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SEASONAL VARIATION OF SOME TRACE ELEMENTS CONTENT IN THE RED SEA WATERS AT AL-GHARDAQA.

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ABSTRACT

A study of the seasonal variation of three trace elements, namely iron, copper and manganese, was carried out in the Red Sea water at Al-Ghardaqa. An area covering approximately 900 km^2 was surveyed during the periods 1967 - 1968 and 1974 - 1976.

The seasonal variation patterns of the elements were not alike. Total iron in the area showed maximum concentrations during winter months and minimum concentrations during summer months. Copper showed two relative maximums during winter and summer seasons, with higher values during summer months. Minimum copper concentrations were recorded during autumn. Manganese showed maximum concentration during autumn and minimum concentration during spring months.

The seasonal variations of the elements were attributed to:

1) the selective utility of these elements by different marine organisms; 2) decomposition of dead organic matter;3) air-borne material transported to the sea by strong winds during winter time.

INTRODUCTION

Chemical oceanographers are concerned with the chemical composition of sea water and the biochemical, geochemical and hydrochemical factors that affect the concentration and distribution of the chemical constituents of sea water. Analysis for various chemical constituents of sea water have received a great deal of attention. However, complexities and difficulties involved in obtaining uncontaminated samples, have been obstacles to the chemical analyst in studying trace elements in sea water. Unlike the major constituents, which represent from 99.7% to 99.9% of the dissolved material in sae water, our knowledge of concentration of the other 0.3% is quite limited. The later group contains the principle plant nutrients like nitrogen compounds, phosphorus compounds and silicon compounds. It also includes trace elements like Co, Mn, Cu, Fe etc. which are necessary for life and Hg, Pb and Se, which are dangerous to marine life.

A full description of the biological significance of iron has been reported in detail by Vinogradov (1953). The effect of iron on the growth of phytoplankton has been showen by a number of investigators (Harvey, 1927; Menzel and Ruther, 1962). Iron in sea water acts as scavenger for other trace elements and this possible property of iron has been discussed by Goldberg (1954). Also, iron was used by Jeffery and Hood (1958) to remove all dissolved organic compounds from sea water.

Like iron, which is necessary in the biosynthesis of chlorophyl, copper is needed for the synthesis of porphyrins. Traces of the element have been shown to be very important in the stabilization of the chloroplast. On the other hand, toxicity of copper in greater amounts is well known, and compounds containing copper are used in antifouling paints.

Manganese is also known to be essential in primary production. Emerson (1939) demonstrated that manganese deficiency greatly reduces the rate of photosynthesis in dim light. Harvey (1963) has shown that the marine diatom **Ditylum brigthwelli** is severly affected by manganese deficiency. According to Harvey (1963), differences in the manganese contnet from one water body to another, and from one season to another, may play a part in regulating the qualitative composition of phytoplankton in the sea. Manganese also acts as a scavenger to other trace components in sea water. Manganese nodules, present on the ocean floor in different parts of the world, contain high concentrations of other trace elements present in sea water.

The area under investigation has been subjected to extensive biological studies (Beltagy, 1975). However, no chemical or physical studies have been carried out on it.

MATERIAL AND METHODS

During the year 1967-1968, samples for the present study were collected from eleven stations, covering an area of about 900 km^2(Fig.la-b).For low variance in the results, besides other practical reasons, samples were also collected from a station (No.6), off-shore to the east of the MBS during the peirod 1974-1976, using plastic coated Nansen bottles. To minimize contamination, a motor-boat with a wooden hull was used throughout this study.

Samples collected were filtered through 0.45 μ millipore filters. The filtered samples were analysed for the total Fe, Cu and Mn content on the dav of collection.

