عمرو عبد العزيز السماك
كلية العلوم - قسم الجيولوجيا - جامعة الإمارات العربية المتحدة

يعتبر خور دبي المنطقة الرئيسية لدبي لما له من أهمية كبرى في حركة التجارة و المنظر الجمالي لدبي . تم تحليل المعادن الثقيلة (الجزء الكلي والجزء المتاح) و الكربون العضوي والكربونات الكلية في رواسب القاع في منطقة الدراسة . وقد أتضح من حسابات مؤشر حمل التلوث والحسابات الإحصائية بالإضافة إلى تسوية الحسابات لتقليل تأثير حجم الحبيبات أن منطقة الخور يمكن أن تقسم إلى منطقتين :-

- المنطقة الأولى : تبدأ من فتحة الخور حتى منتصف المجرى بالإضافة إلى منطقة شاطئ الجميرة و أمام الخور.
- المنطقة الثانية : تضم الجزء الداخلي من الخور بالإضافة إلى منطقة البحيرة . وقد أتضح أن هناك زيادة في حمل التلوث مع الزمن و لذلك يوصي بمحاولة تقليل حمل التلوث في الخور علماً أنه بمقارنة النتائج الحالية مع النتائج السابقة فإن خور دبي لايعتبر منطقة ملوثة.

ABSTRACT

Dubai creek can be considered as the focal point of Dubai. It has great importance for trading and aesthetic values. Total and leachable heavy metals (Cd, Co, Ni, Pb and Zn), organic carbon and total carbonate were studied in the bottom sediments of the creek. Pollution Load Index, statistical analysis, were used in order to quantify the pollution load as well as to discriminate the data into significant groups. Normalization of the data using organic carbon and total carbonate was done in order to reduce the effect of grain size. Quantification and methods normalization allow the sampling stations to be differentiated into two groups. The first group of clustered stations are those located in the upper channel up to Abra, including the Gomera beach, off creek and the creek mouth. The second groups of stations are those from Jadaf, including the lagoon area, It is concluded that there is an increase in the pollution load with time, however comparing the present results with the previous data, Dubai creek can not be considered as a polluted region. Care should be taking in order to reduce the pollution load in future.

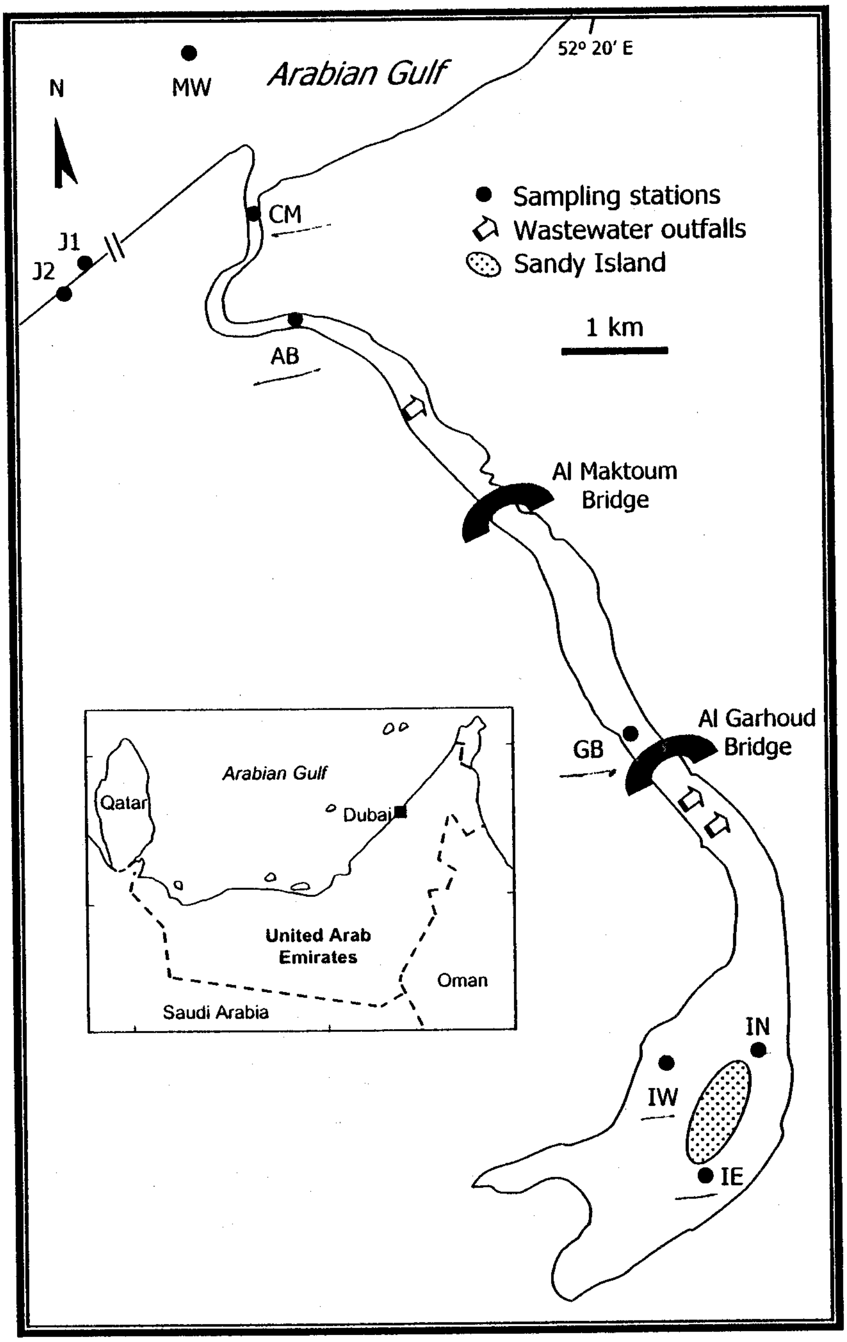
INTRODUCTION :

