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# BIOGEOCHEMICAL STUDIES ON THE MOLLUSK BIVALVE ANADARA DILUVII (LAMARCK, 1805) (PTERIOMORPHA ARCIDAE)

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## ABSTRACT

Anadara diluvii (Lamarck, 1805) is an edible marine bivalve popular in Egypt. The X-ray diffraction of its shell proved that it is entirely composed of aragonite during its whole age stages. The variations of carbonate elements in the shell during its growth are controlled by the selective uptake of the organism from the desired elements, the ecological conditions of both the water and sediments and the mineralogy of the shell. The hardness of the shell through growth is due to lamination rather than to quartz formation. In addition to calcium, the elements more involved in building up the shell are $Mg^{++}$, $Pb^{++}$, $Zn^{++}$, $Cu^{++}$ and $Fe^{++}$.

A description of the species, its habitat and distribution, as well as, the chemical composition of the shell and its correlation with the mineralogy and growth had been provided and discussed.

## INTRODUCTION

In spite of the importance of Anadara diluvii in Egypt as a popular edible marine bivalve, no attempts have been done to study its structure, geochemistry, biogeochemistry or even its fisheries. The present study is an attempt to understand the structure of this species in concern with its geochemical composition.

In some literature, the authors are affiliating their analyses to one species, while in fact the analyses were carried out on a different species. This often occurs due to misidentification and confusion in synonym names of the species. In order to avoid this confusion, a description of the species under investigation, its habitat and its distribution are provided here.

# MATERIAL AND METHODS OF ANALYSES

Thirty five shells of Anadara diluvii were selected from about 100 shells collected from the beach extending from Port Said to km 28.5 westward (Fig. 1). The selected shells represent the different age stages of the species from nepionic stage to the adult one. They were arranged in 7 groups according to their heights. The shells of each group were washed to eliminate any surficial impurities, then pulverized to pass through 44 $\mu$ mesh sieve. The powdered samples were divided into two portions. The first is subjected to X-ray diffraction analysis using Philips 1840 to determine the mineralogical composition variations throughout the life stages of the studied species. The second portion was attacked with 3 ml of concentrated HCl to ensure the dissolution of all carbonate elements, then diluted with deionized water to 25 ml in a volumetric flask.

The concentrations of $Mg^{++}$ , $Mn^{++}$, $Zn^{++}$, $Pb^{++}$, $Cu^{++}$, $Fe^{++}$ and $Sr^{++}$ were measured using Perkin Elmer 2380 Atomic Absorption Spectrophotometer (AAS).

## RESULTS AND DISCUSSION

### 1- Identification

Anadara diluvii (Lamarck, 1805); (Plate 1).
Synonymous; Diluvarca diluvii (lamarck, 1805).

Distinctive Characters:

Solid equivalve shell, inequilateral strongly swollen, oval, subquadrangular. Obliquely truncated posteriorly with subangled posteroventral tip, slightly curved ventrally, curved anteriorly, without byssus notch. Beaks curved anteriorly to midline, directed forwards and inwards with fine concentric striae and about 30 external radiating ribs which are subequal, more or less granulated and equal to the inter-ribs which are furnished with concentric narrow lamellae. Cardinal area more or less wide, perpendicular to the plane of the valves junction, external ligament extends across it, hinge with 50 cardinal teeth and oblique towards both ends. Inner margin strongly crenulated.

Colour : whitish with a ferruginous brown tan externally.
Length : up to 7 cm, common from 3 to 4 cm (Poutiers, 1987).
Habitat : detrital, coarse, sandy, muddy sand or muddy bottom, between 5 to 500 m deep (Poutiers, 1987).
Distribution: Mediterranean (Steuer, 1939; Hasan, 1974, 1983; Poutiers, 1987).

