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DISTRIBUTION AND ABUNDANCE OF ZOOPLANKTON IN THE SHATT AL-ARAB ESTUARY, NORTHWEST ARABIAN GULF

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ABSTRACT

Monthly samples of zooplankton were collected from the Shatt Al-Arab estuary, NW Arabian Gulf for the period from July 1993 to July1995. Sampling was carried out with a 90 µm mesh-sized net. Five stations were selected in this region. Three distinct zooplankton assemblages were categorized in the study area. An estuarine-neritic assemblage comprised of Copepoda (87%), Larvacea (5%), Mullosca (3%), larvae of Annelida (2%) and marine Cladocera (1%) was noted at the lowermost station in the estuary. In contrast, a freshwater assemblage constituted freshwater Cladocera (58%), Copepoda (27%), nauplii of Cirripedia (10%) and larvae of Mullosca (4%) was occurred at the uppermost one. At the intermediate stations however, a mixed or a true estuarine assemblage was occurred. The numerical abundance of zooplanlton was increasing downstream towards the Arabian Gulf. High numerical abundance of zooplankton was occurred at the lowermost station in the estuary, (5838-208143 ind./m^{-3}) whereas the lowest abundance was at the uppermost one (97-13438 ind./m^{-3}). Bimodel two peaks of abundance were noted in all stations the former during the summer (July-August) and the after during late winter (January-February). The numerical abundance of zooplankton is governed by salinity and freshwater discharge, and to lesser extent by temperature and chlorophyll-a.

INTRODUCTION

The Shatt Al-Arab river, is the major freshwater discharge to the Arabian Gulf. It affects the general oceanography of the Arabian Gulf (Brewer *et al.*, 1978; Saad, 1978; Abaychi *et al.*, 1988; Mohammed *et al.*, 1995). It has also direct effect upon the plankton productivity in the NW part of the Arabian

Gulf (Yamazi, 1974; FAO, 1984; Lee *et al.*, 1985; Michel *et al.*, 1986) and the fisheries of the area (Al-Hassan and Hussain, 1985; Hussain *et al.*, 1989; Al-Mahdi, 1996). However, very few studies were carried out on zooplankton of Shatt Al-Arab estuary (Mohammed, 1965; Salman *et al.*, 1986; Abdul Hussein *et al.*, 1989). Discomplete Information on the zooplankton abundance is available, for the upper Shatt Al-Arab river only (Salman *et al.*, 1986), yet data on the zooplankton of the estuary are lacking. Hence, as the first in a series of articles on the zooplankton along the salinity gradient in the Shatt Al-Arab estuary, this paper is the first attempt to provide information on the composition, abundance and distribution of the zooplankton in this area.

STUDY AREA AND METHODS

The present study was carried out for two years from to July 1993-July 1995. Surface water and zooplankton samples were collected from five stations along the Shatt Al-Arab estuary (Fig. 1). These are the Arabian Gulf proper (station 1), the Outer bar (station 2), Ras Al-besha (station 3), Al-Fao (station 4) and Al-Sebah (station 5).

Water temperatures were recorded to the nearest 0.1°C. Salinity determinations were carried out immediately with a digital salinometer E 202 type, Tourume Seiki. Light penetration readings were measured using a Secchi disc (30 cm in diameter). Chlorophyll-a estimations were based on Strickland and Parsons (1972). Zooplankton samples were taken using a 90 μm mesh-sized zooplankton net having a mouth aperture of 40 cm. A digital flowmeter (model 438 110)-Hydrobios Ltd., was mounted in the middle of the mouth. Net samples for counting the zooplankton were immediately fixed with 10 % formalin while those for biomass were deep-freezed without fixation. Counting of zooplankton plus the systematic arrangement of results were made according to Wickstead (1965). Numerically important groups of zooplankton at each of the sampling stations, which form percentages composition > 1% of the total zooplankton, are considered here as dominant groups. Zooplankton biomass were determined as displacement volume, wet weight, dry weight and ash-free dry weight. Displacement volume were made by using a vaccum filtration (Wickstead, 1965). The filter with the plankton was then used for the estimations of wet weight, dry weight and ash-free dry weight (Bradford, 1972). Measurements of zooplankton biomass were carried out only at stations 1 and 2, as it was rather impossible to get a reasonable estimate for stations 3-5 due to the presence of high-suspended particulate matter.

