ANNUAL REPORT

SEPTEMBER 74 – SEPTEMBER 75

STUDIES ON THE TOXIC ELEMENTS AND ORGANIC DEGRADATION PRODUCTS IN AQUATIC BODIES AND SEDIMENTS AROUND KENNEDY SPACE CENTER (K S C) HAULOVER CANAL AND MOSQUITO LAGOON

NASA RESEARCH GRANT NO. NSG – 803

JOHN F. KENNEDY SPACE CENTER, FLORIDA

SUBMITTED BY

SAVANNAH STATE COLLEGE

SAVANNAH, GEORGIA

– – – – – – – – – – –

PRINCIPAL INVESTIGATOR

G. S. GHUMAN

PROFESSOR OF EARTH SCIENCES

CO–INVESTIGATORS

M. P. MENON

PROFESSOR OF CHEMISTRY

C. OBI. EMEH

ASSISTANT PROFESSOR OF BIOLOGY

DECEMBER 1975

ANNUAL REPORT

SEPTEMBER 74 - SEPTEMBER 75

STUDIES ON THE TOXIC ELEMENTS AND ORGANIC DEGRADATION PRODUCTS IN AQUATIC BODIES AND SEDIMENTS AROUND KENNEDY SPACE CENTER (KSC)

HAULOVER CANAL AND MOSQUITO LAGOON

NASA RESEARCH GRANT NO. NSG - 803
JOHN F. KENNEDY SPACE CENTER, FLORIDA

SUBMITTED BY
SAVANNAH STATE COLLEGE
SAVANNAH, GEORGIA

\- - - - - - -

PRINCIPAL INVESTIGATOR
G. S. GHUMAN
PROFESSOR OF EARTH SCIENCES

CO-INVESTIGATORS
M. P. MENON
PROFESSOR OF CHEMISTRY
C. OBI EMEH
ASSISTANT PROFESSOR OF BIOLOGY

DECEMBER 1975

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE OF CONTENTS

FIELD SAMPLING PROCEDURES

METHODS OF WATER ANALYSIS

Analysis of Major Constituents

METHODS OF SEDIMENT ANALYSIS

STUDY OF MICROORGANISMS

RESULTS AND DISCUSSIONS

EVALUATION OF RESULTS AND CONCLUSIONS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

This progress report is a compilation of work accomplished on the NASA/KSC grant during the first year ending September, 1975. Our studies are designed to cover Indian River, Haulover Canal, Mosquito Lagoon, and other aquatic areas of discharge around Kennedy Space Center (KSC) over a three-year period. The first-year report includes presentation and interpretation of data on water and sediment samples collected from Haulover Canal and Mosquito Lagoon.

The overall objectives of this study are three fold: (1) to establish and improve the laboratory procedures for research work in the estuarine environment; (2) to determine the physical, chemical, and biological characteristics with special reference to toxic elements of the water bodies around KSC and (3) to provide experience of scientific work to the Earth Science, Chemistry, and Biology students through their involvement in the project. These objectives are befitting the qualifications and interests of the investigators and are being achieved in a satisfactory manner. Laboratory work has been considerably improved since the inception of the project. Through the auspices of this grant up till now 8 students got the opportunity to work for varying periods of time and they learnt the technical skills.

In the implementation of analytical work, most of the stated estimations of major and trace elements have been carried out. The determinations of Hg, Pb, As, and Ni could not be made partly due to lack of proper equipment and partly due to limitation of time in view of the magnitude of the project work. However, in the ensuing period an attempt will be made to assess these elements in the stored sediments. Microbial studies using the pyrolysis-gas-liquid chromatography will also be pursued as the gas chromatograph has been received recently.

In the present report, the field and laboratory data are presented and tentative conclusions have been drawn in the discussion of various aspects of the study. An attempt has been made to correlate the physical, chemical, and biological parameters of the investigation. Although every effort has been made to improve the quality of this report, yet the investigators are aware of their limitations and the shortcomings that may be apparent. Future efforts will be continued to further improve upon this work.