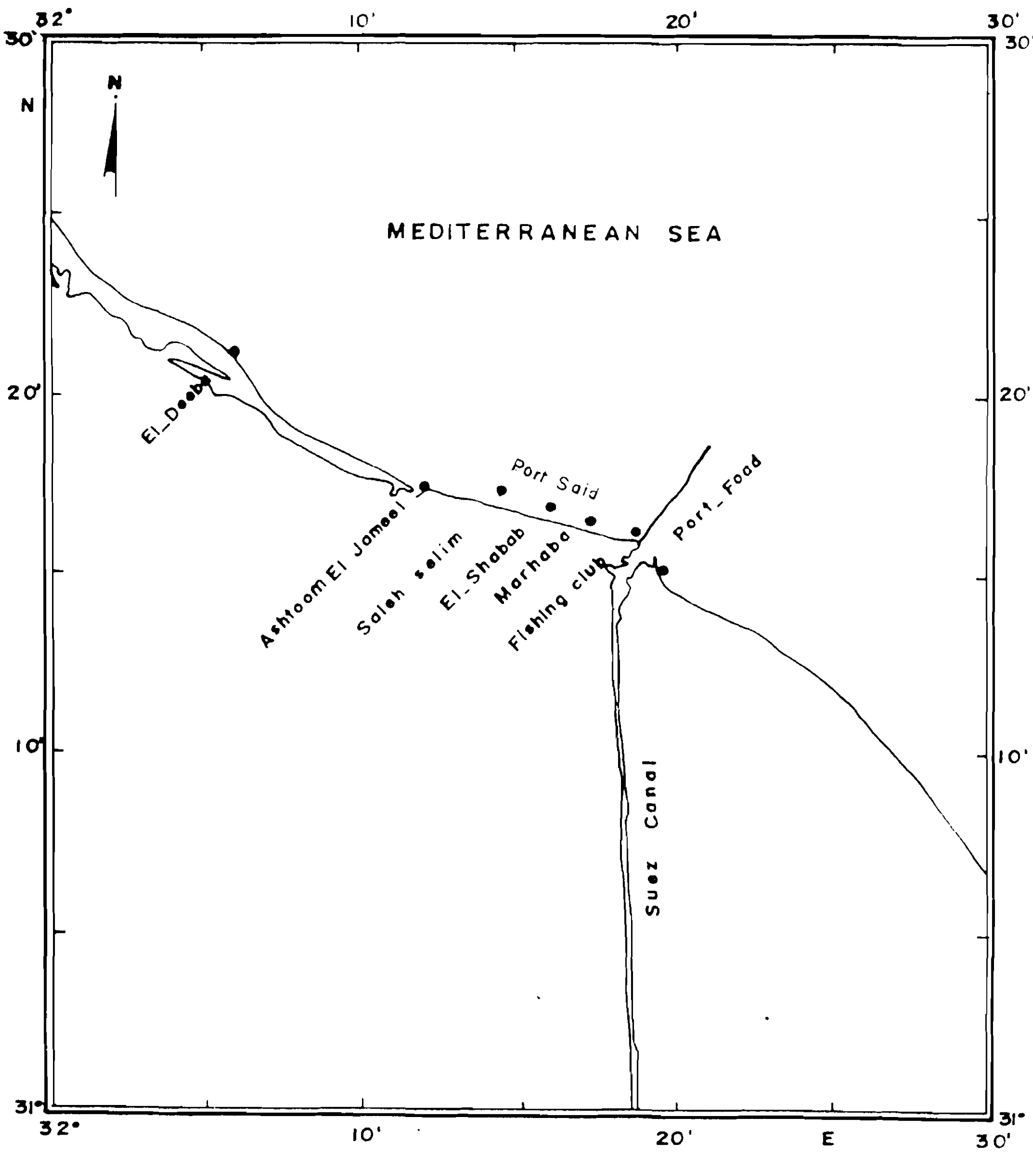


Figure 1: Investigated area showing the sampling localities.