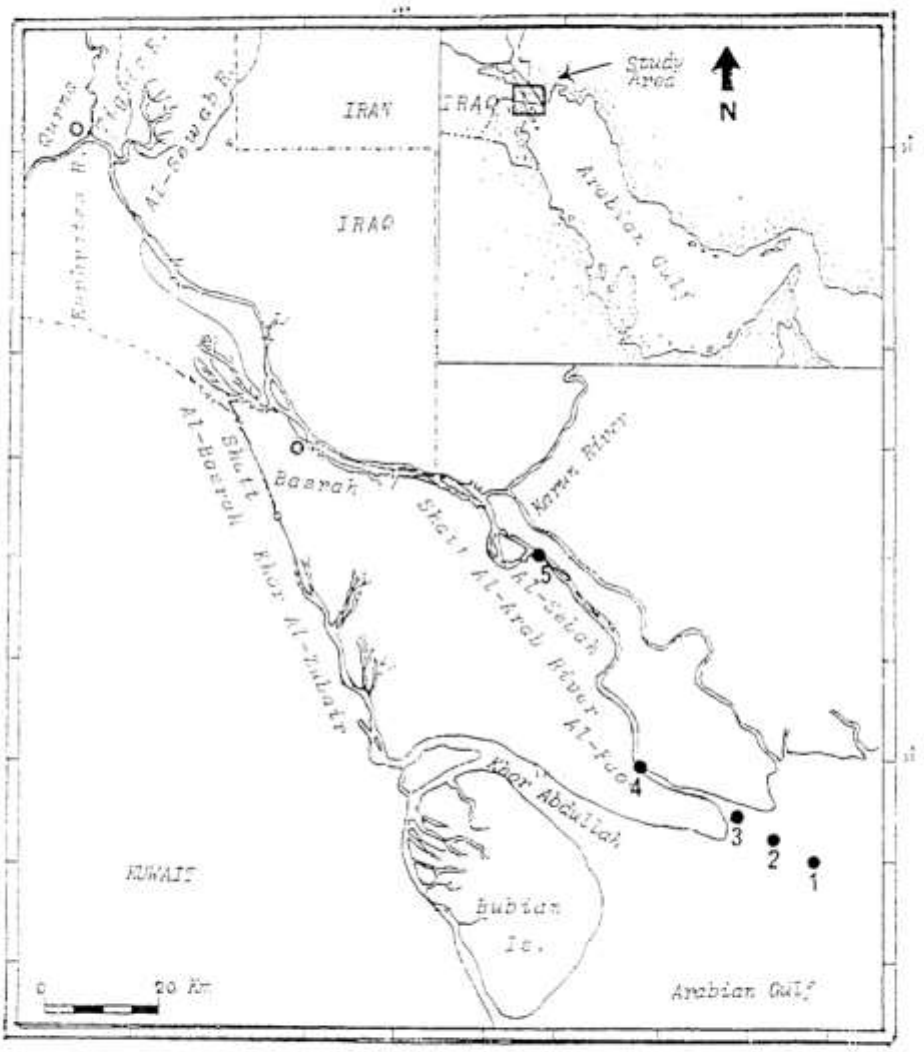

Fig. 1 : Map of the Shatt Al-Arab estuary and North-West Arabian Gulf showing the position of stations .

RESULTS AND DISCUSSION

Composition and distribution

Zooplankton composition observed in the Shatt Al-Arab estuary, could be categorized into 3 distinct assemblages based on the dominant zooplankton groups in the study area (Table 1). These are estuarine-neritic, true estuarine and freshwater assemblages at the sampling stations 1, 2-4 and 5 respectively.