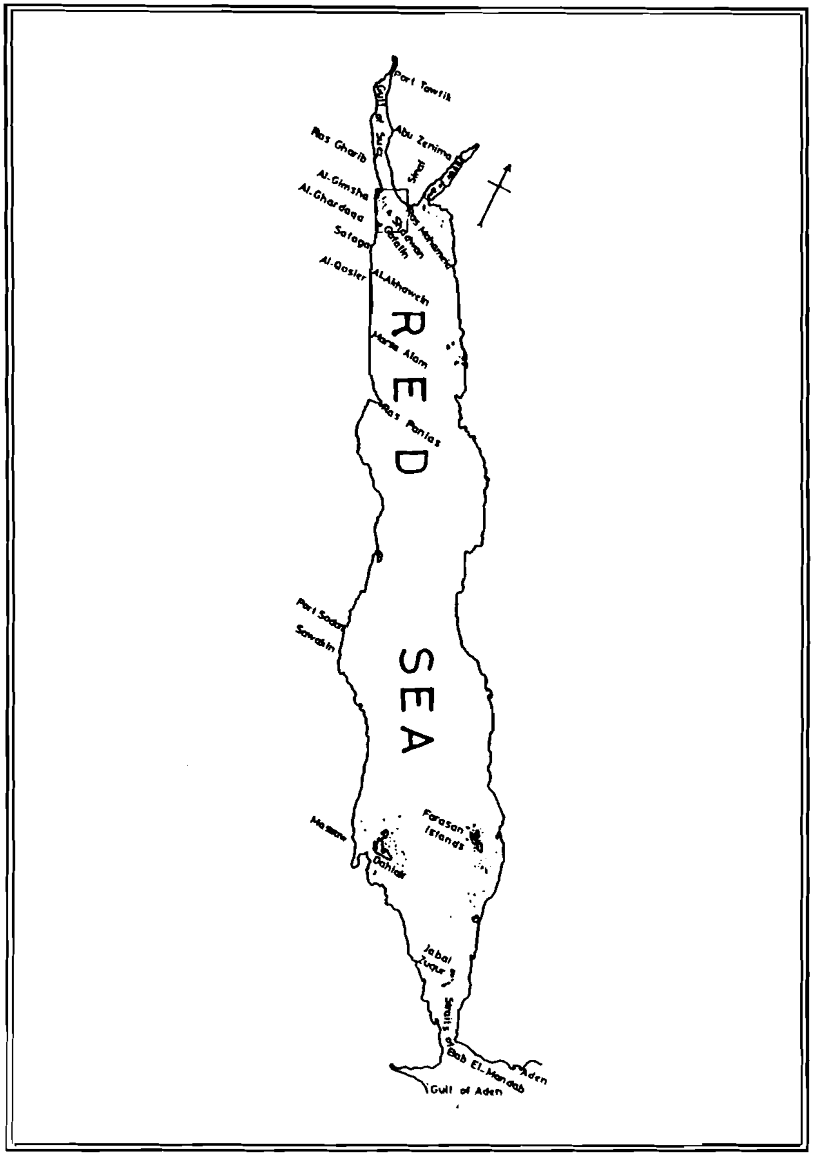

Fig. 1 a. Area investigated relative to the Red sea.