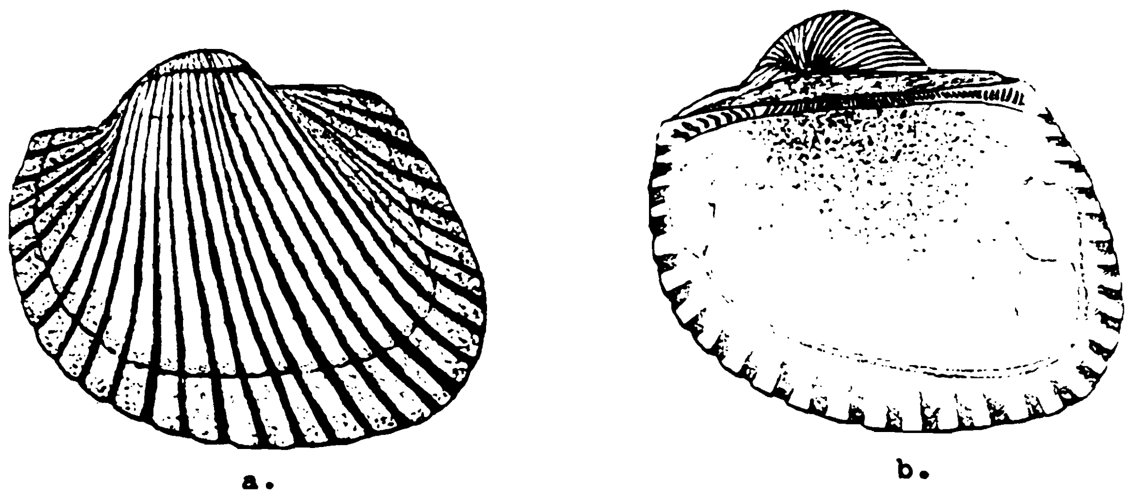


Plate 1: Anadara diluvii (Lamarck. 1805)

(a): External view of left valve.

(b): Internal view of right valve.

2- Mineralogical composition:

X-Ray diffraction analysis (Fig. 2) illustrates that the shell of A. diluvii in Port Said area is entirely composed of aragonite during all age stages.

The concepts of mollusk shell calcification have been studied extensively by many authors (e.g. Hare, 1963; Wilbur, 1964; Hare and Meenakshi, 1968; Towe and Hamilton, 1968; Kennedy et. al., 1969). They suggest that calcification is a phenomenon influenced by internal as well as, external factors. Hare (1963) and Towe and Hamilton (1968) concluded that calcification probably involves a template phenomenon in which some charged proteins attract $Ca^{++}$ and others attract CO3 . Hare (1963) and Hare and Meenakshi (1968) explained that the specific mineralogy of the shell appears to reflect the composition of the proteins within the neighboring organic matrix, and calcitic shell has higher acid to base ratio than aragonitic shell. Milliman (1974) and Folk (1974) suggested that the importance of $Mg^{++}$ in solution, high water temperature (20-30°C), high pH, presence of some organic compounds and possibly $Ba^{++}$ and $Pb^{++}$ ions are important for the formation of Aragonite. In the present work, besides the high water temperature, the pH value as measured by Dr. El Deek from the N.I.O.F. Egypt; ranged between 7.8 and 8.

The quartz is absolutely absent from the mineralogical composition of A. diluvii. This suggests that the increase of hardness (expressed by thickness) of the shell with age (Table 1) is due to the lamination rather than the quartz formation.

The observed homogeneity of the mineralogical composition during the age stages of Anadara diluvii suggests the homogeneity of selective uptake of the living organisms. It also proves the homogeneity of environmental conditions in Port Said area which is markedly affected by the Nile Delta sedimentation.

3- Chemical composition:

Both the quality and quantity of the elements required for building up the shell during the life span of an organism depend on the uptake of the organism of the desired elements, the surrounding environmental or ecological conditions, i.e. the concentrations of the desired elements in water and sediments as well as, the carbonate elements. The latter are involved in the building of the shell.

Table (1) shows the concentrations of $Mg^{++}$ , $Mn^{++}$, $Zn^{++}$, $Pb^{++}$, $Cu^{++}$, $Fe^{++}$ and $Sr^{++}$ during the different age groups of Anadara diluvii in Port Said area.

Magnesium concentration in the shell ranged from 118 ppm recorded in the nepionic stage to a maximum of 707 ppm recorded in the middle stage (Fig. 3) with an average of 288 ppm (Table 1). This level of $Mg^{++}$ is considered low if compared with the $Mg^{++}$ level (up to 1800 ppm) recorded by Abdel Aal and Frihy (1987) in the shell of Glycymeris glycymeris (Linné). The low concentration of $Mg^{++}$ in the shell corresponds to its mineralogy which is entirely composed in