Dubai creek can be considered as the focal point of Dubai. It has a great importance for trading and aesthetic values. It provides an important means of transport, water sports and other activities. The creek divides into two sectors : the upstream (Al Garhoud bridge to the end) and downstream (creek Mouth till Al-Garhoud bridge) refers as lagoon and channel respectively. The creek is approximated 13 km long. Its width varies from 100 ±10 m at the mouth and 1200 ±100 m at the shallow head. The depth of the creek varies in the range of 5.5 ±1.0 m and 7.0 ±1.0m during ebb and flood tied respectively, The creek is a seawater intrusion with no hydrodynamically significant freshwater inputs. Dubai creek is alkaline while the salinity of the creek water is 39.00 ±1.0‰ which is comparable with the salinity of the gulf water (Environmental protection and safety section, [1]. The water temperature varies from 21 °C in winter to 34°C in summer with annual average temperature of 29°C (Environmental protection and safety section, [1].

The present study aims to measure the level of the total and the leachable parts of heavy metals in the sediments of Dubi creek. It aims also to quantify the metals pollution using statistical methods and simple quantification method (Pollution Load Index, PLI), Normalization of the data to reduce the effect of grain size on the metals contents will also be done using organic carbon and carbonate as normalizers.

Material and Methods :

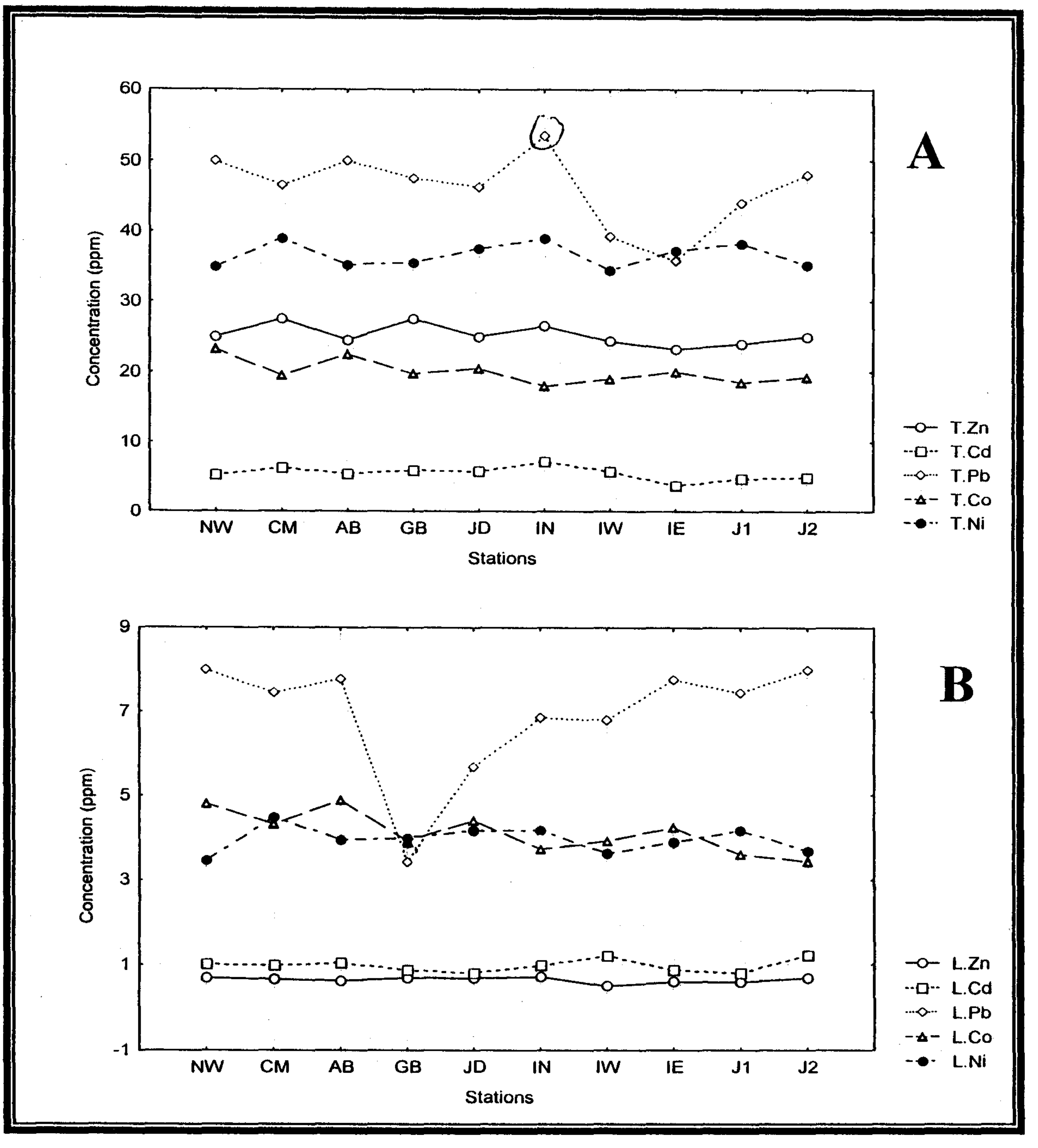
Samples were collected during October 1998, from creek channel, creek lagoon, off creek and from Gomera beach (Figure 1). The total and leachable (Biovailable) parts of Zn, Cd, Pb, Ni and Co were analyzed according to the method described by Loring and Rantala [2]. Total carbonate contents were analyzed according to the method of Molnia [3].The method described by Gaudette and flight [4] was used for organic carbon determination. The precision and accuracy of the results were checked by applying the same procedure on triplicates of some selected samples and checked the results against Certified Reference materials (HISS-1, marine Sediment Reference Material). The precision and accuracy were within the acceptable limits (<5%).



