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EVALUATION OF IRAQI COASTS USING LITTORAL AND MARINE BIVALVE SHELLS

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ABSTRACT

The geochemical analysis of both of Crassostrea cucullata and Chione californensis shells and hydrochemical analyses of water are carried out to study the environmental evaluation in the Iraqi coasts. Shells and water are collected during low tide period (March to August 2011), from seven different stations (Fadakia, Rass AlBishah, Khor Abdullah, Khor Shytianah, Hacham Island, Khor AlZubair and Shatt AlBasrah). The hydrochemical analyses reflect two zones of water salinity, Fadakia and Shatt AlBasrah of brackish water with TDS range (15148 – 18130 ppm), and the other marine coastal sites of saline water with TDS range (34123 – 45220 ppm). XRD of shells of Chione californensis reveals that they have two layers, an inner layer constitutes of aragonite and outer layer constitutes of calcite, while the shells of Crassostrea cucullata have only calcite layer. Water salinity increasing associate with increase of major chemical constituents of oyster shells. Mg/Ca and Sr/Ca values in the coastal line Crassostrea cucullata shells are higher than Fadakia and Shatt AlBasrah shells that may be due to increment of salinity in the coastal line compared with Fadakia and Shatt AlBasrah areas. Zn, Cu, Pb, Sr, and Cr metals in Khor Shytianah Crassostrea cucullata are higher than the other areas may attribute to higher contamination in this area. The chemical constituents of CaO%, MgO, Sr/Ca and Mg/Ca in Khor Shytianah and Hacham Island Chione californensis shells are higher than Khor Abdullan shells, this result may be indicator to higher salinity of sea water in Khor Shytianah and Hacham Island compare with the sea water of Khor Abdullah. Heavy metals (Co, Ni, Rb, Sr, Zn, Ba, Cr, Th, Mo, and Pb) in Khor Shytianah Chione californensis shells were more than the other shells may be due to high range of contamination of sea water by this metal.

Keywords: Contamination, Littoral and marine bivalves' shells, Iraq

INTRODUCTION

Marine pollution is a global environmental problem. Human activities in the coastal area and marine water contribute to the discharge of various kinds of pollutants such as major and minor components (CaO%, MgO%, SiO_2%, Al_2O_3%, K_2O%, Na_2O%, Fe_2O_3%, LOI%, Sr/Ca, Mg/Ca) and Sr, Zn, Cu, Ba, Co, Cr, Pb, Ni, Rb, heavy metals into the marine ecosystems (Censi *et al*., 2006, and Al-Jaberi, 2015). The main reason for the metal contamination is considered as persistent and due to their toxic properties, could create several problems for different kinds of marine ecosystems and could be accumulating in marine organisms (Boening, 1999; Babukutty and Chacko, 1995; Cravo *et al*., 2004, and Nicholson and Lam, 2005). Biomonitoring process has been widely used to monitoring metals in the last years (Zorita *et al*., 2006, and Hamed and Emara, 2006). The use of bivalves shells as indicator to the pollution because they are precipitated under differing environmental conditions tends to reflect that deference in the chemistry of shells (Hubbard *et al*., 1981; Szefer *et al*., 2002; Liu and Kueh, 2005; Darvish, 2007, and Dalbeck, 2008). Concentration of trace elements to specific carbonate shell layers are controlled by the relative acceptability of the elements into the lattice , since the quantity of foreign elements in the shell reflects the concentration of those elements in the surrounding water (Dodd, 1965; Chow *et al*., 1976, and Phillips, 1977). Bivalves are believed to incorporate trace elements into their shells in proportion to the concentration of those elements in water (Censi *et al*., 2006). This incorporation is also influenced by other circumstances, including water temperature and salinity (Al-Dabbas *et al*., 1983 and 1984). The incorporation of trace elements into marine bivalves could be used to monitor temporal changes in aspects of the marine environment, including the elemental composition of the water (Boening, 1999). Al-Dabbas (1980) showed that filter feeders such as Mytilus are particularly valuable in water quality investigation since shell variation developing during growth should directly reflect the ambient water condition (temperature, salinity, dissolved and suspended load). Many of pervious study have been used shells as indicator to environmental changes (Mustafa 1985; Abaychi and Mustafa,1988; Afaj and Al-Dbbas, 1998, and Salman, 2007). Iraqi Coasts of the Arabian Gulf, Khor AlZubair, Shatt Al-Arab and Shatt Al-Basrah are developing areas. Water discharge by boats and ships, marine transportation and ballast water discharges are main sources of pollutants in this area. While, wastewater, industrial and agricultural discharges and dredging are another sources of pollutant in this coastal area. These activities along the Iraqi coasts have caused this area to be exposed to different kinds of pollutants especially heavy metals. Although bivalves especially *Crassostrea cucullata* and *Chione californensis* are widely distributed in this area, but there is a lack of information related to heavy metal content of them. The molluscs bivalves *Crassostrea cucullata* and *Chione californensis* are chosen in this study due to their wide distribution in all the Iraqi shore lines as well as their ability to survive in the intertidal zone, where they are subjected to frequent periods of salinity and temperature changes, as well as their tolerance and adaptability have made them the preferred organisms for monitoring contaminants, and constitute reliable indicators of the quality of given ecosystems (Al-Dabbas *et al*., 1983 and Al-Jaberi, 2015). The aim of this research is to study the variation in the chemical and physical characteristics of mollusc's shells which are useful tool for environmental monitoring in the Iraqi aquatic brackish and marine environments within the Iraqi coasts (Fig. 1).