At stations 1-4, Copepoda predominated the zooplankton (87%, 90%, 81%, 55%, respectively). On global scale, copepods are almost the most numerous zooplankton group in oceans, bays and estuaries (Longhurst, 1985). Following copepods, the neritic zooplankton groups (Walker *et al.*, 1979; Raymont, 1983) including Larvacea (5%), Mollusca (3%), larvae of Annelida (2%) and marine Cladocera (1%) which dominated station 1, apparently indicate an estuarine-neritic assemblage at this station. However at stations 2-4, a mixed zooplankton composition was occurred. The cirripede nauplii, which is an important group of zooplankton in estuaries (Reid, 1961; Perkins, 1974) attained high abundance at these stations (1%, 12%, 5%, respectively). At station 3, in particular it was the second dominant group of zooplankton following copepods, which may clearly indicate a true estuarine assemblage in this area. In contrast, a freshwater zooplankton assemblage was clearly occurred at station 5. At this station, the freshwater Cladocera was the first dominant group (58%), as it was reported earlier in the upper Shatt Al-Arab river (Salman *et al.*, 1986).

The above distinct spatial differences appeared to be quiet consistent with salinity gradicut in the estuary (Table 2). Hence, the present account agree quiet well with the previous studies which considered salinity as the most important environmental factor affecting the zooplankton distribution in estuaries (Kinne, 1971; Goswami and Selvakumar, 1977; Guisande and Toja, 1988; Laprise and Dodson, 1994). In addition, the present account in relation to salinity, both confirm the previous suggestion of Al-Mahdi and Salman (1997), which considered Al-Fao as the boundary of the fresh-marine water characteristics.

Abundance and seasonal variations

Horizontal gradient of increasing in numerical abundance of total zooplankton in a seaward direction was noted in the Shatt Al-Arab estuary (Table 1). Highest zooplankton abundance was at the lowermost station (5838-204143 ind. m^{-3}, x = 49173 ind. m^{-3}) in the estuary, whereas the lowest abundance was at the uppermost station (97-13438 ind. m^{-3}, x = 2399 ind. m^{-3}). Similarly, the highest zooplankton biomass estimations were

Table (1)- Abundance of zooplankton (average No. m^{-3}) in the Shatt Al-Arab estuary during the period July 1993-July 1995 (Numbers in parenthesis indicate overall percentages of total zooplankton).

	Station 1	Station 2	Station 3	Station 4	Station 5
Total Zooplankton	49173	38881	8178	3676	2399
Coelenterata	<1 (<1)	5 (<1)	<1 (<1)	-	-
Ctenophora	3 (<1)	<1 (<1)	5 (<1)	-	-
Annelida, larvae	1168 (2.4)	364 (<1)	-	16 (<1)	16 (<1)
Arthropoda, Crustacea	43477 (88.4)	35892(92.3)	7878 (96.3)	3558 (96.8)	2281 (95)
Cladocera	499 (1.1)	331 (<1)	273 (3.3)	1329 (36.2)	1388 (57.8)
Marine spp.	498 (1.1)	279 (<1)	3 (<1)	-	-
Freshwater spp.	1 (<1)	52 (<1)	270 (3.3)	1329 (36.2)	1388 (57.8)
Ostracoda	10 (<1)	2 (<1)	4 (<1)	6 (<1)	3 (<1)
Copepoda	42607 (86.6)	34911 (89.8)	6638 (81.2)	2004 (54.4)	639 (26.6)
Cirripedia, nauplii	129 (<1)	561 (1.4	946 (11.6)	193 (5.2)	233 (9.7)
Amphipoda	5 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)
Isopoda	42 (<1)	-	-	<1 (<1)	<1 (<1)
Decapoda	185 (<1)	87 (<1)	16 (<1)	25 (<1)	18 (<1)
Mollusca, larvae	1629 (3.3)	896 (2.3)	274 (3.4)	97 (2.6)	101 (4.2)
Gastropoda	312 (<1)	433 (1.1)	259 (3.2)	96 (2.6)	101 (4.2)
Bivalvia	1317 (2.7)	463 (1.2)	15 (<1)	1 (<1)	<1 (<1)
Chaetognatha	323 (<1)	102 (<1)	<1 (<1)	-	-
Echinodermata, larvae	169 (<1)	8 (<1)	-	-	-
Chordata	2387 (4.9)	1606 (4.1)	16 (<1)	-	-
Larvacea	2386 (4.9)	1606 (4.1)	16 (<1)	-	-
Thaliacea	1 (<1)	-	-	-	-
Fish eggs and larvae	17 (<1)	6 (<1)	3 (<1)	5 (<1)	1 (<1)

Table (2)- Some hydrographic parameters of the Shatt Al-Arab estuary during the period July 1993-July 1995.