(Fig. 1)

Results and Discussion :

Figure (2a) shows the results obtained for the total metal's content, while figure (2b) represents the results obtained for the leachalbe part of different analyzed metals at different stations. The descriptive statistics are shown in table (1). No obvious variations can be observed in the metals contents between different stations. Total Pb decreases in the island stations (creek lagoon). On the other, the leached part decreases at Al-Grhoud Bridge and Al-Jadaf stations. Figure (3a) shows the distribution of organic matter at different stations. It is clear that organic matter increases in the lagoon stations (IN, IW and IE) and experiences the minimum values in the creek channel. On the other hand, carbonate shows the opposed



(Fig. 2)

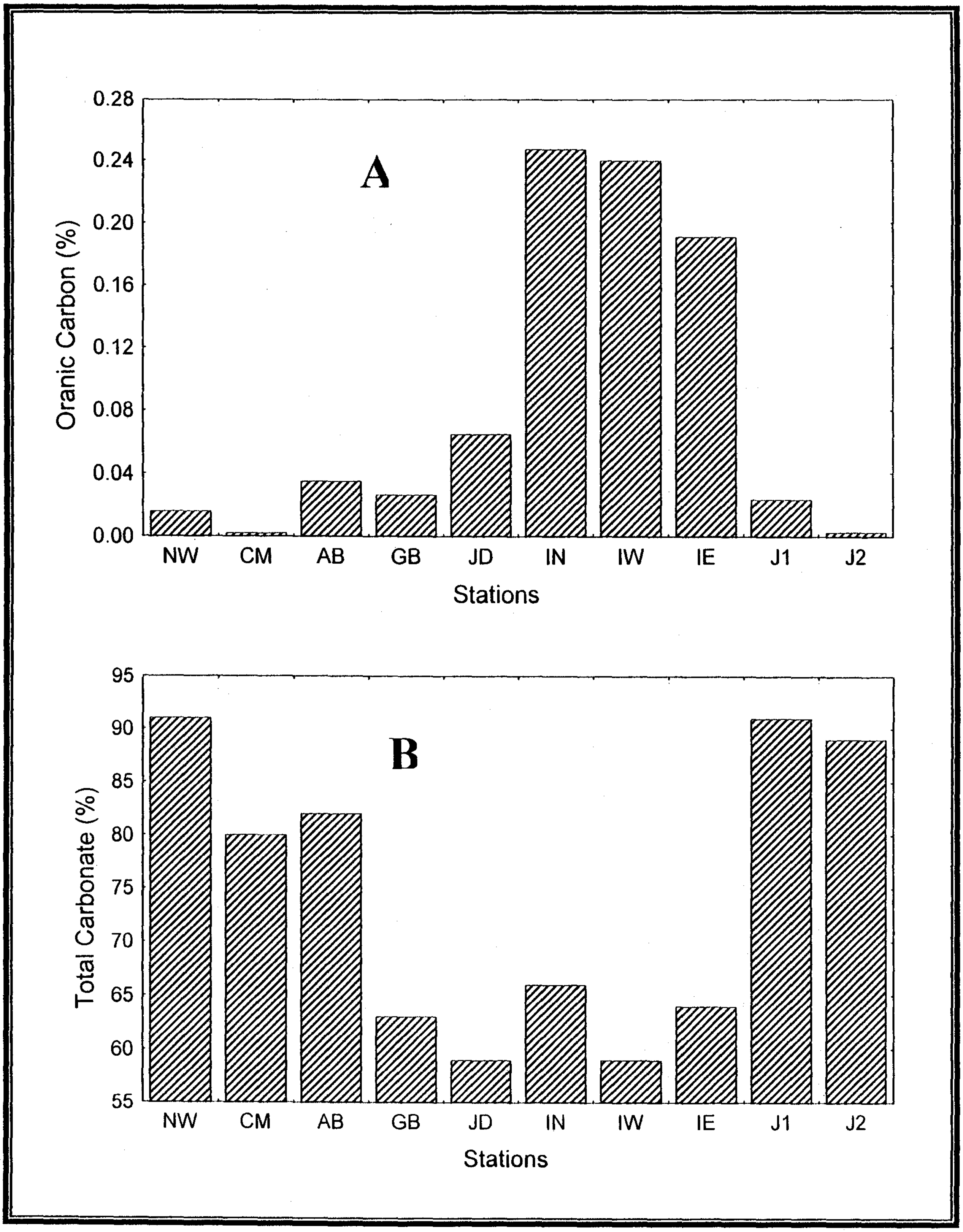
distribution pattern to that of organic (Figure 3b). The lagoon stations exhibit the lowest values for carbonate, while the channel stations have the highest values for carbonate contents. Organic carbon is related to carbonate by the following equation :

