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SESTON AND SEDIMENT* CARBOHYDRATES IN LAKE BUROLLUS, EGYPT.

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ABSTRACT

Lake Burollus has levels of seston ranging between 14.9 and 849.0 mg dm^{-3} dry weight. Concentrations of particulate organic carbon were found to be 2.3 and 126.9 mg dm^{-3}. The relationship between seston and particulate organic carbon is highly significant. Also, particulate carbohydrate (insoluble) is significant with particulate organic carbon and seston. Carbohydrate fluctuated from 0.117 to 5.52 mg dm^{-3}. Sediment carbohydrate appears to be largely dependent on variations in the nature of the organic matter input. A high correlation is found between particulate carbohydrate and total carbohydrate. The carbohydrate values range between 5.78 and 23.14 mg g-1. A high correlation was also recorded between inorganic carbon and calcium carbonate. No correlation between seston carbohydrate and sediment carbohydrate was observed.

INTRODUCTION

Lake Burollus has been a subject of many investigations particularly during the last two decades (Anon., 1980 and Moussa, 1984). Lake Burollus is about 120,000 feddans, it receives water from two sources: fresh water through six main land drains beside one fresh water canal (Brimbal), and Mediterranean sea water through Al-Boughaz. The distribution of seston in the Lake is affected by a number of parameters; phytoplankton and zooplankton communities, resuspended bottom sediment (often contains biogenous compounds), in addition to autochthonous, and allochthonous organic matter discharged from drains into the Lake. The Lake is of shallow water and varies in depth between 40 and 210 cm. The sediments are composed of matrix of sand, silt and clay. Calcaraeous shells are mainly represented by **Cardium** spp.; **Venus** spp. and others. The calcareous shells tend to increase westwards. Lake Burollus harbours macrophytes spread near islets.

Interaction between sediments and organisms are important to the trophic level of sedimentary ecosystem. The sediment plays an important role in the nutrition of aquatic organisms (El-Sarraf and Olah, 1982). Generally, seston is considered as a good diet for Tilapia and other fish species (El-Sarraf, 1976 and Bowen, 1982).

A major portion of the organic matter is deposited mainly from discharging of fresh water drains as original terrigenous organic matter, allochthonous and autochthonous sources through the decomposition of aquatic organisms inside the Lake (Fig. 1). Free and combined sugars consitute a large fraction of aquatic organisms (up to 80 % in macrophytes) and 15 to 90 % of the photoassimilated is released as carbohydrates by algae during growth periods (Hellebust, 1974). Even at low concentrations of carbohydreates, the heterotrophic bacteria are responsible for consumption of carbohydrate (Wright and Hobbie, 1966 and Meyer-Reil, 1981).

The present work deals with the distribution of soluble and combined carbohydrates in sediments, and particulate carbohydrates of seston.

MATERIAL AND METHODS

Nineteen stations were chosen at the Lake Burollus, their positions as are shown in Fig. 1. The samples were collected in February, 1988, a time not related with a phytoplankton bloom. The stations are divided into 4 sections.

Sampling:

1- Duplicate aliquots 1000 ml were filtered through Whatman CF/C filters (Previously combusted at 550^{o}C). Seston was measured by the phenol-sulphuric acid method of Dubois et al. (1956). The dry seston was placed in capped tube, ground with 1 ml of distilled water, 1 ml of 5 % phenol was added, the sample shaken vigorously immediately, and 5 ml of concentrated sulphuric acid were added directly and rapidly onto the surface of the liquid sample to improve mixing. The tube was allowed to stand for 15 min., shaken and incubated in water bath in 60 ^{o}C for 20 min. and then centrifuged at 2600 rpm for 30 min. to eliminate glass fibres. The supernatants were transferred into 1 cm path length cuvettes and their absorbances were measured at 485 nm with Shimadzu Double Beam Spectrophotometer UV - 150 - 02. Control blanks were treated by CF/C filters applying the procedure described above (Pick, 1987).