Hydrographic Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Average for the study area
Water Temp. C						
Min.	-	-	-	-	-	12.4
Max.	-	-	-	-	-	30.0
Freshwater discharge(m^3sec^{-1})						
1993-1994* Min.	-	-	-	-	-	580
Max.	-	-	-	-	-	1863
Mean	-	-	-	-	-	1020
1994-1995** Min.	-	-	-	-	-	1258
Max.	-	-	-	-	-	2002
Mean	-	-	-	-	-	1576
Light Penetration (cm)						
Min.	10	10	5	5	5	-
Max.	200	110	100	80	80	
Mean	85.5	50.5	47.5	45.3	40.5	-
						-
Salinity ‰						
Min.	18.8	2.1	0.80	0.77	0.6	-
Max.	38.2	25.2	11.0	6.0	1.23	
Mean	25.5	13.5	4.07	1.36	0.96	-
						-
Chlorophyll-a ($mg\ m^{-3}$)						
Min.	1.6	1.6	0.50	0.50	0.5	-
Max.	10.7	9.2	11.1	11.7	11.7	
Mean	5.0	4.2	3.5	3.2	3.1	-
						-

*Al-Mahdi and Salman (1997)
** Al-Mansory (1996)

Table 3 : Zooplankton biomass at the sampling stations 1and 2 expressed as displacement volume ($ml\ m^{-3}$), wet weight ($mg\ m^{-3}$), dry weight ($mg\ m^{-3}$) and ash free dry weight ($mg\ m^{-3}$).

Date	Station 1				Station 2			
	Displ. vol. $ml\ m^{-3}$	Wet wt. $mg\ m^{-3}$	Dry wt. $mg\ m^{-3}$	Ash free wt. $mg\ m^{-3}$	Displ.vol. $ml\ m^{-3}$	Wet wt. $mg\ m^{-3}$	Dry wt. $mg\ m^{-3}$	Ash free wt. $mg\ m^{-3}$
8 -1993	1.46	975.6	134.7	54.7	0.21	110.5	28.6	8.4
9 -1993	0.28	225.2	42.2	18.2	0.08	36.4	5.0	3.3
10-1993	0.25	167.1	17.7	10.5	0.06	48.3	8.3	4.0
12-1993	0.48	289.7	56.7	27.8	0.23	164.0	17.5	11.4
2 -1994	0.97	1017.7	40.1	21.4	0.63	871.2	35.3	21.6
3 -1994	0.86	1286.2	51.5	34.8	--	--	--	--
4 -1994	3.49	2912.6	668.7	84.5	0.50	509.4	86.7	22.7
6 -1994	2.92	3251.5	551.9	134.0	0.42	406.2	103.3	26.4
7 -1994	1.25	947.3	190.0	39.9	0.25	139.3	17.6	7.9
8 -1994	5.65	4724.5	239.8	69.5	7.50	6545.0	686.8	225.4
10-1994	0.63	672.5	128.4	27.4	0.55	525.0	86.5	22.7
12-1994	0.62	483.3	37.3	19.0	0.48	537.2	54.8	9.9
1 -1995	0.13	197.9	15.7	--	0.38	331.3	48.9	13.8
2 -1995	0.91	1019.1	118.4	31.9	0.11	81.8	10.1	4.0
4 -1995	0.99	545.9	86.4	21.5	0.18	78.4	17.3	4.0
5 -1995	0.16	167.7	31.4	13.5	0.09	113.9	21.5	7.4
7 -1995	1.00	1073.5	74.8	35.5	0.15	201.0	30.9	7.1
Total	22.25	19957.3	2483.7	849.7	12.06	11698.9	1239.1	400.1
Mean	1.30	1173.9	146.1	49.8	0.75	668.6	77.4	25

occurred at the lowermost station in the estuary (Table **3**). Several researchers in other estuaries elsewhere exhibited a similar pattern of zooplankton abundance (Nair and Tranter, 1971; Rodriguez, 1975; Goswami and Selvakumar, 1977; Pace *et al.*, 1992; Laprise and Dodson, 1994).