$$OC = 0.452 - 0.05\ CO_3$$
$$(r = -0.67,\ p = 0.036)$$

Pollution Load Index (PLI) is used in order to find out the mutual effect of the different studied metals. PLI is calculated according to the following equation, [5]

$$PLI = \sqrt[5]{CF_{Cd} \times CF_{Pb} \times CF_{Co} \times CF_{Ni} \times CF_{Zn}}$$

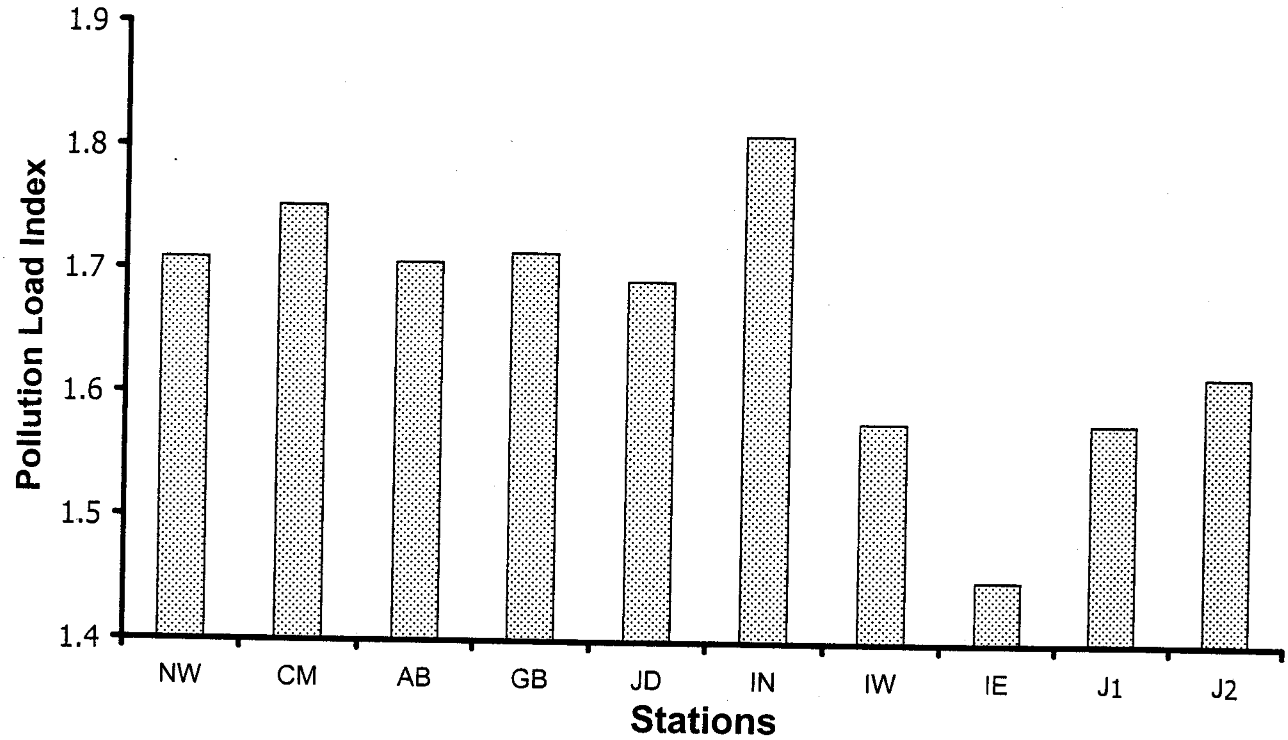
CF is the Contamination Factor. CF is the concentrations of a metals divided by the background value for this metal.



(Fig. 3)

Background value used here is the standard shallow water sediment reported [6], [5].