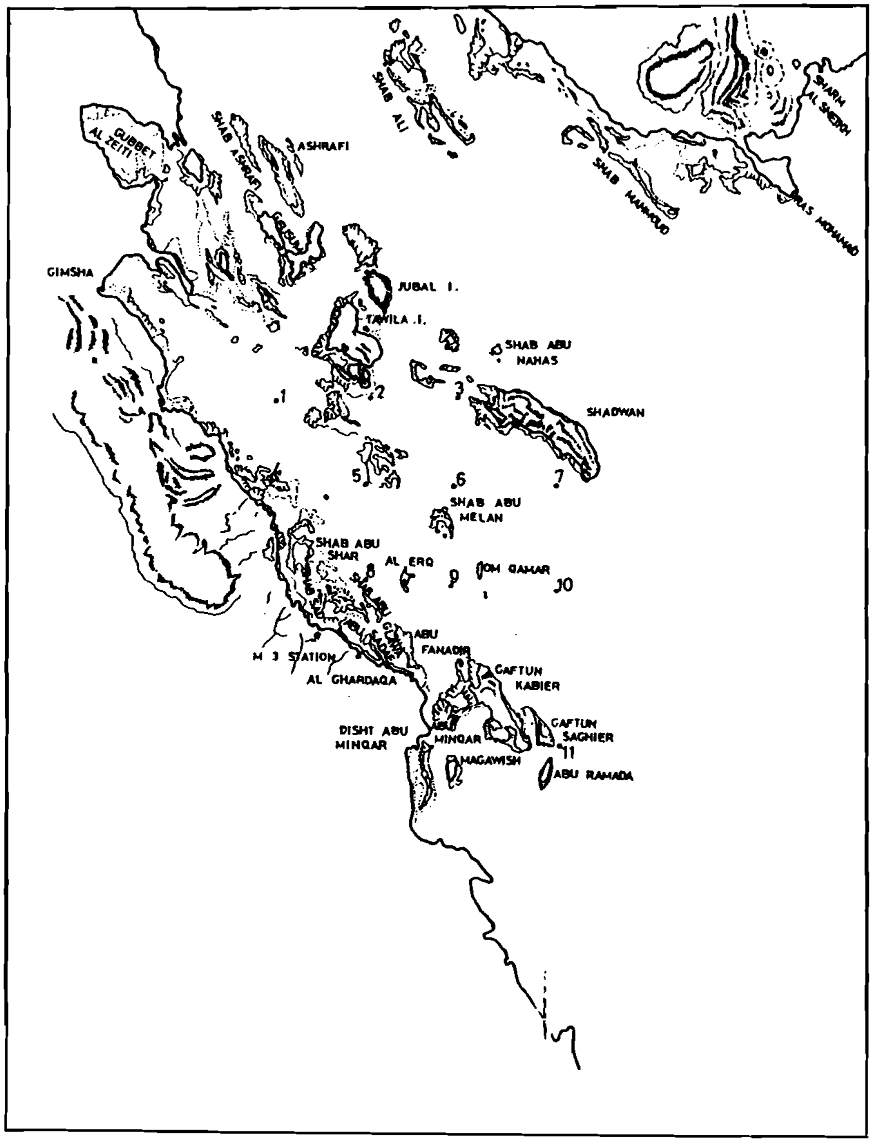

Fig. 1 b. The study area and location of sampling stations.

The orthophenanthroline method described by Armestrong (1957) was used for the total iron determination; the Diethyldithiocarbamate method, described by Strickland and Parsons (1965), was applied for copper analysis; the leucomalachite green procedure given by Strickland and Parson (1965), was used for the determination of manganese.

RESULTS

Table 1 gives the average concentration of different elements, analyzed during the year 1967-1968; Table 2 gives the cocnentration of different elements, analyzed during the period 1974-1976. The results are also shown on Figs 2,3 and 4.

However, the cocnentration of total iron decreased regularly during the spring months. It fell to its minimum in late spring or early summer, when it started to increase during the summer and autumn months to reach maximum values again during winter months.

Although differences in concentration from year to year and from month to month existed, the same general trend observed during various years, which may indicate that the total iron content may be characteristic of the area and follows other physical and biological characteristics.

On the other hand, copper showed a different pattern (Fig. 3). It had two relative maxima during winter and summer month, with higher concentrations reported during summer months (37 µg Cu/l). It followed the same pattern during the different years of the study and this may indicate that the controlling factors were operating in the area in a similar way during different years. However, they may be different from those affecting iron distribution.

Manganese behaved in a completely different manner, compared with both iron and copper. Manganese showed a minimum concentration of 0.9 µg Mn/l during spring time and a maximum concentration of 6.0 µg Mn/l during autumn. The same trend was observed during different years.

DISCUSSION

Concentration and distribution of trace metals in sea water in a particular area may be controlled by one or more of the following factors

1) Biological activities in this particular area; 2) terrestrial input; 3) physico-chemical conditions in the area.

Iron in the area investigated is subject to intense biological consumption during early spring, due to phytoplankton blooming (Harvey, 1957).

TABLE 1

AVERAGE, COPPER AND MANGANESE CONTENT (μg/l) OF THE SURFACE WATERS AT AL-GHARDAQA DURING THE PERIOD 1967 - 1968.

Year	Element	MONTH											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1967	Fe	*-	79.0	-	-	64.0	-	-	25.0	29.0	-	38.0	-
to	Cu	-	27.0	-	-	16.3	-	-	36.7	-	-	10.3	-
1968	Mn	-	2.9	-	-	0.95	-	-	3.6	4.9	-	5.5	-

TABLE 2

IRON, COPPER AND MANGANESE CONTENT (μg/l) OF THE SURFACE WATERS AT STATION 6 DURING THE PERIOD 1974 - 1976.

Year	Element	MONTH											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Fe	-	-	-	-	-	20.0	33.0	29.0	41.0	45.0	50.0	65.0
1974	Cu	-	-	-	-	-	26.5	31.0	33.5	25.0	16.5	20.0	21.1
	Mn	-	-	-	-	-	1.3	1.7	3.0	3.7	3.6	4.0	3.3
	Fe	70.0	74.0	50.0	41.0	33.0	25.0	28.0	36.0	33.0	40.0	43.0	62.0
1975	Cu	23.7	27.0	22.5	18.0	20.5	24.0	27.0	29.5	31.5	15.0	18.6	21.2
	Mn	3.3	3.4	2.5	2.0	1.5	1.4	3.0	4.3	5.0	5.0	6.2	4.5
	Fe	74.0	72.0	45.0	45.0	39.0	32.0	19.0	19.0	28.0	51.0	60.0	60.0
1976	Cu	21.0	23.0	25.0	23.7	20.5	20.0	25.0	3.0	34.0	9.0	13.5	17.5
	Mn	2.6	1.8	1.2	0.6	-	0.8	1.9	2.5	3.7	3.5	3.5	4.0