FIELD SAMPLING PROCEDURE

For the collection of study samples in the first year, five trips were made to KSC on December 21, 1974; March 8, 75; May 10, 75; July 26, 75; and September 21, 1975. The study area extended over a distance of 16 Km from the eastern end of Haulover Canal through the Mosquito Lagoon to the North boundary of KSC near the village Oak Hill. The sampling sites were selected near the flag posts along the Intracoastal water way. As shown in Fig. 1 two sampling sites (1H & 2H) were selected in the Haulover Canal and seven sites (1L to 7L) were selected in the Mosquito Lagoon. Approximate geographic locations of the sampling sites are given as follows:

Sample #	Field Site	Location	
		Latitude	Longitude
1-H	West of bridge	28° 44'N;	80° 45'.5W
2-H	East of bridge	28 44.5N;	80 45W
1-L	Post 43	28 44.7N;	80 44.6W
2-L	Post 37	28 45.4N;	80 45.8W
3-L	Post 31	28 47 N;	80 46.4W
4-L	Post 25	28 48.5N;	80 47.4W
5-L	Post 19	28 50 N;	80 49.3W
6-L	Post 13A	28 51.5N;	80 49.2W
7-L	Post 10	28 52 N;	80 49.8W

The samples were collected by using a rented boat arranged by Mr. E. E. Perkins, NASA Technical Officer. On each of the 5 trips except the first one both the water and sediment samples were collected.

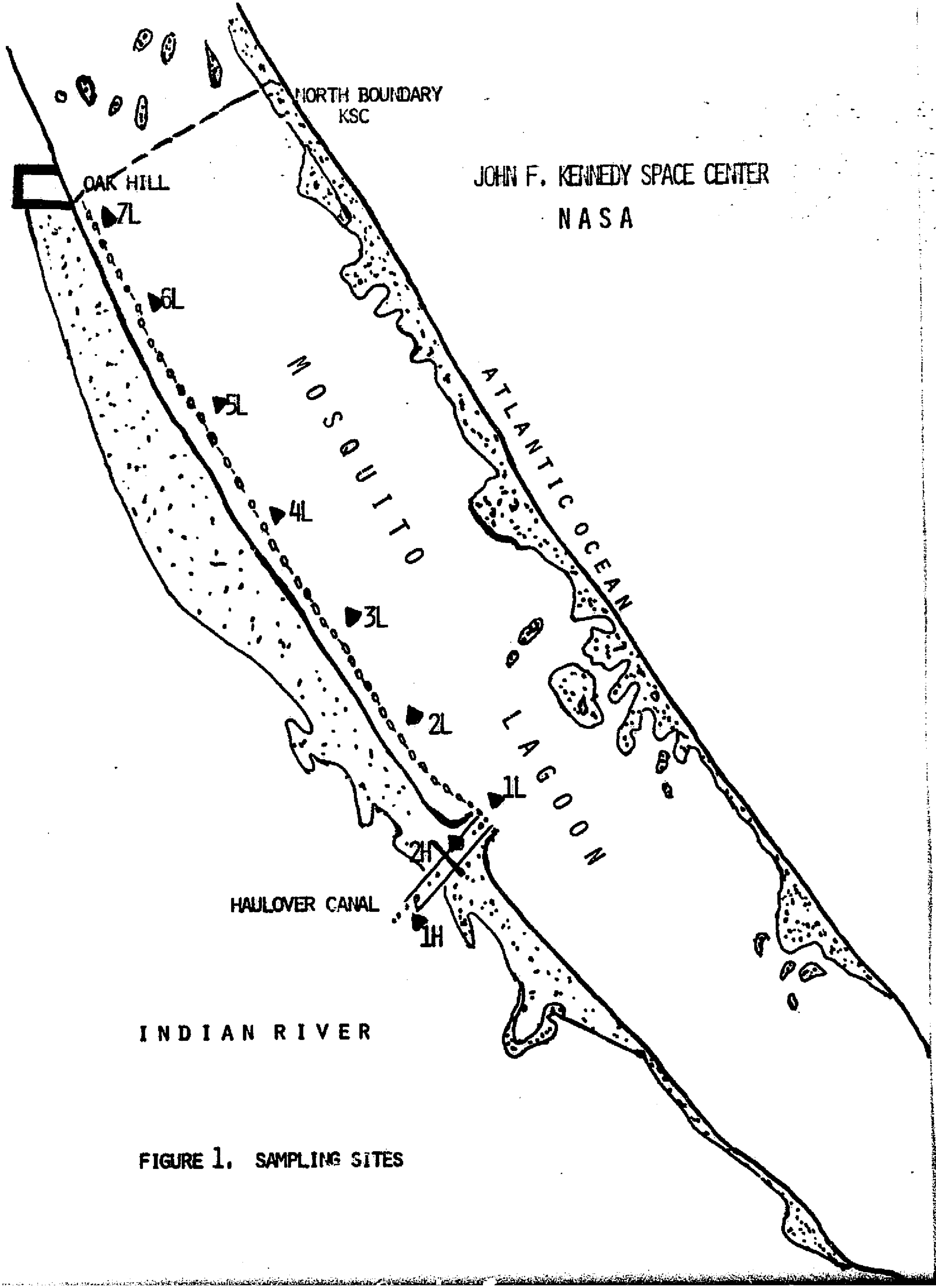

FIGURE 1. SAMPLING SITES

During the first trip only the water samples were collected since the core-sampler for the sediment collection was not available.