2- Surface sediment samples were collected by means of a modified Ekman bottom sampler. The samples were spread on glass plates and disaggregated with a spatula to remove large shells. The samples were then dried at 70^{o}C in an electric oven. The dried samples were crushed in a mortar to a fine powder 63 um and stored dry in desiccator for analytical use. Total organic carbon and total inorganic carbon were determined by combusion in a muffel furance at 550 and 1100^{o}C, respectivelly.

Each sample 5 to 10 mg was agitated with 7 ml of double distilled water at 100^{o} C for 20 min. (Compiano and Romano, 1988). Thereafter it was centrifuged at 4000-5000 rpm for 30 min. 1 ml of the supernant (soluble fraction) and the dried residue (insoluble fraction) were treated by the

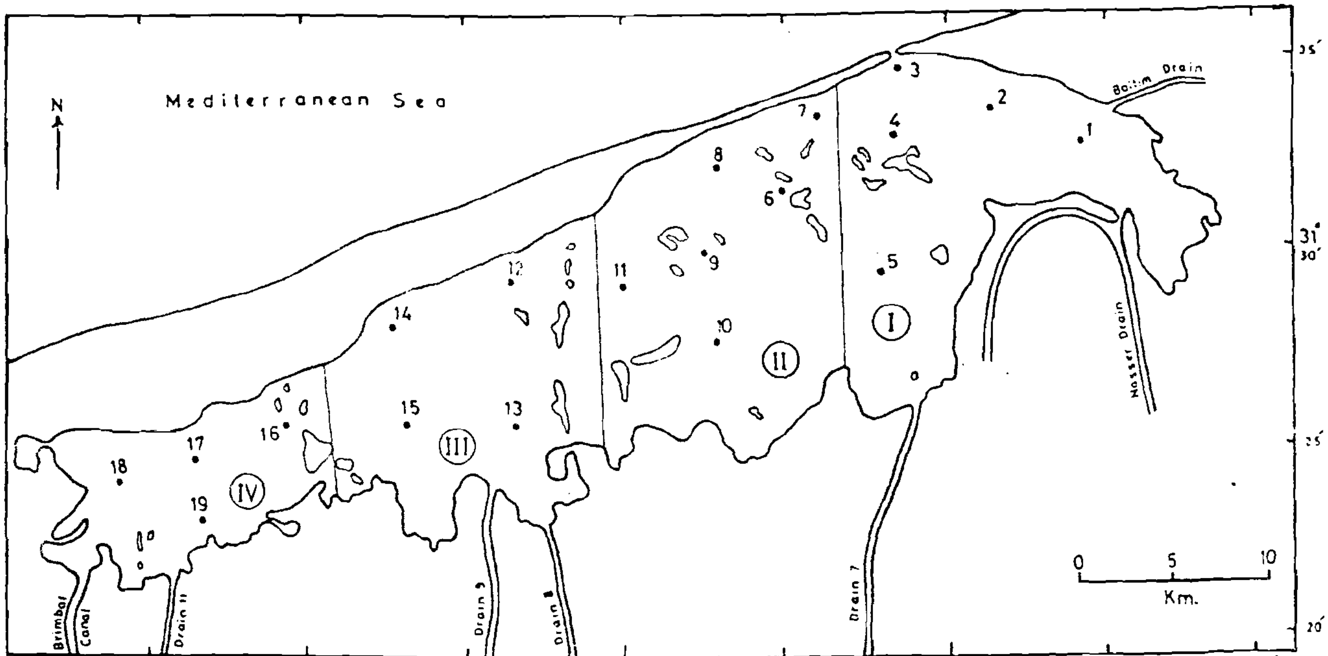

Fig. 1
Sampling locations for suspended particulate matter (seston) and sediment

phenol-sulphuric acid method described by Dubois et al. (1956) as improved by Gerchakov and Hatcher (1972) with spectrophotometer at 485 nm.

Total carbohydrates were estimated for soluble carbohydrate and particulate carbohydrates. The results were expressed in terms of glucose equivalent obtained from a series of glucose standards.