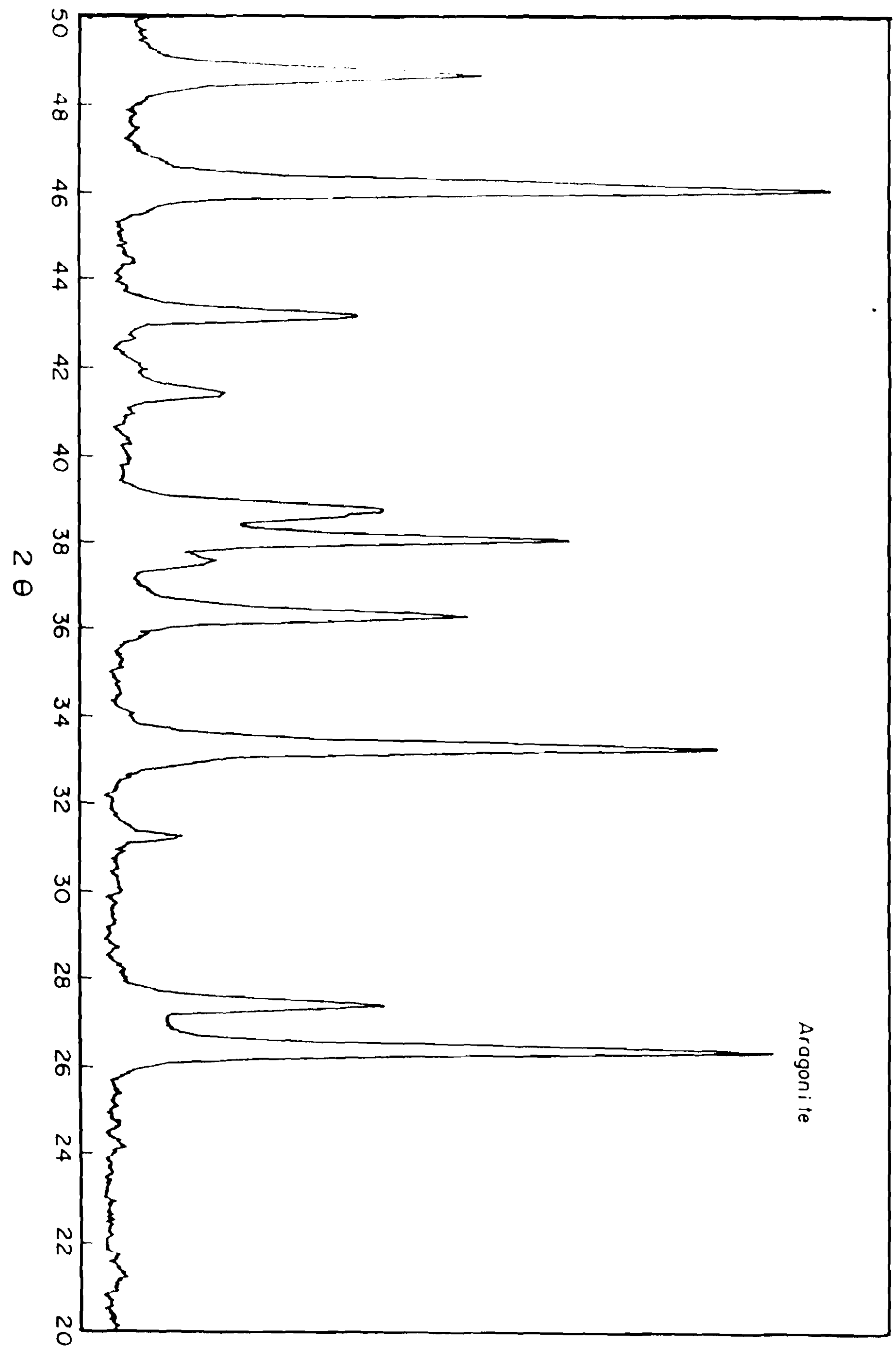


Figure 2: X-Ray diffraction pattern for mineralogical composition of Anadara diluvii

Table (1): Level of the main chemical components (ppm) of the shell of Anadara diluvii during the different age groups.

| Age group | No. of shells | average hight (mm.) | average length (mm.) | average thickness (mm.) | Mg | Mn | Zn | Pb | Cu | Fe | Sr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 21.7 | 25.6 | 1.20 | 304 | 15 | 69 | 138 | 26 | 210 | 3500 |
| 2 | 5 | 27.3 | 30.6 | 1.60 | 118 | 12 | 108 | 130 | 25 | 146 | 6000 |
| 3 | 5 | 34.3 | 39.2 | 1.85 | 253 | 14 | 97 | 138 | 54 | 309 | 3000 |
| 4 | 5 | 37.3 | 42.5 | 2.06 | 707 | 16 | 325 | 160 | 50 | 305 | 5500 |
| 5 | 5 | 42.9 | 48.9 | 2.60 | 201 | 15 | 125 | 148 | 41 | 136 | 4000 |
| 6 | 5 | 46.7 | 52.7 | 2.50 | 169 | 13 | 70 | 145 | 27 | 148 | 8000 |
| 7 | 5 | 50.3 | 56.4 | 3.00 | 264 | 25 | 190 | 128 | 36 | 100 | 5000 |
| Average | | 37.2 | 42.3 | 2.10 | 288 | 15.7 | 138 | 141 | 37 | 193.7 | 5000 |