Collection of Water Samples. At each site water sampling Alpha Bottle was lowered from the boat to the proper depth of one or two meters and then its ends were closed by dropping a messenger weight along the rope. For the fifth collection a Sewage-Sampler was used for this purpose and it was found more convenient and efficient as compared to the sampling bottle. Four sample containers (3 polyethylene bottles and one glass bottle) making up a total volume of about three liters were filled with water for various types of analyses to be performed later in the laboratory. One ml of dilute sulfuric acid was added to each of the glass bottles for stopping the activity of micro-organisms and preserving the real status of inorganic nitrogen in the water at the time of sampling.

Collection of Sediment Samples. For the collection of sediment samples, the core-sampler lined with polyethylene tube was pushed at the water bottom into the sediment layers. The lowermost 50 cm section of the sampler was filled with the sediment column and was mechanically pulled up while sitting in the boat. The 50 cm soil core was split into Top and Bottom samples and transferred separately into the polyethylene bags. In some cases only the Composite samples could be collected. The sediment bags were immediately closed tightly and then were frozen by storing into dry ice provided by Mr. Perkins from the NASA laboratory in an insulating container of polystyrene.

Field Observations. At each sampling site, with the help of portable models of pH meter and salinity meter, the pH value, salinity and conductivity of water were recorded. Water temperature was also recorded by using a thermometer. The samples were then brought to Savannah State College.

On returning to Savannah, the sediment samples were stored into the freezer and the water samples for nitrogen analyses and microbial studies were stored into the refrigerator at 4°C until the time of analysis.

METHODS OF WATER ANALYSIS

Analysis of Major Constituents. The total dissolved solids (salts) in water samples were estimated by drying 25 ml volume of each sample in a pre-weighed porcelain dish placed into a forced air-oven. The oven was maintained at about 40°C and the drying was completed by raising the temperature to 105°C for one hour. The samples were cooled in a desiccator before final weighning.

The chloride content was determined by argento-metric method using potassium chromate as the indicator (1). The sulfate concentration was measured by turbidimetric method using a glycerol-HCl-ethyl alcohol as the conditioning reagent before precipitation with barium chloride (1). The turbidity of $BaSO_4$ suspension was measured in a Bausch& Lomb Spectronic 20 Colorimeter at a setting of 420 mu.

The bicarbonate was determined by a simple titration method using 0.12 N HCl as the titrant and methyl red as the indicator.

The major cationic elements of Ca, Mg, Na, and K were determined by atomic absorption technique after proper dilution of the original samples to the levels where these elements could be measured with precision. For each element the standard conditions as recommended by Perkin-Elmer Corporation in their manual were employed.

Analysis of Trace Elements. Determinations of six trace elements namely Fe, Mn, Cr, Zn, Cd, and Cu were made in the original water samples by the atomic absorption technique. Lead was also measured in some samples, but the values seemed doubtful and are not reported. It was found that zinc, manganese, cadmium and possibly Fe & Cr can be measured in the original sample with reasonable precision.

It was also found that pre-concentration of the original estuarine samples for increasing the trace element levels within the detection limits is not helpful. Due to high salinity of these water samples, some salts upon evaporation begin to precipitate. It is now clear that for the estimation of trace elements such as Pb, Cu, and Ni the extraction with organic solvents is necessary. For these lengthy procedures and other practical reasons stated earlier, all the intended elements could not be measured. The sensitivities of iron, chromium, zinc, cadmium and lead at 1% absorption as reported by Perkin-Elmer Corporation are .12, .10, .018, .025, and .50 ug/ml respectively. The accuracy of data on trace elements included in this report will be further confirmed as the work on this project is continued.

Measurement of Chemical Oxygen Demand (COD). The procedure employed for the estimation of COD in water samples of high salinity was taken from the U.S. EPA Manual (2). The method is based on the oxidation of organic acids and oxidizable inorganic substances in water by potassium dichromate solution containing 50% by volume of H_2SO_4 and back titration of the un-used dichromate with standard ferrous ammonium sulfate. Chlorides, the most common interference are quantitatively oxidized by dichromate in acid solution with 1 ppm of chloride as Cl^- exerting the equivalent of 0.226 ppm COD. Chloride correction factors have to be applied for the interference in this estimation. The COD measurement was made in the 1st and 2nd collection of water samples. The resulting values are as follows:

COD values in Water Samples

Sample #	1H	2H	1L	2L	3L	4L	5L	6L	7L
1st Coll.	-	136	369	456	278	341	130	70	108
2nd Coll.	29	-0-	173	-0-	110	120	-0-	38	62

It is apparent these values are inconsistent and thus cannot be relied upon.