RESULTS AND DISCUSSION

Seston Carbohydrate:

Seston levels are presented in Table 1 (14.9 - 849.0 mg dm^{-3} dry weight), with a mean value of 160.8 mg dm^{-3}. The particulate organic carbon (POC) concentration ranged between 2.3 and 126.9 mg dm^{-3} with an average of 28.0 mg dm^{-3} which comprises 5.2 to 37.1 % of the seston. The horizontal distribution of POC is similar to that of seston. Concentrations of particulate carbohydrate ranged between 0.117 and 5.52 mg dm^{-3} with mean of 2.269 mg dm^{-3}, i.e. 3.9 and 54.4 % of the particulate organic matter.

Seston levels in Lake Burollus were high in sections I and III, the highest seston value was recorded at station 7. This station is shallow, the bottom sediments are silty-clay and covered by emergent macrophytes as Potamogeton pectinatus L. High seston values reveal a concentration of detritus, clay, phytoplankton, and remains of macrophytes. The lowest seston values were observed in station 8, the seston in this station is composed of low concentration of detritus and phytoplankton (Table 1). Seston values are regarded as an indicator of the degree of eutrophication. The seston seems to be affected by incoming waters from drains and wind direction.

Horizontal concentration of particulate organic carbon was made to determine the main cell components of living and nonliving plankton. The increase in POC seems to be a good indicator of allochthonous organic matter that was loaded by chlorinated hydrocarbons. The Lake water contains between 144 and 1421 x 10^{-6} ppm (Beltagy, 1985). Breakdown of macrophytes increases the particulate organic matter (POM). Naiman and Sedell (1979) found that, the highest organic seston was transported during winter in low order Streams in Oregon. The dramatic decrease in level of seston from station 7; 849.0 mg dm^{-3} to 14.9 and 15.7 mg dm^{-3} at stations 8 and 18 respectively, may be an indication of POM settling. Also, this may be attributed to the suspended particulate matter gradients as the result of the near inlet's and shores of the Lake. The distribution of particulate organic carbon follows the same pattern of seston (Table 1). High levels of POC were found in sections I and II, with the highest concentration at station 7 (126.9 mg C dm^{-3}). Concentration gradients decreased toward the western part of the Lake. The high levels of POC indicate that seston contains high concentration from detritus of

Table 1
Seston, particulate organic carbon and particulate carbohydrate in Lake Burollus mg dm^{-3}.

Station		Seston	POC	POC/seston %	Carbohydrate+	Carbohydrate/POC %
Section I						
station	1	219.0	39.1	17.9	2.40	6.1
	2	349.9	44.1	12.6	2.94	6.7
	3	129.7	13.4	10.3	1.65	12.3
	4	491.9	83.1	16.9	3.73	4.5
	5	49.7	12.7	25.0	0.823	6.5
Section II						
station	6	25.9	2.3	8.7	0.153	6.7
	7	849.0	126.9	15.0	5.52	4.4
	8	14.9	3.0	20.4	0.117	3.9
	9	54.0	6.7	12.3	0.471	7.0
	10	20.8	N.D.	N.D.	N.D.	N.D.
	11	174.0	23.2	13.4	3.84	16.6
Section III						
station	12	269.2	61.8	23.0	2.69	4.4
	13	64.0	16.0	24.9	3.25	20.3
	14	97.9	6.5	6.6	3.44	52.9
	15	123.3	6.4	5.2	3.48	54.4
Section IV						
station	16	64.7	24.0	37.1	2.77	11.5
	17	17.1	3.6	20.7	0.788	21.9
	18	15.7	N.D.	N.D.	N.D.	N.D.
	19	25.0	2.6	10.2	0.507	19.5
Range		14.9 - 849.0	2.3 - 126.9	5.2 - 37.1	0.117 - 5.52	3.9 - 54.4
Mean		160.8	28.0	16.5	2.269	15.3

+ : Average of two determinations
N.D. : Not detected

macrophytes. The average values of carbohydrate of aquatic plants are 53.39 to 71.74 % of dry weight (El-Sarraf, 1976). The ratio of POC/seston ranges from 5.2 % at station 15 to 37.1 at station 16 with a mean value of 16.5 %. Although, the ratios increase sharply in westward direction the highest correlation coefficient between seston and particulate organic carbon is P> 0.001 (r = 0.79).