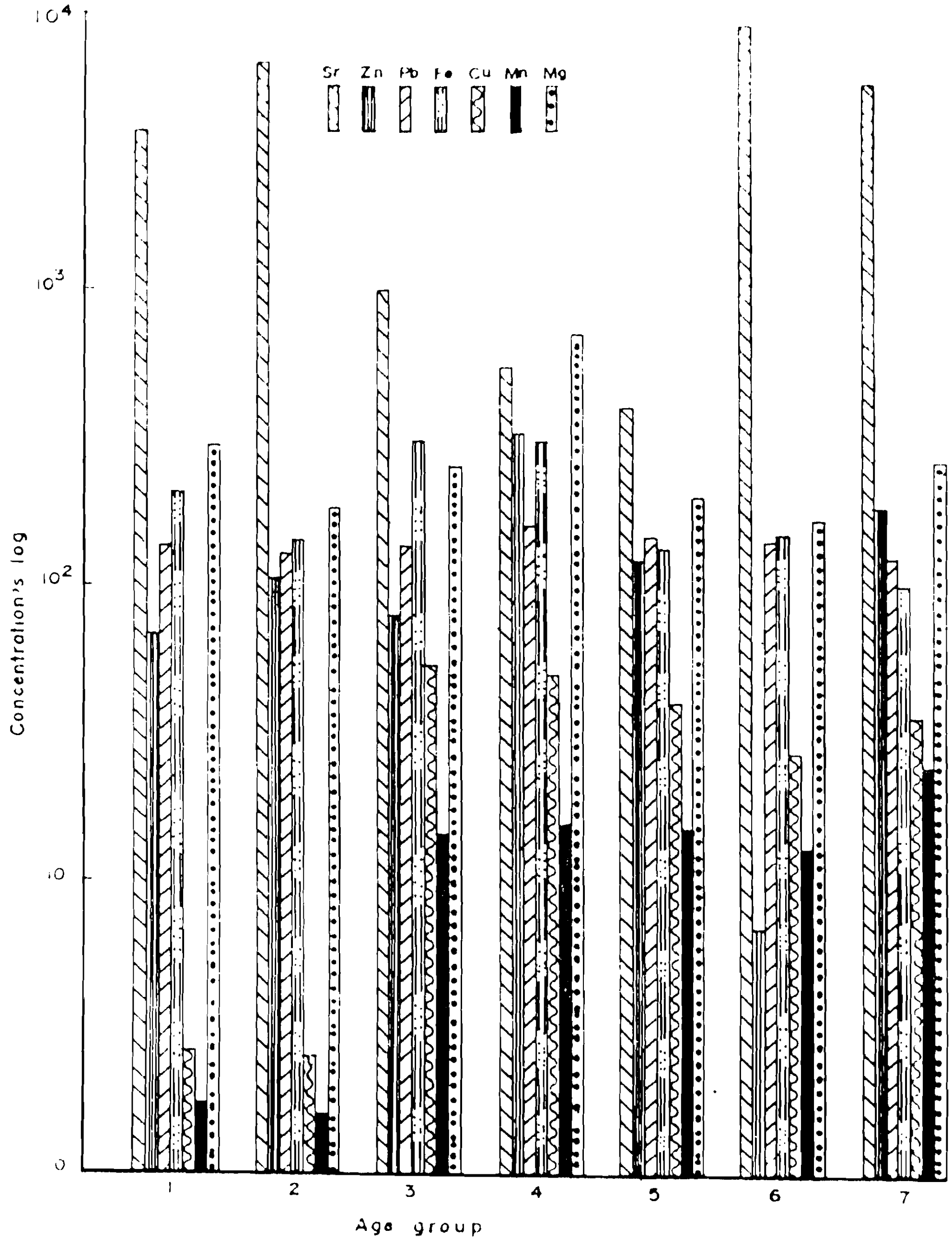


Figure 3: Concentration's log of the measured elements in Anadara diluvii.

the case of A. diluvii of aragonite. The presence of the $Mg^{++}$ peak at the middle stages of A. diluvii may suggest that the organism reduces its uptake of $Mg^{++}$ while its shell is still growing.