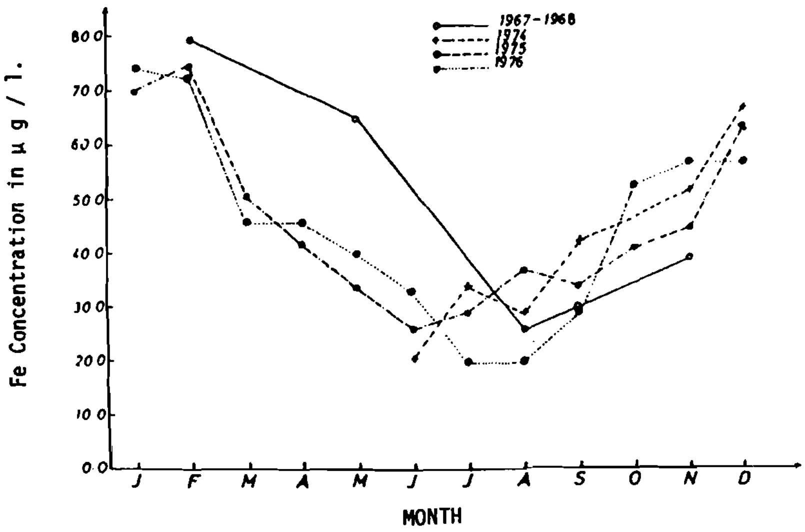

Fig. 2. Seasonal variation in the concentration of total Fe.

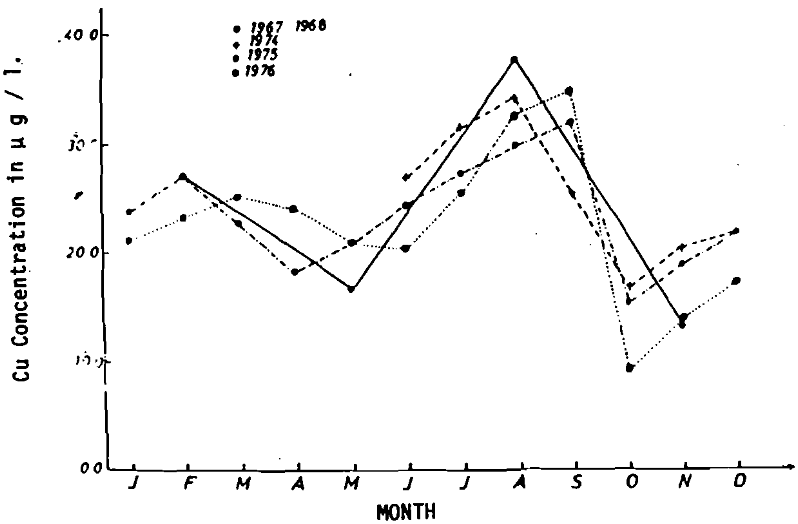

Fig. 3. Seasonal variation in the concentration of Cu.

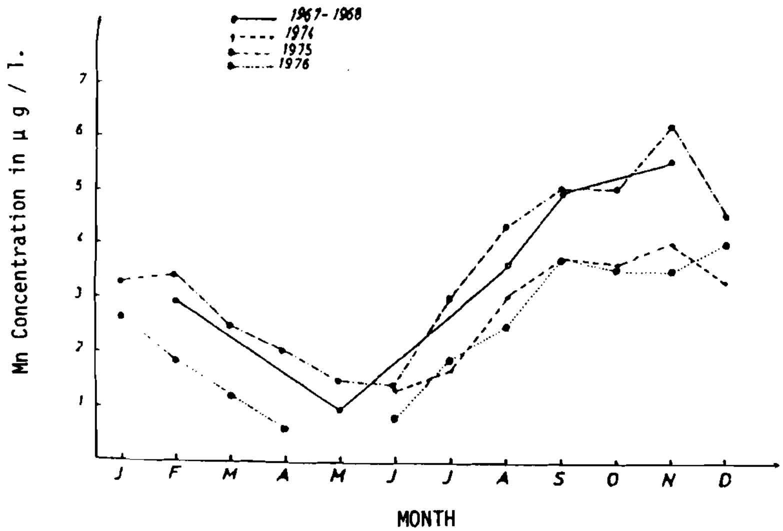

Fig. 4. Seasonal variation in the concentration of soluble Mn.