The levels of particulate carbohydrate vary from 0.117 to 5.52 mg dm^{-3} and account for up to 54 % of seston. The horizontal distribution of seston carbohydrate is characterized by increase from western section to the central Lake, and there is a slight decrease toward the eastern section. In the eastern section the values increase northwards (Fig. 2).

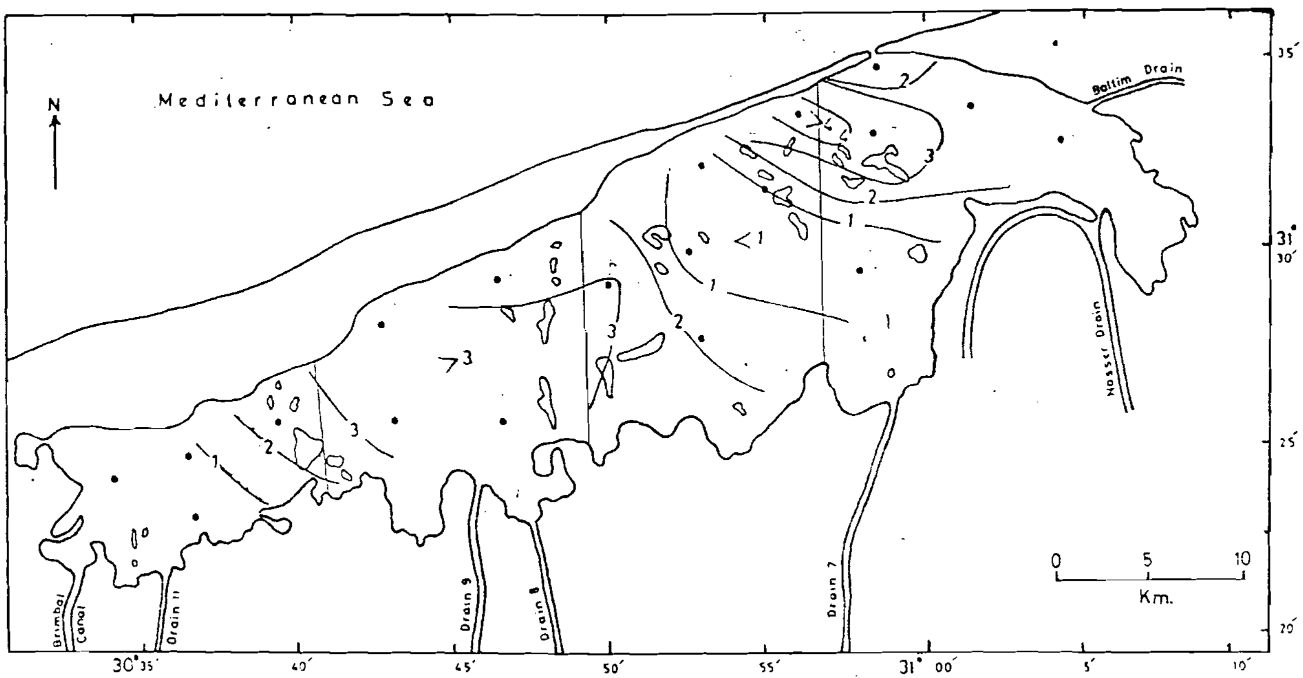

Fig. 2
Horizontal distribution of seston carbohydrate
(mg dm^{-3})