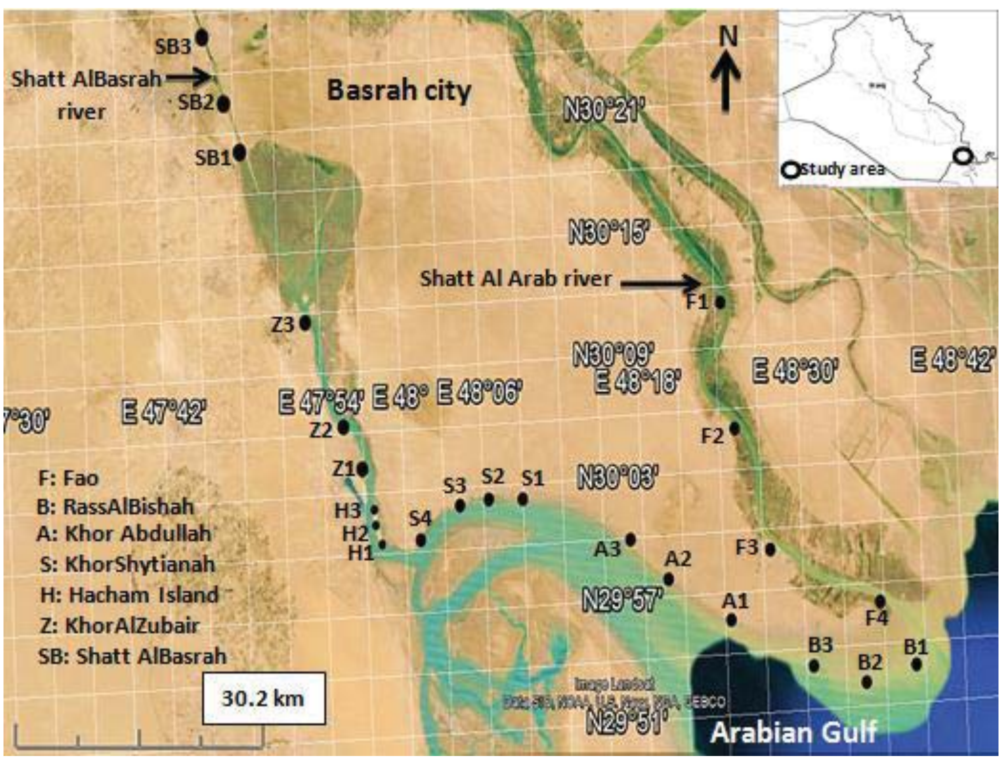

Fig. 1: Map of the study area showing location of sampling sites

MATERIALS AND METHODS

Twenty three samples in seven sites of different aquatic environments were chosen to study the geochemistry of *Crassostrea cucullata* and *Chione californensis* shells along Iraqi coasts and shorelines from Fadakia (at Shatt Al-Arab river at the east of the study area) to Shatt AlBasrah (at the Main Drain Channel at the northwest of the study area) (Fig. 1). Samples of shell and water were taken during low tide period from March to August 2011.

A- Hydrochemical study was done to determine the physical and chemical parameters of the studied samples. Physical parameters include hydrogen number (pH), total dissolve solid (TDS) and electrical conductivity (EC). Chemical parameters include the major cations (K^{+}, Na^{+}, Ca^{2+} and Mg^{2+}) and anions (Cl^{-}, SO_4^{2-}, HCO_3^{2-}, and CO_3^{2-}) (Table 1).

B- Thirty of littoral bivalve *Crassostra cucullata* shells of the same size (3.7 to 6.8 cm) were collected from Fadakia, Rass Al Bishah, Khor Abdullah, Khor shytianah, Hacham Island , Khor Al Zubair and Shatt AlBasrah areas (Fig. 2). As well as thirty of marine bivalve *Chione californensis* shells of the same size (4 to 7 cm) are collected from Khor Abdullah, Khor Shytianah and Hacham Island and absent in other sampling sites.

Bulk minerals in *Crassostra cucullata* and *Chione californensis* were recognize by X-ray diffraction (CuKq) analysis and Zeiss Supra 35-VP field emission scanning electron microscope – energy dispersive analysis for X-ray spectroscopy (SEM-EDAX) and inductively coupled plasma – Atomic emission spectrometry (ICP-AES), and Inductively coupled plasma – Mass spectrometry (ICP-MS) (ICP analysis) (Al-Jaberi, 2015).