The highest zooplankton abundance occurred at the lowermost station in the Shatt Al-Arab estuary was coincident with highest mean values of light penetration, salinity and chlorophyll-a recorded throughout the estuary (Table 2). Moreover, the lower reaches of the Shatt Al-Arab estuary represent a calm environment (Albadran *et al.*, 1995). Hence, higher salinities, reduce current velocities and increase transparencies at this part of the estuary may have resulted in increasing retention time, phytoplankton and high zooplankton abundance observed (Bakker, 1994; Bakker and Rijswijk, 1994).

The monthly changes in abundance of the total zooplankton in the study area (Fig. 2), showed two peaks: one during the summer (July-August) and the other during late winter (January-February). The former was annually distinct at all stations, while the later was variable. According to Day *et al.*, (1989) the temperature, salinity and food have been identified as important factors regulating zooplankton abundance in estuaries. The results however showed that the abundance of zooplankton in the Shatt Al-Arab estuary is varied mainly as a function of salinity, and secondly related to temperature and chlorophyll-a (Table 2). Similar result was obtained in other estuaries (Nair and Tranter, 1971; Goswami and Selvakumar, 1977; Laprise and Dodson, 1994).

As salinity in the Shatt Al-Arab estuary is inversely correlated with freshwater discharge, this discharge may have further effect in creating high current speed, particularly during flooding periods in the estuary (Al-Manssory, 1996). Thus, the annual variations of zooplankton abundance occurred in late winter peak of zooplankton, is considerably related with the annual variations observed in freshwater discharge (Table 2), as it was found in many estuaries (Tett, 1987), rather than with salinity alone. The late winter peak in stations 1 and 2 in February 1994 was coincident with low freshwater discharge in the year 1993-1994, whereas the peak along approximately the entire study area (stations 2 –5) in January 1995 was coincident with higher freshwater discharge reported in the year 1994-1995. Similar findings were noticed in the upper Shatt Al-Arab river (Salman *et al.*, 1986) and Tigris and Diayla rivers (Mangalo and Akbar, 1988; Sabri *et al.*, 1993).

As regarding the role of temperature upon the seasonal cycle of the zooplankton abundance in the study area, the situation of the Shatt Al-Arab

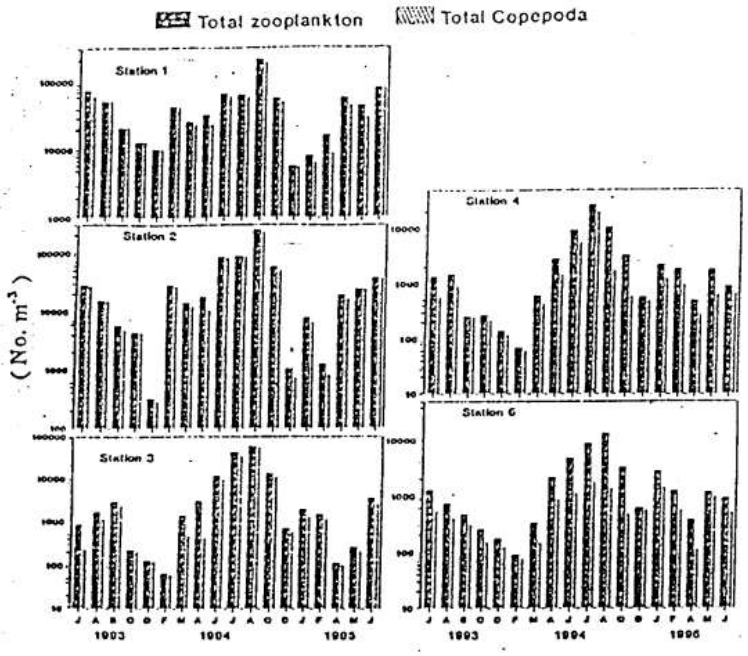

Fig. 2 : Seasonal variations in abundance of total zooplankton and total Copepoda (No. m^{-3} on a log scale) in the Shatt Al-Arab estuary during the period July 1993 - July 1995 .

Table 4 : Values of Correlation coefficient (r) and number of samples (n) for the relationship between the numerical abundances of total zooplankton (upper line) and total Copepoda (lower line) with water temperature , salinity and chlorophyll -a at the sampling stations. The significant values are underlined.