The particulate carbohydreate shows significant positive correlation with seston, $P' < 0.001$ ($r = 0.74$), and the correlation between particulate carbohydrate and POC is $P < 0.001$ ($r = 0.71$). De Haan and De Boer (1979) recorded that the high values of carbohydrates in winter are sometime more than 50 mg dm^{-3}. The ratio of carbohydrate and POC increases sharply from eastern to western parts. Daumas and Laborde (1976) mentioned that particulate carbohydrate ranged from 4 to 7 mg dm^{-3} in polluted zone and 0.221 to 0.41 mg dm^{-3} in nonpolluted zone respectively. The production of carbohydrate from seston as a function of environmental conditions is, therefore, important to indicate the pollution of waters. Liebezeit et al. (1980) found that,

seston concentration, ranges from 0.42 to 0.13 mg dm^{-3} and particulate carbohydrate varied between 0.25 and 0.132 mg dm^{-3} in Sargasso Sea.

Sediment Carbohydrate:

The nature of bottom sediments depends on the proportions of sand, silt and clay. Al-Boughaz region contains sand fraction and very low amount of finer particles. The sediments contain remains of macrophytes and calcareous shells (**Cardium** sp., **Venus** sp, and other broken shells).

Total organic carbon (TOC) ranged between 16.1 and 53.4 mg g^{-1} with a mean of 33.9 mg g^{-1}. The major part of organic carbon in the Lake sediments is due to autochthonous organic carbon (plankton and remains of macrophytes), and allochthonous organic carbon (introduced from drains and Al-Boughaz). Moussa (1984) found that the organic carbon ranged between 0.8 and 8.3 % with a mean of 2.5 ± 0.6 %. The higher values of TOC were recorded in the eastern section. Organic matter content of the sediment varies between 1 and 2 % (Anon., 1980). The organic carbon in the seston is higher than that in the sediment by 4.88 folds. The enrichment in organic matter of sediment is probably enhanced by polychlorinated biphenyl (El-Sarraf, in preparation).

Carbohydrate content is shown in Table 2. It was observed that slouble carbohydrate in sediments fluctuated from 0.28 to 2.75 mg g^{-1} and comprises 1.4 and 5.2 % of the total organic carbon with a mean value 1.05 mg g^{-1}. The concentration of particulate carbohydrate varied from 5.5 to 21.04 mg g^{-1} with a mean value of 10.05 mg g^{-1} and accounted for about 58 % of the total organic carbon. The concentration of total carbohydrate varied from 5.78 to 23.14 mg g^{-1} with a mean value of 11.09 mg g^{-1}, i.e. from 13.8 to 64.7 % of total organic carbon. Sediment carbohydrate shows a slight decrease in concentration from western section to the center Lake (intermediate values), and a tendency to increase in eastern section, (Fig. 3). The ratio of insoluble to soluble carbohydrates, decreased westwards with increasing total organic carbon. Each of the carbohydrate types shows significant positive correlation P

Table 2

Carbohydrate content of Lake Burollus in relation to total organic carbon (TOC), inorganic carbon (IOC) and calcium carbonate ($CaCO_3$) mg g^{-1}.