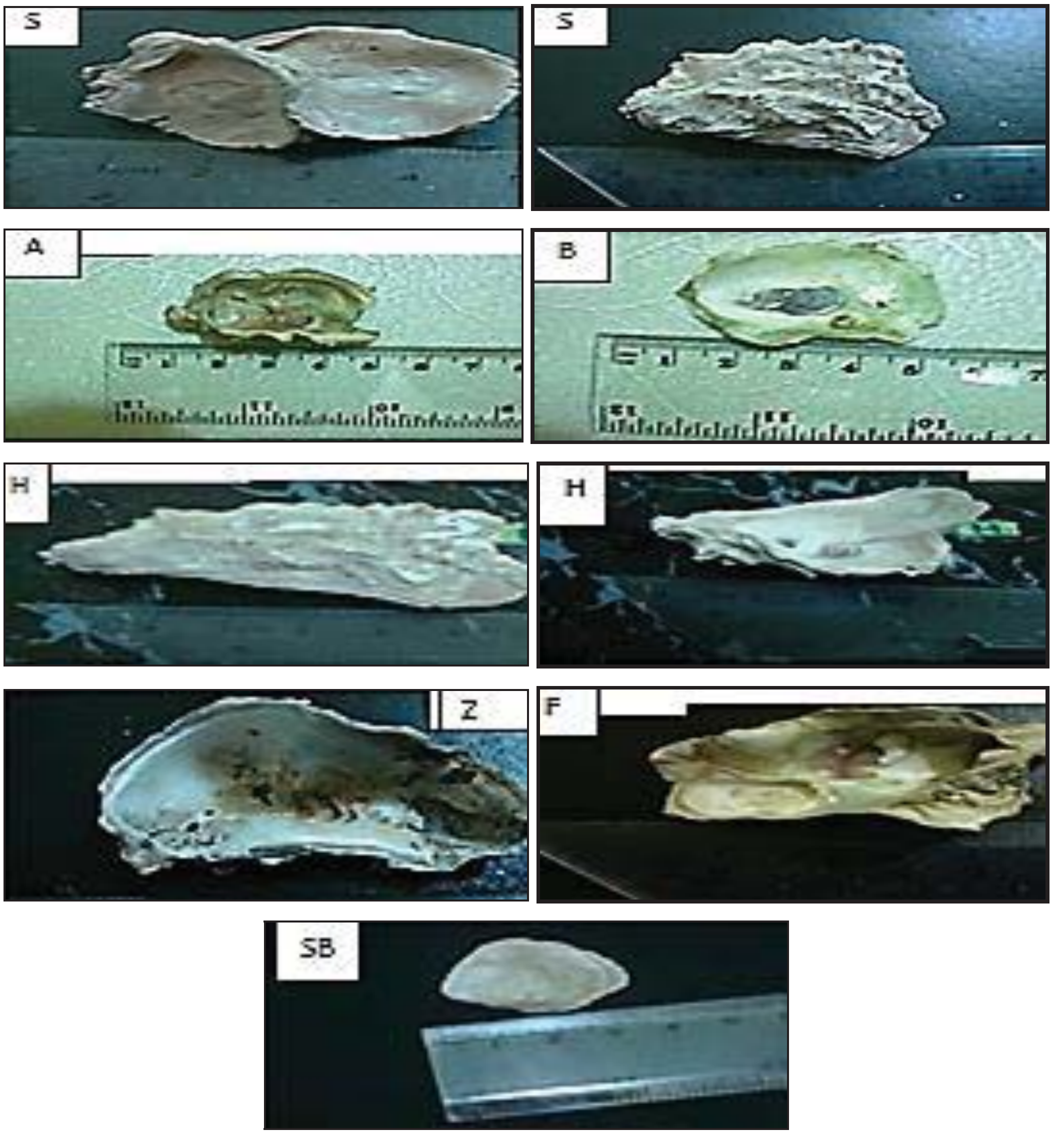

Fig. 2: ***Crassostrea cucullata*** **shells in Khor Shytianah (S), Khor Abdullah (A), Rass AlBishah (B), Hacham Island (H), Khor AlZubair (Z), Fadakia (F), Shatt AlBasrah (SB)**

RESULTS AND DISCUSSION

A. Hydrochemical Analysis

1. Physical parameters

The hydrochemical analyses reflect two zones of water salinity according to Lewis (1982) and Hem (1985). Fadakia and Shatt AlBasrah of brackish water with TDS range (15148 – 18130 ppm), Rass Al-Bishah of saline water with TDS range (34123 – 36521 ppm), and the other marine coastal sites (Khor AlZubair, Hacham

Island, Khor Shytianah, Khor Abdullah) of saline water with TDS range (39215 – 45220 ppm) (Table 1). Moreover, due to the positive relationship between electrical conductivity (EC) and TDS, the same is true for the EC values. Three zones had been indicated according to the EC. Fadakia and Shatt AlBasrah with EC range (23 – 29 mmohs/Cm), Rass AlBishah with EC range (53 – 57 mmohs/Cm), and the other marine coastal sites with EC range (64 – 71 mmohs/Cm). While, the pH values for Fadakia and Shatt AlBasrah with range (7.5 – 7.9), Rass AlBishah with range (7.7 – 8), and the other marine coastal with pH range (7.8 – 8.2).

2. Chemical parameters

The calcium ion concentration (ppm) for Fadakia and Shatt AlBasrah are ranging from 285 to 412 ppm, Rass AlBishah with range (465 – 509 ppm), and the other marine coastal with range (513 – 610 ppm) (Table 1). The magnesium concentration (ppm) for Fadakia and Shatt AlBasrah with range (1043 – 1208 ppm), Rass AlBishah with range (1441 – 1478 ppm), and the other marine coastal with range (1482 – 2040 ppm). Sodium concentration (ppm) for Fadakia and Shatt AlBasrah with range (4413 – 4654 ppm), Rass AlBishah with range (10675 – 12944 ppm), and the other marine coastal with range (13028 – 15100 ppm). Potassium concentration (ppm) for Fadakia and Shatt AlBasrah with range (78 – 106 ppm), Rass AlBishah with range (295 – 349 ppm), and the other marine coastal with range (311 – 358 ppm). Chloride concentration (ppm) for Fadakia and Shatt AlBasrah with range (8768 – 9066 ppm), Rass AlBishah with range (20561 – 21420 ppm), and the other marine coastal with range (22846 – 26800 ppm). Sulfate concentration (ppm) for Fadakia and Shatt AlBasrah with range (1089 – 1990 ppm), Rass AlBishah with range (2026 – 2577 ppm), and the other marine coastal with range (3082 – 3700ppm). Bicarbonate concentration (ppm) for Fadakia and Shatt AlBasrah with range (41 – 75 ppm), Rass AlBishah with range (147 – 151 ppm), and the other marine coastal with range (150 – 201 ppm). Carbonate concentration (ppm) for Fadakia and Shatt Al Basrah with range (6 – 22 ppm), Rass AlBishah with range (9 – 11 ppm), and the other marine coastal with range (13 – 21 ppm).