Figure (4) shows the values of PLI for different stations. it is obvious that there is a slightly decrease in the values of PLI

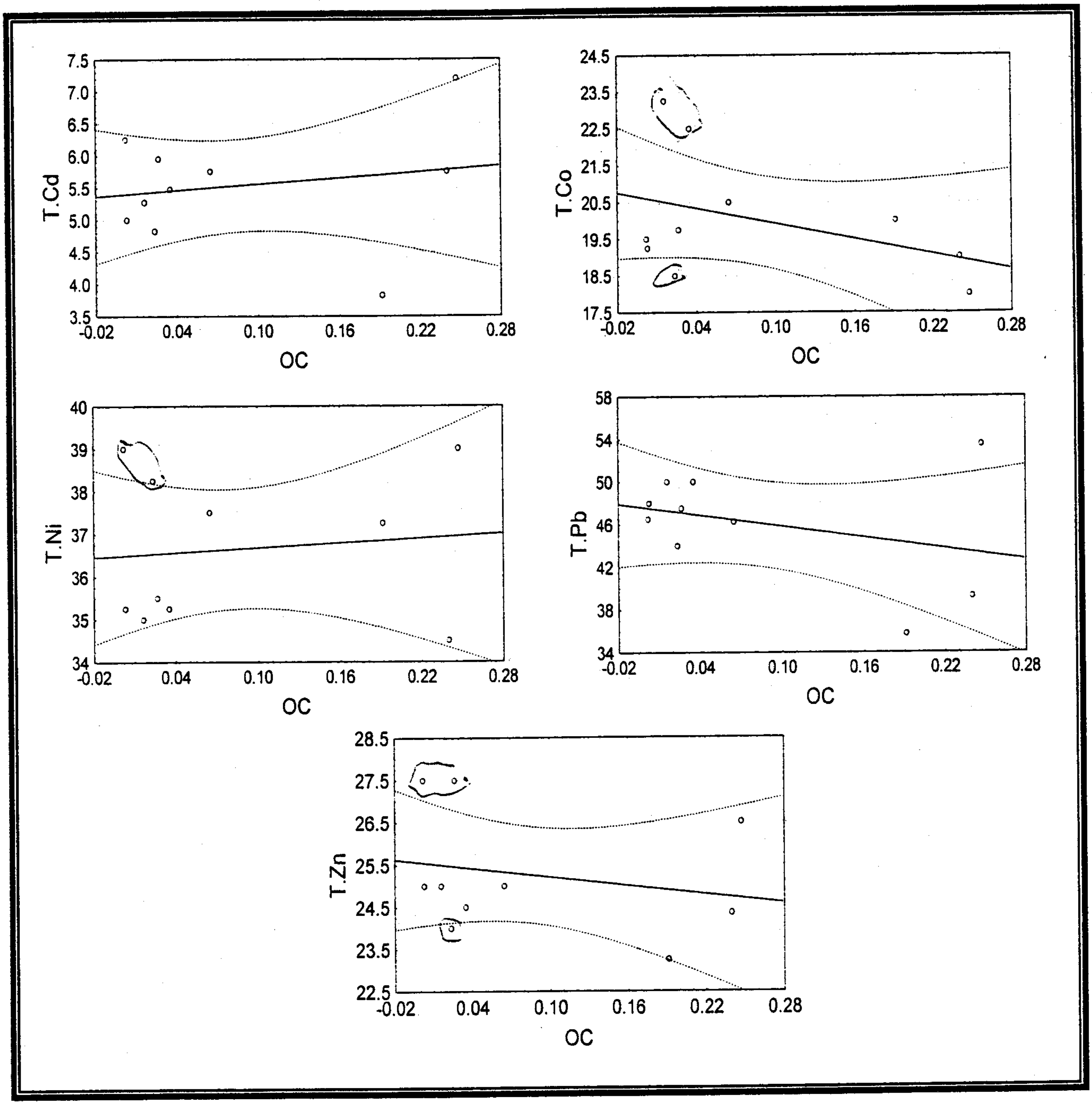


(Fig. 4)

toward the lagoon area. Gomera beach exhibits low values comparing with the values for the channel area.