This activity extends throughout the spring and early summer months. By late summer, iron uptake diminishes and a considerable amount of the element is released to the water through regeneration processes.

The second factor, which contributes to the shaping of the patterns, is terrestrial input. It was observed that during the winter season, strong winds blew over the area in a NW-SE direction, carrying dust of ultra-small sizes. Particle size analysis of air-borne dust samples from the area indicated that approximately 20% by weight of the dust has a diameter of less than 2 µ. Chemical analysis of this air-borne dust showed that it has on the average 0.62% w/w leachable iron (Beltagy, 1979). Thus, many of these particles could have passed through the millipore filters and added to the iron content of the samples. It may also have added soluble iron to sea water by dissolution, as new equilibrium between sea water and suspended particles must be achieved within a short period, unless suspended particles are removed to the bottom sediments. However, small particles need a relatively longer time to settle down in calm conditions and in such turbulent conditions, which prevail during winter months, it is likely that these particles stay in the water column throughout the whole season. In addition, stirring of the sediments might occur in shallow areas and add to the suspended matter content of the water column.

No correlation was found between iron concentration and either salinity or temperature. It seems that water movements in the area have little effect on the distribution of this element, although wind generated waves may have some effect on the distribution and concentration of the element during different seasons.

Both pH and organic content in sea water are closely related to biological activity in the water, Accoridng to Al-Sherief and Beltagy (1968), iron increases proportionally with the increase of organic carbon in sae water in the same area during winter months.

Unlike iron, copper is much less used by phytoplankton, though complex compounds with dissolved organic matter help in keeping copper in soluble form. Al-Shereif and Beltagy (1968) have shown that copper varies proportionally with organic matter. Biological activity, however, does not seem to affect copper concentration. A high value of approximately 27 ug Cu/l was recorded during winter months. In summer months much higher values were recorded - approximately 37 ug Cu/l. A probable explanation may come if we consider the nature and distribution of life in the area. Extensive growth of coral reefs is the main feature of the area. Some of these reefs are exposed during low tide and dead corals and their decompostion products can be smelled throughout the area during summer time. Decomposition of organic materials is invariably accompanied by reduction in dissolved oxygen and pH of the water. Thus, during summer months, higher solubilitiees of copper associated with suspended or sediment components occur.

The winter high concentration may be attributed to terrestrial input of dust particles containing removable copper ions. Turbulence, due to strong winds, causes deep water with low oxygen and low pH to be distributed throughout the water column, inducing favourable conditions for Cu ions to be transferred from solid suspended particles to the water.

Water masses and currents in the area appeared to have no effect on the distribution of copper.

Manganese occurs mostly in the form of soluble Mn^{2+} (Goldberg, 1965). It is precipitated as $Mn\ O_2$ by oxidation to Mn^{4+} as in the manganese nodules. Its distribution is thus controlled to a large extent by the pH and Eh of the water.

From Figure 4 it can be seen that manganese had a regular cycle in the area that was repeated during different years. It had the lowest concentration (approximately 0.9 ug Mn/l) during spring months and increased gradually to reach its maximum during the winter months, decreasing again thereafter. Because biological activity during spring months may have consumed manganese from sea water (Harvey, 1957), converting it into organometallic complexes or oxidizing Mn^{+2} to Mn^{+4}, the concentration of active manganese was much reduced during this season. By the summer time, much manganese appeared in the area. This may be due to decomposition of dead corals, as mentioned above, and consequently a decrease in pH and Eh values, which brought back the active Mn form.

However, water masses and current in the area seem to contribute to the manganese distribution in the area.

CONCLUSION

Total iron in the area showed maximum concentrations during winter months, and minimum concentrations during summer months, while copper showed two relative maxima during winter and summer with higher values during summer months. Minimum values were recorded during autumn. Manganese showed maximum concentration during autumn and minimum concentration during spring months.

Biological activity in the area is the major operational factor that affects the distribution and seasonal variation of the trace elements studied.

Air-borne dust and strong winds over the area during the winter season tend to affect the distribution of total iron.

Oxidation and decomposition of organic matter in the area help regeneration of trace elements in the column, particularly manganese.

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