Table 1: Physical and chemical parameters of the studied sites of Iraqi aquatic environments

Sampling site	pH	EC mmohs/Cm	Na^{+} ppm	K^{+} ppm	Ca^{2+} ppm	Mg^{2+} ppm	Cl^{-} ppm	SO_4^{2-} ppm	HCO_3^{2-} ppm	CO_3^{2-} ppm	T.D.S ppm	Water Classi (Lewis, 1982)
KhorAlZubair, Hacham Island, KhorShytianah, Khor Abdullah	7.8 – 8.2	64 – 71	13028 – 15100	311 – 358	513 – 610	1482 – 2040	22846 – 26800	3082 – 3700	150 – 201	1321	39215 – 45220	Saline water
Rass AlBishah	7.7 – 8	53 – 57	10675 – 12944	295 – 349	465 – 509	1441 – 1478	20561 – 21420	2026 – 2577	147 – 151	9 – 11	34123 – 36521	Saline water
Fadakia and Shatt AlBasrah	7.5 – 7.9	23 – 29	4413 – 4654	78 – 106	285 – 412	1043 – 1208	8768 – 9066	1089 – 1990	41 – 75	6 – 22	15148 – 18130	Brackish water

B. Geochemical Analysis of *Crassostrea Cucullata* Shell

Crassostrea cucullata is a littoral bivalve shell found in brackish-marine environments (Wang and Guo, 2008) (Fig. 2). *Crassostrea cucullata* is classified using Ahmed (1975) classifications, as Phylum: Mollusca, Class: Bivalvia, Subclass: Pteriomorphia, Order: Ostreina, Family: Ostreidae, Genus: *Crassostrea cucullata*. The shells of *Crassostrea cucullata* in the studied areas along Iraqi coastal line, show mean contents of 100 % calcite (Fig. 3).