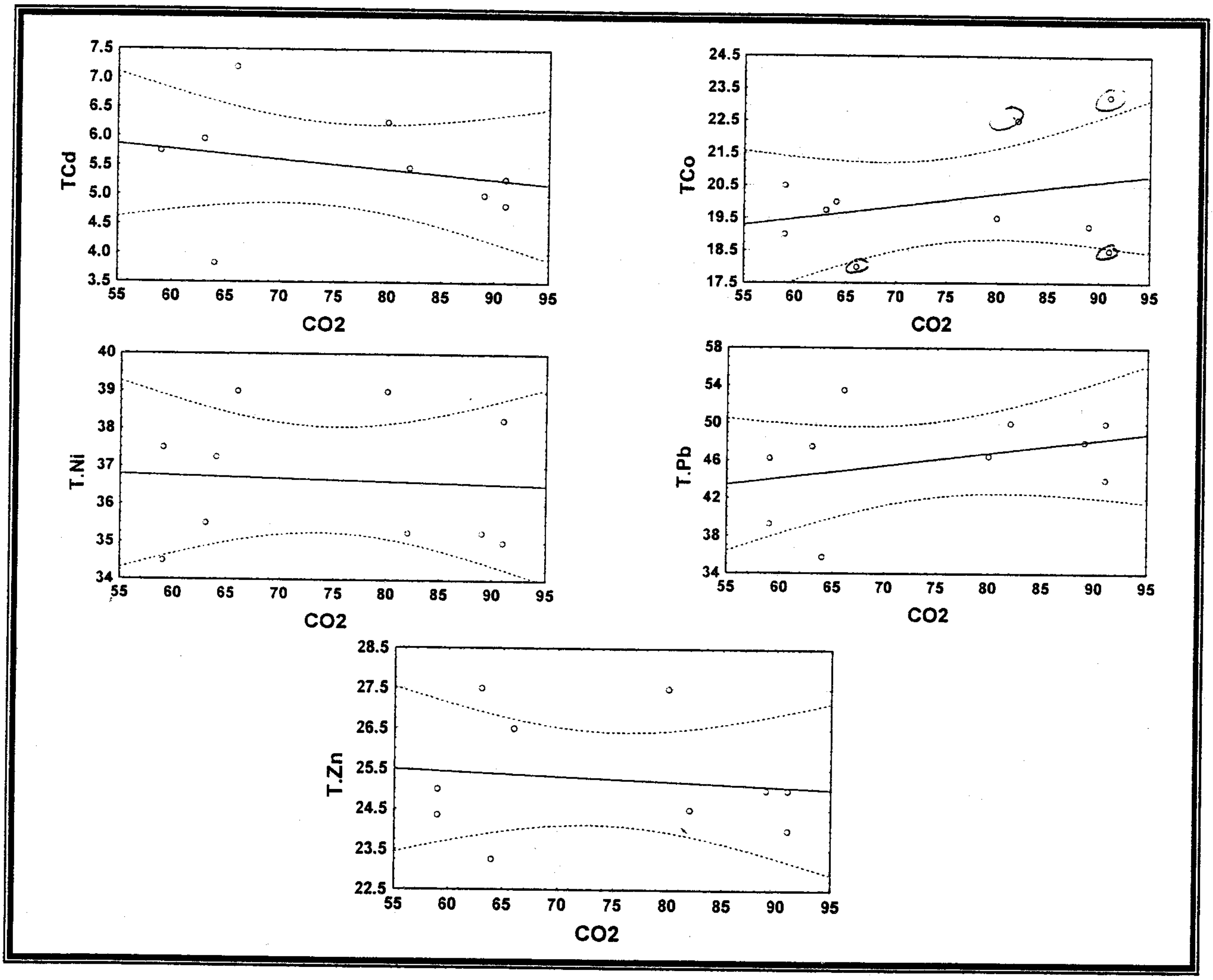
In order to normalize the data and reduce the effect of grain size, many parametres had been suggested as normalizers [6]. In the present study total carbonate and organic carbon are used as normalizers. To do that, scatter plots between the concentrations of organic carbon as well as total carbonate against the concentrations of different metals were constructed. The regression line were graphed along with the 95% confidence limits, so that natural geochemical population of the investigated trace metals in relations to both variables can be defined [8]. This means that there is a 95% probability that point which fall outside the confidence limits are from different or anomalous populations, i.e. pollution indicates [8]. It is obvious that only few stations fall outside the 95% confidence limit for the organic carbon (Figure 5) as well as total carbonate (Figures 6). This may indicate that pollution is very low. Also the polluted area mainly concentrated in the channel area rather than in the lagoon.

Figure (7) Show the percentages of the bioavailable portions to the total metals contents. Cd and Pb have the highest percentages of the bioavailable fractions in the lagoon area. On the other hand, the percentage of the bioavailable fraction for Ni decreases from the creak mouth towards the channel area.