Stations		Insoluble carb.	Soluble carb.	Total + carb.	I/S carb.	TOC	T.carb./TOC %	IOC	TOC/IOC	$CaCO_3$	$CaCO_3$ %
Section I											
station	1	9.611	0.664	10.278	14.4	38.2	26.9	119.9	0.32	272.5	27.3
	2	8.659	0.460	9.119	18.8	26.9	33.9	98.8	0.27	224.5	22.5
	3	6.429	0.289	6.718	22.3	21.8	30.8	57.7	0.38	131.1	13.1
	4	20.568	2.059	22.627	10.0	49.4	45.8	119.2	0.41	270.9	27.1
	5	7.769	0.602	8.371	12.9	26.9	31.1	94.6	0.28	215.0	21.5
Section II											
station	6	7.200	0.509	7.709	14.2	33.4	23.1	139.9	0.24	318.0	31.8
	7	12.245	1.357	13.602	9.0	37.6	36.2	131.7	0.29	299.3	29.9
	8	11.527	1.206	12.733	9.6	39.8	32.0	181.3	0.22	412.0	41.2
	9	9.861	1.042	10.903	9.5	32.1	34.0	148.8	0.22	338.2	33.8
	10	7.291	0.919	8.210	7.9	27.0	30.4	167.5	0.16	380.6	38.1
	11	10.579	1.213	11.792	8.7	21.5	54.9	189.5	0.11	430.6	43.1
Section III											
station	12	10.100	1.090	11.190	9.3	17.3	64.7	62.3	0.28	141.6	14.2
	13	9.054	0.820	9.874	10.0	28.8	34.3	121.1	0.24	275.2	27.5
	14	5.500	0.280	5.780	19.6	20.0	20.1	144.5	0.14	328.4	32.8
	15	9.094	0.781	9.875	11.6	16.1	61.3	138.2	0.12	314.0	31.4
Section IV											
station	16	6.503	0.760	7.263	8.6	52.5	13.8	77.2	0.68	175.4	71.5
	17	6.580	0.970	7.550	6.8	52.0	14.5	235.9	0.22	536.2	53.6
	18	11.242	2.745	13.987	4.1	53.4	26.2	136.1	0.39	309.4	30.9
	19	21.040	2.098	23.138	10.0	49.30	47.0	101.5	0.21	230.6	23.1
Range		5.5-21.04	0.28-2.75	5.78-23.14	4.1-22.3	16.1-53.4	13.8-64.7	57.7-235.9	0.11-0.68	131.1-536.2	13.1-53.6
Mean		10.05	1.05	11.09	11.4	33.9	34.8	129.8	0.27	294.9	29.5

Carbohydrate = Carb.

+ = Average of two determination.