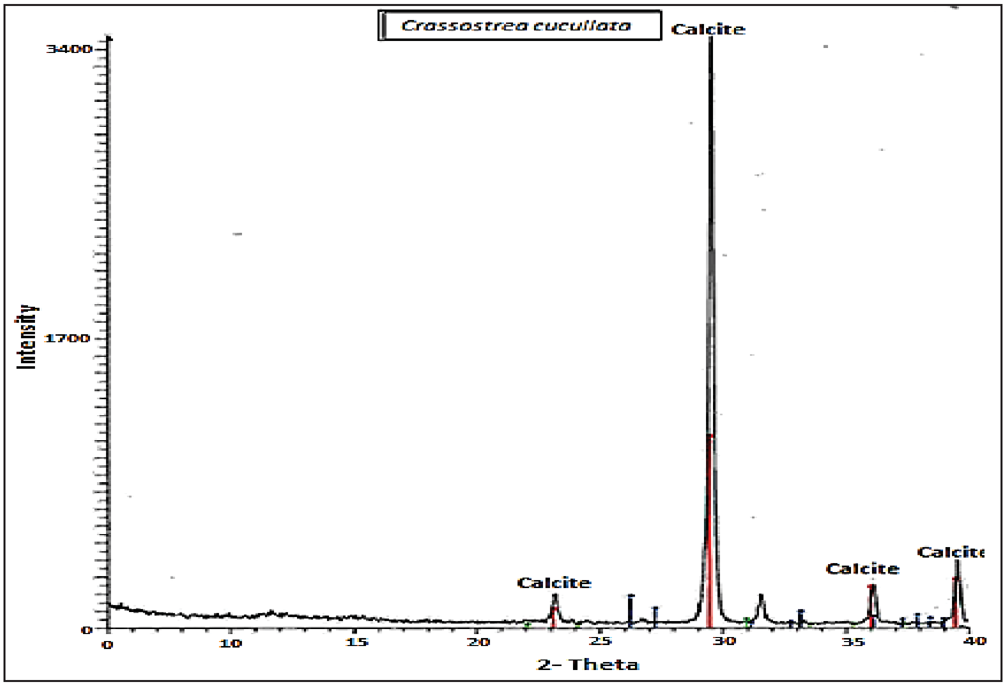

Fig. 3: X-ray diffraction for Crassostreacucullata shell

The range of the measured chemical constituents (major oxides and heavy metals) (CaO%, MgO%, SiO_2%, Al_2O_3%, K_2O%, Na_2O%, P_2O_5%, as well as Co, Ni, Rb, Sr, Zn, Cu, Ba, Cr, Pb, elements in ppm, LOI%, Sr/Ca , Mg/Ca) in the *Crassostrea cucullata* shells at the studied areas shown in (Table 2).The results of the geochemical analysis showed positive relationships between water salinity and chemical constituents in the calcite shells of *Crassostrea cucullata* , as a result to higher content of these ions in the surrounding sea water compared with the Shatt Al Arab river in Fadakia area and Shatt AlBasrah river as continuation of the Main Drain, (Tables 1 and 2) . Obviously, the results reflect that the relatively higher values of most of the major oxides and heavy metals (CaO, LOI, MgO, Na_2O, Sr, Cu, Zn, Pb, Cr, Ba, Rb, Ni, Co) lies within the Iraq marine coastlines {Khor Shytianah (S), Khor Abdullah(A), Rass AlBishah (B), Hacham Island (H), and Khor AlZubair (Z)}. The maximum values of these chemical constituents are indicated in Khor Shytianah site (S), except for SiO_2, Al_2O_3, P_2O_5 and K_2O percentages that they had lower values, while, the minimum values of these chemical constituents are indicated generally in brackish water sites Fadakia (F) at Shatt Al-Arab river and Shatt AlBasrah (SB) site at the Main Drain Channel, (where the water salinity range 15148 – 18130 ppm ,that classified as brackish water according to Lewis, 1982), except for SiO_2, Al_2O_3, and P_2O_5 percentages that they had their higher values , (Tables 1 and 2). The results showed the order of major oxides and heavy metals accumulation in the shell of oyster in descending order are CaO > LOI > SiO_2 > MgO > Al_2O_3 > Na_2O > Sr > K_2O > P_2O_5 > Cu > Zn > Pb > Cr > Ba > Rb > Ni > Co and Mg/Ca > Sr/Ca. Variation in Mg/Ca and Sr/Ca ratios in the mulluscs shells employed as environmrntal indicator (Al-Dabbas *et al*., 1984). Mg/Ca and Sr/Ca values in the coastal line *Crassostrea cucullata* shells are higher than in the Fadakia and Shatt AlBasrah areas that may be due to increment of salinity in the coastal line compared with Fadakia and Shatt AlBasrah areas. Such finding is in agreement with Al-Dabbas *et al*. (1984) result. The average concentration of magnesium and strontium in *Crassostrea cucullata* shells in the coastal line{Khor Shytianah (S), Khor Abdullah (A) Rass AlBishah (B), Hacham Island (H), and Khor AlZubair (Z)} are higher than Mg and Sr content in the shells of Fadakia (F) and Shatt AlBasrah (SB), that may be attributed to higher of Mg and Sr ions in sea water content. Accordingly, CaO% and LOI% are the highest percentages of all the analyzed chemical constituents and they have positive relationship between each other and with water salinity, (Tables 1 and 2). Calcium (CaO%), magnesium (MgO%), sodium (Na_2O%) and potassium (K_2O) in the *Crassostrea cucullata* shells are relatively higher in the marine coastal sites (Rass AlBishah ,Khor AlZubair, Hacham Island, Khor Shytianah, and Khor Abdullah) that may be probably due to increase of these ions in the sea water of these sites compared with the Shatt Al Arab river in Fadakia area and Shatt AlBasrah river. SiO_2%, Al_2O_3%, and P_2O_5% in Fadakia *Crassostrea cucullata* shells were higher than the other sampling sites (Table 2). SiO_2% and Al_2O_3% are usually residual component in soil. most silica and alumina are related to surfcial contamination, related to interstitial grains of amorphous silica or clays that accumulated in the black holes spread at surface of *Crassostrea* *cucullata* shells (Fig. 4). Si, Al, and P ions may be related to the abundance of the fine fraction clay minerals in the suspended sediment load of Shatt Al-Arab river areas and the phosphorus-rich fertilizers and organic matter that transported from agricultural land near Fadakia area.

Table 2: The ICP analysis results of Crassostrea cucullata shells for the studied seven sites

Elements	Shatt AlBasra (SB)	Khor Zubair (Z)	Hacham Island (H)	Khor Shytianah (S)	Khor Abdullah (A)	Rass Al-Bisha (B)	Fadakia (F)	Constituents Range
CaO%	53.8	54.7	54.8	54.9	54.5	54.3	53.7	53.7 (F) – 54.9 (S)
MgO%	0.56	0.75	0.7	0.78	0.66	0.61	0.53	0.53 (F) – 0.78 (S)
SiO_2%	0.695	0.413	0.249	0.31	0.345	0.21	0.852	0.21 (B) – 0.852 (F)
Al_2O_3%	0.505	0.0976	0.065	0.072	0.096	0.091	0.514	0.065 (H), 0.514 (F)
K_2O%	0.08	0.178	0.132	0.163	0.14	0.188	0.021	0.021 (F) – 0.188 (B)
Na_2O%	0.387	0.417	0.399	0.436	0.391	0.393	0.312	0.312 (F) – 0.436 (S)
P_2O_5%	0.061	0.058	0.030	0.0324	0.012	0.0613	0.13	0.0124 (A) – 0.13 (F)
Co ppm	0.48	0.922	1.05	2.33	0.88	0.722	0.52	0.48 (SB) – 2.33 (S)
Rb ppm	1.3	15.3	11.1	11	12.22	11.5	0.85	0.85 (F) – 12.23 (A)
Sr ppm	1001	1164	1084	2015	1033	1122	996	996 (F) – 2015 (S)
Zn ppm	218	224	235	240	232	220	217	217 (F) – 240 (S)
Ba ppm	4.17	10.6	8.9	27.2	9.93	7.4	14.4	4.17 (SB) – 27.2 (S)
Pb ppm	0.098	38	40	43	36	33	32	0.098 (SB) – 43 (S)
Ni ppm	5.51	8.88	6	8.7	7.75	7.13	4.49	4.49 (F) – 8.88 (Z)
Cr ppm	4.33	8.5	33	41	0.309	5.42	7.13	0.309 (A) – 41 (S)
Cu ppm	470	451	489	491	487	482	456	470 (SB) – 491 (S)
LOI%	42	42	42	43	42	42	41	41 (F) – 43.5 (S)
Mg/Ca x 1000	8.8	11.7	10.3	12.0	10.2	9.4	8.3	8.3 (F) – 12.0 (S)
Sr/Ca x 1000	2.61	2.724	2.727	5.14	2.65	2.63	2.59	2.59 (F) – 5.14 (S)