Manganese level in the present species is low too. It varies from 12 ppm in the nepionic stage to 50 ppm in the adult. The concentration of $Mn^{++}$ is also correlated with the mineralogy of the shell, whereas Ichikuni (1983) suggests that $Mn^{++}$ prefers to incorporate within the crystal lattice of calcite, while aragonite (which is the main mineral in A. diluvii) tends to uptake $Sr^{++}$, $Ba^{++}$ and $Pb^{++}$ in its crystal lattice.

Zinc level ranges from 69 ppm to 325 ppm (Table 1 and Fig. 3) in the nepionic and the adult stages respectively, with an average of 138 ppm.

Compared with the concentration of $Zn^{++}$ measured in the water of Port Said by Dr. M. Abdelmoneim from N.I.O.F. Egypt, it can be concluded that the concentration factor (concentration of metal in organism/ concentration of metal in sea water) for $Zn^{++}$ = CFZn ranges from $111.29 \times 10^3$ to $42.484 \times 10^3$ with an average of $45.847 \times 10^3$.

It seems that lead involved in building up the shell does not change much from the nepionic stages to the adult, whereas it shows a slight increase in the middle stage. Lead concentration varies from 130 ppm to 160 ppm with an average of 141 ppm (Table 1 and Fig. 3). Generally speaking, the concentration of lead in the shells depends on its mineralogy; whereas the aragonite has a general trend to incorporate $Pb^{++}$ within its crystal lattice, Ichikuni (1983) and on the selective uptake of the living organism to build up the shells.

Measuring the lead in the neritic sea water of the area investigated by Dr. M. Abdelmoneim proved its low level where it ranged between 0.3 and 1.99 ppb with an average of 0.9 ppb. That was reflected on the concentration factor for lead in the shells of A. diluvii where its two extremes were $433.333 \times 10^3$ and $80.402 \times 10^3$ and its average value was $156.667 \times 10^3$.

Like $Mg^{++}$, copper level increased gradually from the nepionic stage to the middle, then recorded a gradual decrease towards the adult stage. It varies from 25 to 54 ppm with a mean value of 37 ppm. According to the measurements carried out by Dr. M. Abdelmoneim, the dissolved $Cu^{++}$ in the sea water of the area varies from 0.15 to 2.9 ppb with an average of 1.16 ppb. The low concentration of $Cu^{++}$ in the area can be attributed to its consumption through the biological activities. CFCu ranges from $166.67 \times 10^3$ to $18.62 \times 10^3$ with an average of $31.89 \times 10^3$.

Iron records its lowest value in the adult stage and its highest (309 ppm) in the middle stage. The concentration of $Fe^{++}$ in the studied shells depends, to some extent, on both the iron concentration in the food supply and on the organism's growth rate.

Sultanov et al., (1978) stated that an element can enters a mollusc's skeletal tissue either in food or by adsorption from sea water. It is known that iron occurs in sea water only in the trivalent state (Riely, 1965), The iron recorded in the shell of A. diluvii in the present investigation is in the divalent state. This indicates that the food is the source of iron in this shell.

Strontium shows a somewhat different mode of variation, whereas its concentration varies from 3000 ppm in the middle stage to a maximum of 8000 ppm in the somewhat adult stage. The presence of $Sr^{++}$ is linked with the crystallization of aragonite. Also strontium can be related to the rate of growth of the mollusk shell. Pilkey and Goodell (1963) and Dodd (1965) suggested that fast-growing shells contain higher strontium concentrations. Swan (1956) offered the opposite view, that fast growing of the shell results in less strontium absorption. Hallam and Price (1968) have invoked other physiologic factors to explain strontium variations within molluskan shells. In the present study, except in the second age group, there is a general trend of higher strontium content with elder shells. The irregular variations of the $Sr^{++}$; and its apparent increase through the age stages of the studied shells can be interpreted on basis of the degree of crystallization of aragonite.

4- Correlation analysis:

The correlation analysis has been calculated to follow up the interrelations between the measured elements as well as the effect of growth on the concentration of these elements.