		Station 1	Station 2	Station 3	Station 4	Station 5
	n	r	r	r	r	r
Water temperature °C	18	0.5126 , P<0.05	0.4208	0.3923	0.3941	0.3800
	18	0.5173 , P<0.05	0.4141	0.3766	0.3237	0.3257
Salinity ‰	18	0.4785, P<0.05	0.6402, P<0.005	0.8262 , P<0.001	0.9430 , P<0.001	0.6203 , P<0.01
	18	0.4987 , P<0.05	0.6355 , P<0.005	0.8021 , P<0.001	0.9024 , P<0.001	0.3118
Chlorophyll -a mg m^{-3}	16	- 0.1410	- 0.2510	0.4842	0.4612	0.6009 , P<0.02
	16	- 0.1569	- 0.2466	0.4679	0.3872	0.4219

estuary is apparently different from those of the temperate and tropical estuaries (Madhupratab and Haridas, 1975; Rao, 1977; Day *et al.*, 1989) .

Estuarine zooplankton abundance, on the other hand, often don't follow phytoplankton standing crop (Qasim, 1977) where the ready availability of a variety of organic detritus in estuaries makes the potential food resources available even greater. This may be true also for the Shatt Al-Arab estuary, however at station 5 the abundance of total zooplankton rather than copepods showed a higher correlation with chlorophyll-a (Table 4). This may be due to the predominance of freshwater cladocera at this station in contrast with copepods at other stations. Similarly, Mangalo and Akbar (1988) found that cladoceran density was in the river Diayla affected by chlorophyll-a. Consequently, the pattern of seasonal variations of total zooplankton in the study area was almost the result of those obtained for copepods, but this situation was slightly altered at station 5 (Fig. 2).

Hence, it may be concluded that the seasonal cycle of numerical abundance of zooplankton in the Shatt Al-Arab estuary is governed by salinity and freshwater discharge, and to lesser extent by temperature and chlorophyll-a.

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توزيع ووفرة الهائمات الحيوانية في مصب شط العرب شمال غرب الخليج العربي

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الخلاصـــــــة

جمعت عينات الهائمات الحيوانية شهريا" من مصب شط العرب شـــمال غـــرب الخليـــج العربي خلال الفترة من تموز 1993 ولغاية تموز 1995 . جمعت العينات باستخدام شـبكة هائمات قطر فتحاتها 90 مايكرون من خمسة محطات. قسمت الـــهائمات الحيوانيـــة فـــي منطقة الدراسة الى ثلاث تجمعات حياتية مميزة. الهائمات الحيوانية في المحطـــــة اســـفل مصب شط العرب، شكلت تجمع مصبي–ساحلي تألفت مـــن المجموعـــات Copepoda (87%)، Larvacea (5%)، Mollusca (3%)، larvae of Annelida (2%)، marine Cladocera (1%). وعلى العكس منه، كان هناك تجمع لهائمات مياه عذبة في المحطـــــة اعلى المصب تكونت من المجموعـــات freshwater Cladocera (58%)، Copepoda (27%)، nauplii of Cirripedia (10%)، larvae of Mollusca (4%). أمـــا فـــي المحطات وسط المصب، فقد وجد تجمعا" خليطا" من هائمات المصـــب الحقيقيـــة. كـــانت الوفرة العددية للهائمات الحيوانية تزداد باتجاه اسفل المصب نحو الخليج العربي. ســـجلت أعلى وفرة عددية للهائمات الحيوانية في المحطة اسفل المصب وتراوحت الأعـــداد بيـــن 5838 – 208143 فرد / م^3 بينمـــا سجلت أوطأ وفرة عددية في المحطة أعلى المصـــب وتراوحت الأعداد بين 97–13438 فرد / م^3. وجدت زيادتين فصليتين في وفرة الـــهائمات الحيوانية في جميع محطات الدراسة، الأولى خلال الصيف (تموز– آب) والثانيـــة خـــلال أواخر الشتاء (كانون الثاني– شباط). الوفرة العددية للهائمات الحيوانية في منطقة الدراســة كانت مرتبطة مع الملوحة وتصريف المياه ولدرجة اقل مع حرارة المياه والكلوروفيـــل– أ.