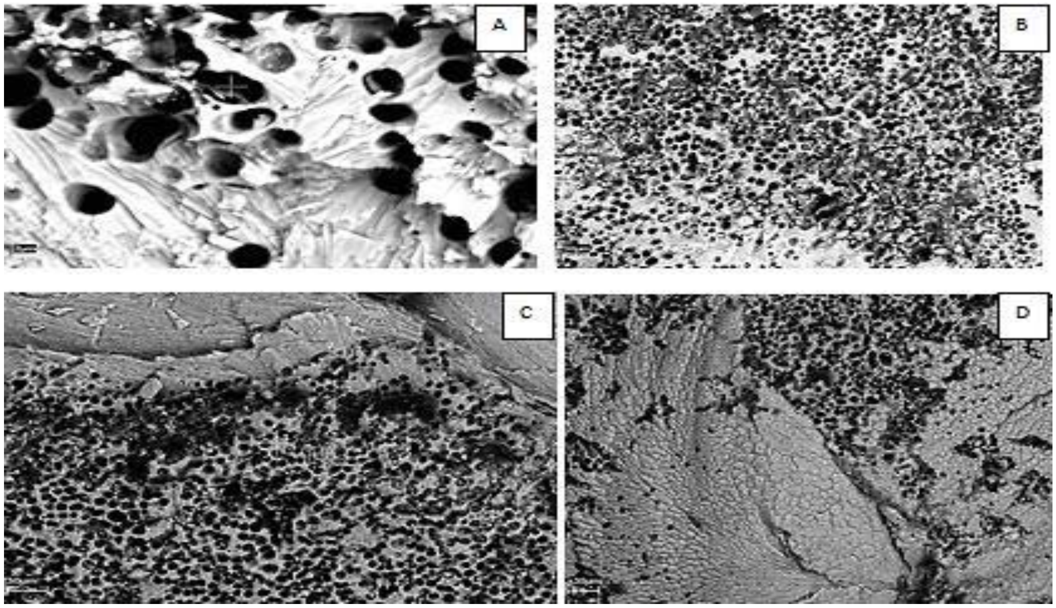

Fig. 4: SEM photograph for Crassostrea cucullata shells, A and B) Black holes in Fadakia shell in size of 2 and 30 µm, C and D) Black holes in Shatt Al-Basrah shell in size of 2 and 30 µm

Clay minerals are playing an important role in the environmental cycling of the studied chemical constituents and heavy metals and clay minerals considered as sink for trace elements (Pendias and Pendias, 2001). The factors controlling trace elements concentration in clay are mainly influenced by: the source of clay minerals, pH – Eh, drainage, climate, time, clay fraction content and organic matter content, pollution, among other factors(Hem, 1985). The Co seems to be associated with clay minerals and organic matter (Pendias and Pendias, 2001). The cobalt ions in sea water were determined to be about 0.03 ppm according to Him (1985), while, it was found in this study that the minimum Co concentration was 0.48 ppm in Shatt AlBasrah *Crassostrea cucullata* shells and the maximum was 2.33 ppm in Khor Shytianah that may be due to high range of contamination of sea water by this metal. Nickel can enter to the structure system of clay minerals. The similar ionic radius between Ni^{2+} = 0.69A°، Co^{2+} = 0.72A° and Fe^{2+} = 0.74A°، Mg^{2+} = 0.66A° caused to replacement of magnesium and iron by nickel and cobalt in the structure system to the clay mineral .The Ni higher mobility in ionic form increases its toxicity effects compared with Cr and Pb (Pendias and Pendias, 2001). Nickel content in the sea water is about 0.007 ppm according to Goldberg *et al*. (1971), while, it was found in this study that the minimum Ni concentration was

4.49 ppm in Fadakia *Crassostrea cucullata* shells and the maximum was 8.88 ppm in Khor Al-Zubair that may be due to high range of contamination of sea water by this metal. Increase of these elements in the sea water may be attributed to the oil spill from the tanker oil ships that passing in the north and Northwest of Arabian gulf. Zinc (Zn) is the most dangerous elements in scale and size of release is Pb and Zn among the elements of the first class of danger and Ni, Co and Cu are among the second class. Currently, 70 to 95 % of all heavy metals are transferred to soil from anthropogenic sources; the rest are from natural source. The anthropogenic sources of Zn are related, first of all, to the non ferric metal industry and then to agricultural practice. Zn was found in this study that the minimum Zn concentration was 217 ppm in Fadakia site *Crassostrea cucullata* shells and the maximum was 240 ppm in Khor Shytianah shells that may be due to high range of contamination of sea water by this metal. The Copper (Cu) concentration in surface soils reflects the bioaccumulation of the metal and also recent anthropogenic sources of the element, the relative enrichment in copper content that could be due to environmental contamination (Pendias and Pendias, 2001). It was found in this study that the minimum Cu concentration was 470ppm in Shatt AlBasrah *Crassostrea cucullata* shells and the maximum was 491 ppm in Khor Shytianah, which may be due to high range of contamination of sea water by this metal. The lead (Pb) concentration in the sea water is about 0.0003 ppm (Pendias and Pendias, 2001). It was found in this study that the minimum Pb concentration was 0.098 ppm in Fadakia *Crassostrea cucullata* shells and the maximum was 43 ppm in Khor Shytianah shells that may be due to high range of contamination of sea water by this metal. Chromium (Cr) higher concentration is mainly due to the transportation of suspended sediments as detrital chromite grains by Shatt Al-Arab river and precipitated in the Iraqi shore lines, and due to pollution from various sources. It was found in this study that the minimum Cr concentration was 0.309 ppm in Khor Abdullah *Crassostrea cucullata* shells and the maximum was 41 ppm in Khor Shytianah site that may be due to high range of contamination of Khor Shytianah sea water by this metal. Strontium (Sr) with highly mobility in aqueous environment, by the weathering the minerals of Celestine $SrSO_4$ and Strontianite $SrCO_3$. It was found in this study that the minimum Sr concentration was 996 ppm in Fadakia *Crassostrea cucullata* shells and the maximum was 2015 ppm in Khor Sahytianah shells. Rubidium (Rb) has the same chemical characteristics of potassium (K) and found in clay minerals as weathered product of the feldspar minerals and mica. It was found in this study that the minimum Rb concentration was 0.85 ppm in Fadakia *Crassostrea cucullata* shells and the maximum was 12.23 ppm in Khor Abdullah shells. Barium (Ba) has the same chemical characteristics of potassium (K) with highly mobility in aqueous environment, by the weathering the minerals of barite $BaSO_4$ and witherite $BaCO_3$. It was found in this study that the minimum Ba concentration was 4.17 ppm in Shatt AlBasrah *Crassostrea cucullata* shells and the maximum was 27.2 ppm in Khor Shytianah shells. The high concentration of Sr, Rb and Ba may be due to high range of contamination of sea water by these metals. Afaj and Al-Dabbas (1998) had studied the *Crassostrea cucullata* shells in the Khor Al-Zubair coastal area and found that the zinc was (20 ppm) and copper (20 ppm) ,while the results of this research indicate that zinc was (224 ppm) and copper (451 ppm) in the *Crassostrea cucullata* shells in Khor AlZubair area which may reflect that these trace elements increased more than 10 time within more than decade that might be due to increase contamination with high environmental changes of Khor AlZubair coastal area.