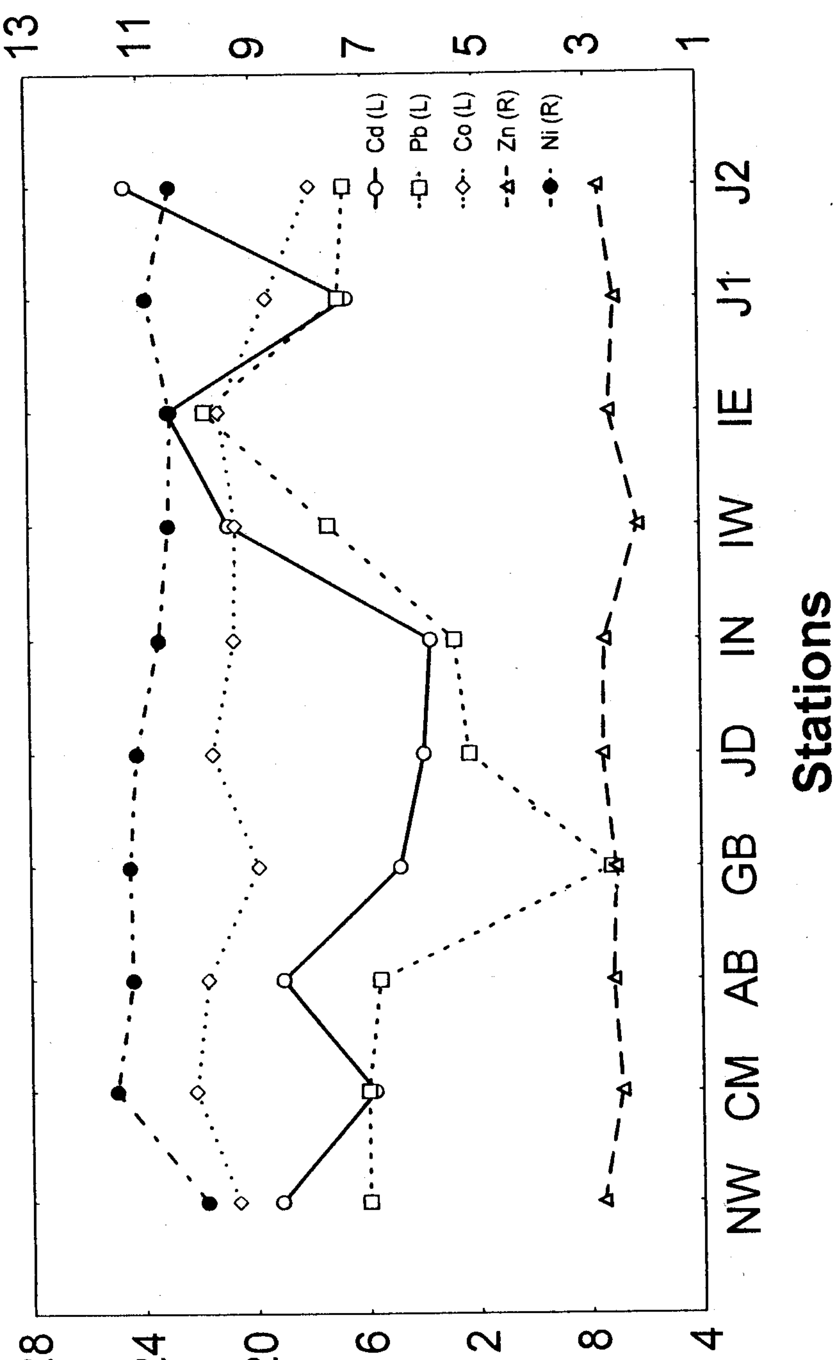
(Fig. 5)

According to [9], Dubai creek and its nearshore sediments exhibited higher range and mean concentrations of heavy metals. The coastal station showed the lowest element concentrations, which tended to increase in the sediments of stations inside the creek. They also mentioned that the stations in the channel area had the highest metals concentration due to their location within the deep internal portion of the creek, where they receive increasing quantities of wastewater from many several outlets in addition to the waste from Dubai Dry Dock and hundreds of boats.



(Fig. 6)

According to [9], an important features of element distribution in Dubai region is the high concentrations of the heavy metals in the top layer (upper 1-2 cm) of the examined sediments, compared to the other subsurface samples. They mentioned that the concentration in the top layer is 2-18 times higher than the bulk of the samples.



(**Fig. 7**)

Using the data from the unpublished report (Environmental protection and safety section, [1]), it is clear that there are some increases in the metals' concentrations of the studied short cores in the upper 10 cm comparing to the concentrations at the core interval 10-20 cm form the coretop (Table 1). The percentages of the increases range between 10.8% for Zn and 38.8% for Pb. Theses increases may indicate an increase in the pollution load with time. The upper 10 cm of the core should be deposited after the deposition of the lower layers.

Table (1). Concentrations of metals in the upper 10 cm, 10-20 cm depth and the percentage of increases (data from Environmental Protection and Safety Section, MESU, 1997).

METAL (PPM)	0-10 CM	10-20 CM	INCREASE %
Pb	229	140	38.8
Cd	3	2.5	16.7
Zn	102	91	10.8
Ni	64	57	10.9

Such distinctly high metals and/or organic carbon concentrations in the top layer of recently deposited surface sediments is usually common in areas receiving anthropogenic inputs of metals and organic matter [9].

Table (2) show a comparison between the present results with the previous results provided by different authors working on the same study area or in similar environments. Taking into consideration the differences in the methods used for determination of heavy metals, the present study is slightly higher that the other previous studies. Nothing that the metals' concentrations in Dubai creek are still low if they compared with the metals' concentration in well-known highly polluted areas.

In order to reveal the similarities between different sampling stations, single linkage cluster analysis was constructed. The resulted tree diagram (Figure 8) reveals that Dubai creek can be divided into two distinct regions. The first group of clustered stations are those located in the upper channel area up to Abra area, Gomera beach, off the creek and the creek mouth stations. The second group of stations can be discriminated into two subgroups. The first subgroup discriminate the stations from Jadaf.

Table (2). Comparison between the present study and the previous study.