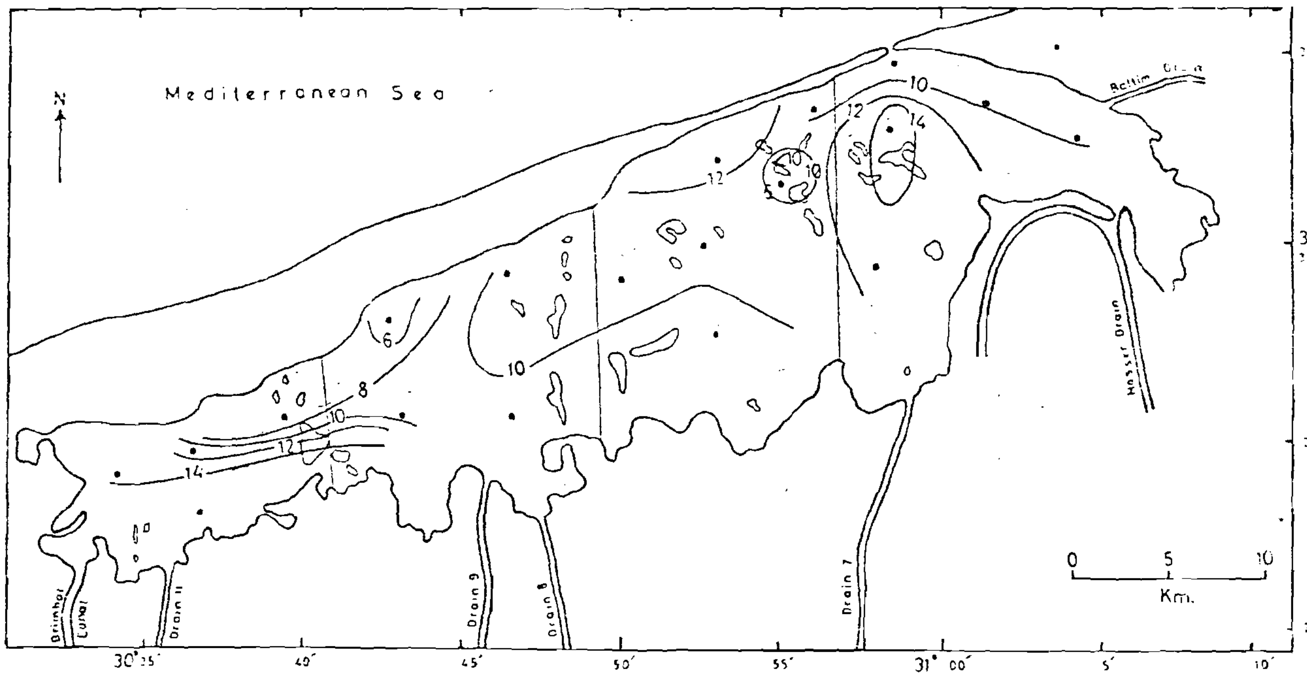

Fig. 3
Horizontal distribution of sediment carbohydrate
(mg g^{-3})

> 0.001 ($r = 0.76$ and 0.996) with each other. The significant correlation between soluble carbohydrate and total organic carbon is $P > 0.01$ ($r = 0.61$), while the correlation between particulate and total organic carbon is $P < 0.05$ ($r = 0.43$). The total carbohydrate and total organic carbon significant correlation is $P > 0.05$ ($r = 0.47$). The increased percentage of carbohydrate with the total organic carbon indicates that the organic enrichment of the sediments from suspended particulate matter may be attributed to the presence of detritus of macrophytes. Generally, the soluble carbohydrate content was low in sediment throughout the Lake except for few stations. The soluble carbohydrates are usually associated with fresh material and insoluble form with more evolved material (Handa et al., 1972). It may be also related to microbial activity in sediment. The variation in relative concentration of all types of carbohydrates increased and/or decreased according to organic matter content. Both are dependent upon wind direction, or the slower rate of precipitation of organic matter or resuspension of the material from the bottom sediments. Sediments of relatively higher carbonate content, produce lower concentration of carbohydrate. This phenomenon agrees with Compiano and Romano (1988), who found that incomplete hydrolysis of the carbohydrates occurs in the presence of large amounts of carbonate and as a result poor glucose recovery. The percent carbohydrate of total organic carbon decreases in stations 16 and 17. This may be attributed to change in the direction of reducing to oxidizing processes. Beltagy (1985), mentioned that Lake water is always rich in oxygen, which reflects high oxidation rate of organic matter of the sediments.

Inorganic carbon ranged between 57.7 and 235.9 mg g^{-1} with a mean value 129.8 mg g^{-1}, also calcium carbonate fluctuated from 131.1 to 536.2 mg g^{-1} (average 294.9 mg g^{-1}). The higher content of carbonate in sediments, is related to shell fragments. Moussa (1984) suggested that the carbonate distribution is affected by the flow of shells and their movements over the bottom. Higher coefficient between inorganic carbon and calcium carbonate was found $P \sim 0.001$ ($r = 0.99$). The absence of significant relationships between types of carbohydrates and organic carbon with inorganic carbon and calcium carbonate is also observed. Significant correlation between seston and sediments is not found. This may be attributed to the fact that the rate of precipitation is very low beside the action of wind and allochthonous terrigenous matter.

Taking into account these results, it can be concluded that, the results presented in this work give primary information about the carbohydrate in Lake Burollus.

1. Burollus is characterized by turbid water. This turbidity is probably caused by high level of productivity resulting from the mixing of nutrient with suspended sediments derived from bottom by the wind action and discharge from Al-Boughaz and land drains.

2. The distribution of seston appears to follow the whole pattern of water circulation and can be correlated with variation in the discharge of drains, terrestrially derived suspended matter (allohthonous), variation in productivity and transport seston by wind action.

3. The seston carbohydrates show significant relationship between each other and organic carbon. The horizontal variation has been attributed to productivity of the water and this, in fact, is definitely related to a major terrigenous source or macrophytes or both as revealed by the high percentage of sediment carbohydrate of total organic carbon.

4. Dissolved carbohydrate may be originated in situ as a result of plankton and detritus. Particulate carbohydrate, which is most abundant, is more affected by enzymes (microbial degradation).

5. Lack of correlation between organic and inorganic sources.

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