C. Chemical Analysis of *Chione Californensis* Shell

Chione californensis is a marine bivalve shell found in marine environments only. It is classified using Wang and Guo (2008) classifications, as Phylum: Mollusca, Class: Bivalvia, Subclass: Heterodonta, Order: Ostreina, Superfamily: Veneracea, Family: Veneridae, Subfamily: Chioninae, and Genus: *Chione californensis*. Two layers, the inner aragonite layer and outer calcite layer (Figs. 5, 6A and 7). Concentration of trace elements to specific carbonate shell layers controlled by the relative acceptability of the elements into the lattice and the quantity of foreign elements in the shell reflects the concentration of those elements in the surrounding water (Dodd, 1965; Chow *et al*., 1976; and Phillips, 1977). Infact, filter feeder, such as *Chione californensis*, are particularly valuable in water quality investigation; since shell variation developing during growth should directly reflect the ambient water condition (temperature, salinity, dissolved and suspended load) (Phillips, 1977). Calcite and aragonite were the main of bulk minerals in *Chione californensis* shells (Fig. 5). The ranges of the measured major oxides (MgO%, CaO%, SiO_2%, Na_2O%, TiO_2%, and P_2O_5%, Ca/Mg, and Sr/Ca) and heavy metals (Co, Ni, Rb, Sr, Zn, Ba, Cr, Th, U, Mo, and Pb) of the *Chione californensis* were done in Table (3). Table(3) emphasized that calcite (CaO) and magnesium (MgO) in the shells of Khor Shytianah and Hacham Island are higher than Khor Abdullan shells , that may be probably due to increase of calcium and magnesium ions in Khor Shytianah and Hacham Island sea water, this result is work with the hydrochemical analysis for sea water as reported in Table (1). On the other hand, increase of salinity in Khor Shytianah and Hacham Island water reflected the higher concentrate of sodium and chloride ions in these water, may interpreted to high concentration of sodium elements in *Chione Californiensis* shells for both of Khor Shytianah and Hacham Island compare with Khor Abdullah shells (Tables 1 and 3). Variation in Mg/Ca and Sr/Ca ratios in the mulluscs shells employed as environmental indicator (Cusack *et al*., 2003, and Dalbeck and Cusack, 2006). Mg/Ca and Sr/Ca values in the shells of Khor Shytianah and Hacham Island were more than Khor Abdullah shells, this result may be indicator to higher salinity of sea water in Khor Shytianah and Hacham Island compare with the sea water of Khor Abdullah, and that work with the hydrochemical analysis in these areas , this result agree with study of Al-Dabbas (1980) and De Deckker *et al*. (1988), considering is given here to using the amount of Mg and Sr in ostracode shell to determine the relationship between sea water composition, salinity, Mg/Ca, and Sr/Ca in the shells. *Chione Californiensis* shells in Khor Abdullah are smaller and thinner compare with the shells of Khor Shytianah and Hacham Islanad (Fig. 6B) may be probably due to lesser amounts of calcite content in Khor Abdullah shells and salinity of surrounding water compared with Khor Shytianah and Hacham Islanad. Heavy metals (Co, Ni, Rb, Sr, Zn, Ba, Cr, Th, Mo, and Pb) in the shells of Khor Shytianah were more than the other shells in the study area, that may be attributed to higher amount of these elements content in sea water of Khor Shytianah. In addition to, this is may be used as indicator to the higher contamination of Khor Shytianah by these elements compared by the other areas. U element in Hacham Island shells, P and Ti elements in Khor Abdullah shells were more than Khor Shytianah shells, reflected to higher concentration of these elements in the surrounding sea water in Hacham Island and Khor Abdullah. Presence of phosphor element in Khor Abdullah may be attributed to transport from the agricultural land in the south part of Basrah city by Shatt Al-Arab river and redistributed by tidal current in Khor Abdullah area.