Figure (4) reveals that $Mg^{++}$ is strongly correlated with $Zn^{++}$ (r=0.85) whereas both $Mg^{++}$ and $Zn^{++}$ are involved in building up of aragonite which constitutes the shell of the studied species.

Magnesium is also positively correlated with $Pb^{++}$ and $Cu^{++}$ concentrations ( r = 0.7 and 0.5 respectively). The correlation coefficients between the measured elements reflect their role in building up the shell of Anadara diluvii.

Iron is also positively correlated with copper (r = 0.7) reflecting their ultimate role in the biological activity in building up the shell of the studied species.

Generally speaking, the correlation analysis reveals that the more involved elements in building up the shell of A. diluvii are $Mg^{++}$, $Pb^{++}$, $Zn^{++}$, $Cu^{++}$ and $Fe^{++}$. Figure (5) reflects the correlation between the growth of the shell and the studied elements.

The regression analysis results the following equations;

(1) height = 2.97 + 16.19 thickness (r = 0.98)

(2) length = 1.37 + 1.099 height (r = 0.999)

(3) length = 4.696 + 17.77 thickness (r = 0.98)

(4) $Zn^{++}$ = 21.36 + 0.405 $Mg^{++}$ (r = 0.85)

(5) $Pb^{++}$ = 129.15 + 0.04 $Mg^{++}$ (r = 0.70)

(6) $Fe^{++}$ = 10.5008 + 4.972 $Cu^{++}$ (r = 0.7)

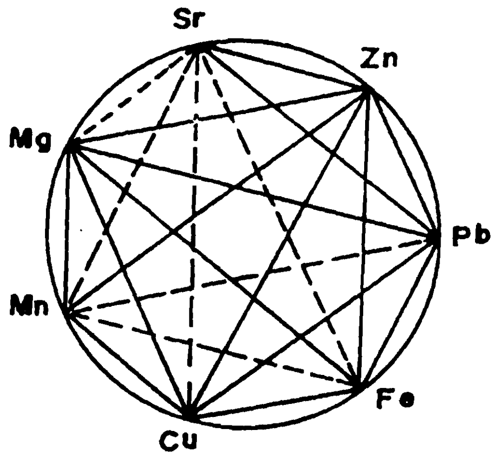


Figure 4: The interrelation of the measured elements during life stages of Anadara diluvii (——, +; ---, -).

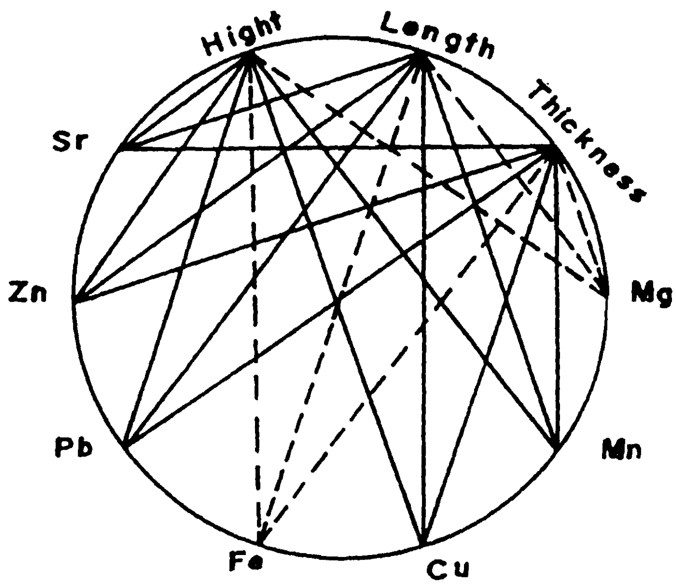


Figure 5: The effect of growth of Anadara diluvii on the interrelation between the measured elements (——, +; ---, -).

## CONCLUSION

The quality and quantity of the required elements for building up the shell are factors for both the requirement of the organism of the desired elements and the surrounding environmental conditions. It has been found that:

1) the more involved elements in building up the shell of A. diluvii are $Mg^{++}$, $Pb^{++}$, $Zn^{++}$, $Cu^{++}$ and $Fe^{++}$.

2) the shell is entirely composed of aragonite during its whole age stages.

3) the iron of the shell is in the divalent state and entered it through the food.

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