AVERAGE (ppm) (RANGE)	Cd	Co	Ni	Pb	Zn
1. Coastal area UAE, Arabian Gulf	5.54 4.32-9.55	10.88 6.01-25.93	27.0 8.01-214.5	29.42 9.03-57.01	77.1 3.01-534.0
2. Coastal UAE., Arabian Gulf	0.03 0 - 0.12	0.73 0 - 3.4	9.0 0.4-35.4	6.06 0.0-35.4	31.2 0.4-142.0
3. Kuwait, ArabianGulf.	1.46 2.54	ND	36.0-102	2.5 35	27 75
4. The Arabian Gulf	0.14 0.23	ND	386 637	5.6 25.6	27.0 43.0
5. Iraq. Arabian Gulf	0.26 0.1 1.0	2.01 1.0 3.0	10.1 5 14	3.55 3.0 6.0	13.7 8 28
6. Dubai Creek	5.3 4.5 6.4	10.4 5.0 12.0	27..2 11.0 241.5	28.1 21.0 43.9	42.1 15.0 109.0
7. Dubai Creek (0-10 cm)	3	ND	64	109	78
8. Dubai Creek (10-20 cm)	3	ND	57	72	33
Present Study	5.53 3.83-7.2	20.01 18 - 23.25	36.65 34.5 39.0	46.1 53.5 35.8	25.26 23.3 27.5

1. Abu-Hilal and Khardgui (1992) 2. Salman et al, 1987. 3. Abayachi and Dou Abul, 1986. 4. Al-Hashimi and Salman 1985
5. Shridah, 1998 6. Shriadah, 1998 7. Environmental Protection and Safety Section, MESU, 1997

Garhoud bridge and island north (IN), while the other subgroup includes those stations that are located in the lagoon area (IE, and IW). This discrimination is mainly depending upon the nature of the channel and the lagoon areas as well as the sources of pollution. The area from Abra to the deep internal portion of the creek receives increasing quantities of wastewater from many several outlets in addition to the waste from Dubai Dry Dock and hundreds of boats [9].

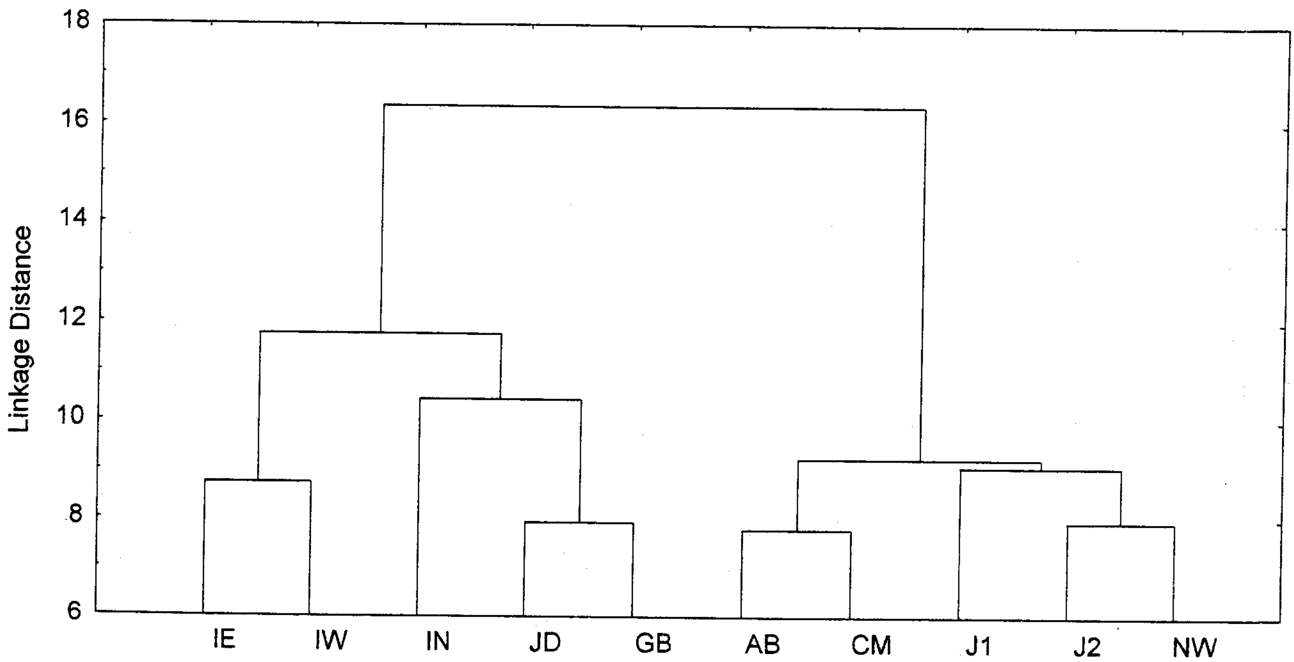
CONCLUSION :

It is concluded that :

1- The present results are mostly comparable to the previous published data especially those on the same area.

2- Notwithstanding the difference between present results and the published data are not significant, however these differences could be due to the different methods used for analyses and digestion of the sediments as well as the distinction in the sampling locations .

3- Cluster analyses separates two groups of sampling stations. This discrimination is mostly based on the organic matter content, carbonate



(Fig. 8)

content as well as the variation in the metals contents .

4- The lowest values for PLI are found in stations located in the lagoon area, while the highest PLI values are found in the stations located in the creek channel.

5- Normalization of the data using organic matter and carbonate as normalizers indicates that most of the stations fall outside the 95% confidence limit band which reflects the natural background composition of different metals. On the other hand the few samples fall inside the 95% band verify the man-made impact on the metals contents in the investigated area.

6- The history of the metals pollution in the creek depicted form the previous data indicates an increases in pollution load with time.

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