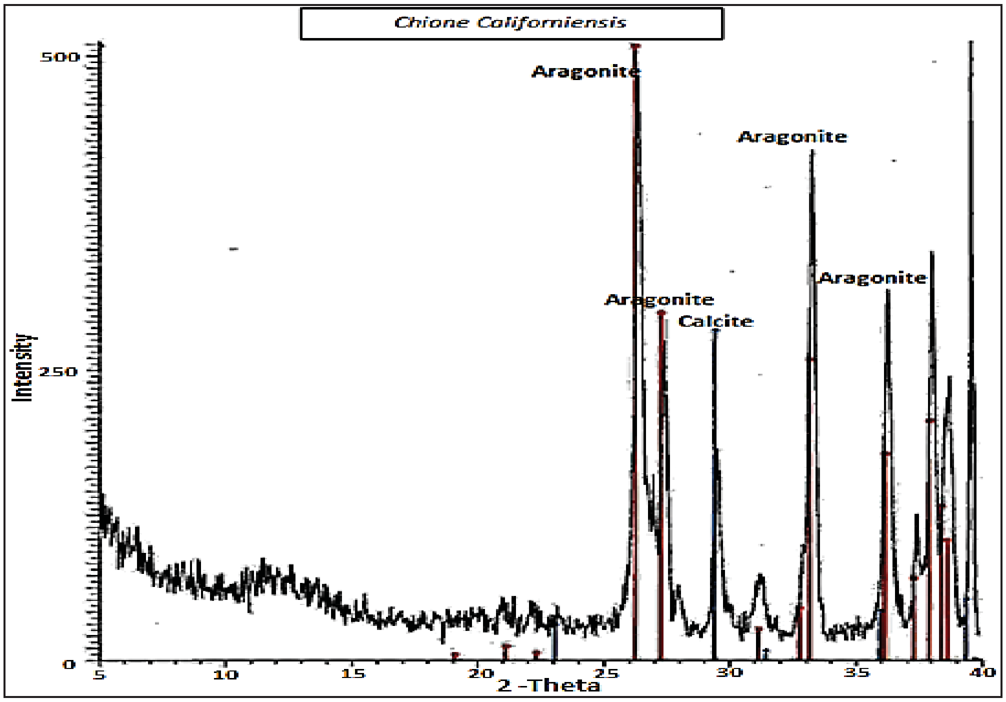

Fig. 5: X-ray diffractogram of Chione Californiensis shells

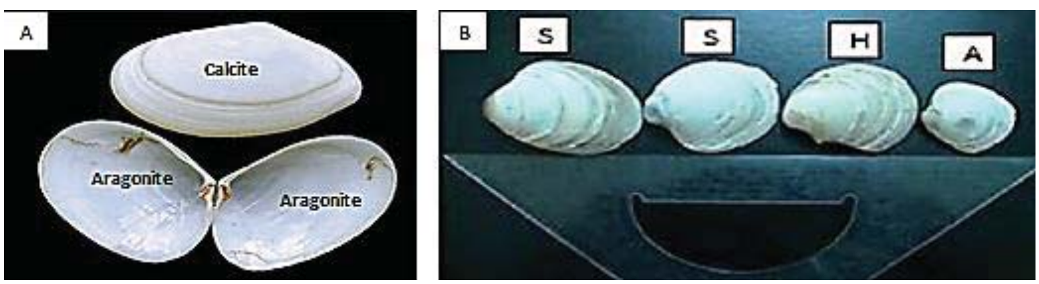

Fig. 6: A) Calcite and aragonite in Chione Californiensis Shell,
B) Length of Chione Californiensis Shells
(A- Khor Abdullah, H- Hacham Island, S- Khor Shytianah)

Fig. 7: A and B) SEM photograph for calcite and aragonite of Chione Californiensis

Table 3: The ICP analysis results of Aragonite and Calcite layers for the Chione californensis shells of Khor Abdullah, Khor Shytianah and Hacham Island

Elements	Khor Abdullah	Khor Shytianah	Hacham Island
CaO%	55	55.5	55.3
MgO%	0.0471	0.065	0.0536
SiO_2%	0.0803	0.08	0.07
P_2O_5%	0.025	0.0133	0.0168
Na_2O%	0.558	0.822	0.628
TiO_2%	0.0021	0.0018	0.0019
LOI%	43	43	42
Ba ppm	10.4	32.4	13.5
Cr ppm	8.7	9.6	9.2
Mo ppm	6.88	12.5	5.52
Ni ppm	8.1	8.85	7.99
Pb ppm	67	74	72
Rb ppm	1.33	2.64	1.17
Sr ppm	1491	2111	1850
Co ppm	1.14	1.22	1.08
Zn ppm	552	644	601
Th ppm	0.051	0.061	0.05
U ppm	0.0594	0.184	0.492
Sr/Ca x 1000	3.694	5.32	4.6
Mg/Ca x 1000	0.716	0.993	0.81

CONCLUSIONS

1. Major oxides and heavy metals accumulation in the shell of oyster in descending order are CaO > LOI > SiO_2 > MgO > Al_2O_3 > Na_2O > Sr > K_2O > P_2O_5 > Cu > Zn > Pb > Cr > Ba > Rb > Ni > Co and Mg/Ca > Sr/Ca.
2. Mg/Ca and Sr/Ca values in coastal line *Crassostrea cucullata* shells are higher than Fadakia and Shatt AlBasrah shells.
3. Values of major oxides (SiO_2%, Al_2O_3%, and P_2O_5%) in Fadakia *Crassostrea cucullata* shells were higher than other areas.
4. Higher content of heavy metals (Ni, Zn, Cu, Pb, Cr, Sr, Rb, and Ba) in Khor Shytianah and Khor Abdullah *Crassostrea cucullata* shells compare with the other areas.

5. Zn and Cu metals increased more than 10 times in Iraqi coasts within more than one decade.
6. Higher salinity of sea water in Khor Shytianah and Hacham Island compare with Khor Abdullah sea water salinity caused to increase both of Ca/Mg and Sr/Ca in Khor Shytianah and Hacham Island *Chione californensis* shells compare with Khor Abdullah shells.
7. Co, Ni, Rb, Sr, Zn, Ba, Cr, Th , Mo, and Pb in Khor Shytianah *Chione californensis* were more than the other shells in the study area.
8. Pollution in the Iraqi coasts water may be formed as a result to the oil spill by the oil bearing ships in the navigation channel in the north and Northwest of Arabian Gulf.
9. It is good to use the mineralogical evidence of *Crassostrea cucullata* and *Chione californensis* shells with their living aqueous habitat to build an aqueous environment models and should be a useful tool for monitoring contamination in the Iraqi aquatic brackish and marine environments.

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