As a general rule COD cannot be accurately be measured at the present time in samples containing more than 2000 ppm Cl^- (3). Thus small amounts of organic matter cannot be reliably measured in presence of high chloride content such as encountered in estuarine waters. Our samples contain 16000 to 25000 parts per million of chloride. In view of this interference problem, the estimations of COD were discontinued pending the refinement of method.

Determination of Inorganic Nitrogen (NH_4-N and NO_3-N). Steam distillation method reported by Bremner and Keeney (4) was used for the determination of ammonium and nitrate nitrogen (NH_4-N & NO_3-N). In this method ammonia is steam distilled in presence of MgO and absorbed in boric acid indicator solution and estimated by titration with 0.005 N sulfuric acid. Finely divided Devarda alloy was added to bring about the reduction of nitrate to ammonium ion before the addition of MgO. Nitrite was not estimated because it appeared to be absent.

Determination of Inorganic Phosphorus. The radio reagent method employed in this study for the determination of phosphorus is essentially ~~is~~ the same as reported by Kenney and Menon (5). This method is much simpler to use as compared to the conventional methods and affords better sensitivity of detection. About 10 mCi of ^{99}Mo isotope in $(NH_4)_2MoO_4$ was procured from New England Nuclear. A three percent solution of tagged sodium molybdate radio reagent was prepared by dissolving approximate amount of sodium molybdate in 250 ml of 5N HCl and mixing it thoroughly with approximately 1 mCi of ^{99}Mo tracer. Five ml of the reagent was added to 20 ml of the water sample and the mixture was left for 5 minutes. At the end of this period it was transferred to a 125 ml separatory funnel and shaken for one minute with 10 ml of 1-butanol-chloroform mixture containing 20% of 1-butanol by volume. After equilibrium, the extract containing molybdophosphoric acid was collected in a polypropylene beaker and 5 ml of the extract was pipetted into a counting tube.

The radioactivity resulting from ^{99}Mo gamma-rays was measured by using a well-type NaI (Tl) gamma ray spectrometer and a single channel analyzer. A known amount (20 ml) of standard phosphate solution was subjected to the same procedure and the gamma-ray activity in a 5 ml of the final extract was measured. A blank, 20 ml water was also processed in an identical manner and the activity in the blank was also measured. After correction for decay and blank activity, the activities of the samples were compared with that in the standard to determine the concentration of P in the samples.

Only the four sets (collections) of water samples were analyzed for P by using this radio reagent method.

METHODS OF SEDIMENT ANALYSIS

Preparation of Soil (Sediment) Samples. For the study of sediment samples the frozen sample bags stored in the freezer were taken out and allowed to thaw at room temperature. The interstitial saline water mixed with the sediments from the sampling sites was filtered through a Buchner funnel containing Whatman #5 filter paper under vacuum suction. The interstitial water was set aside for analysis of trace elements.

A portion of the residual wet sample was used for moisture determination. Another small portion of the wet sample was reserved for the study of microorganisms. A third portion of the sample weighing 50 g was used for the estimation of inorganic nitrogen.

The remaining wet sample of the sediment was air dried in the oven at 35^{o}C. Then it was pulverized and ground by using a pestle and mortar taking care not to crush the shells present in the sample. The sample was sieved through a U.S. Standard #18 mesh sieve with openings of 1.0 mm diameter and stored in sample vial for analysis. The left-over shells were weighed and their percentage was calculated on the basis of air-dry unsieved bulk sample. The color of each dry sample was subsequently observed and recorded.

Moisture Determination in Sediments. About 10 gram portion of the wet sample was accruately weighed in a china dish. It was then dried overnight in an air oven and the drying was completed by raising the temperature to 105°C for one hour. The dried sample was allowed to cool in a desiccator and then weighed. The difference in weight between the wet and dry sample represented the amount of moisture held in the sample. Percentage moisture was calculated on the basis of the air dry sample:

$$\%\ \text{moisture in sediment} = \frac{(\text{wet sample wt}) - (\text{dry sample wt})}{(\text{dry sample wt})} \times 100$$

Measurement of pH of Sediments. Measurement of pH of the sediments not only indicates the acidic or basic nature but also provides information about the availability of phosphorus and trace elements and the possibility of microbial activity. Although different soil:water ratios have been adopted by various analysts in the past for pH measurement, we have chosen 1 : 1 soil : water ratio. Ten grams of air dry soil were mixed with 10 ml of distilled water and the mixture was allowed to equilibrate for half an hour. The pH was measured by using a Corning Model 12 Research pH Meter.

Measurement of Electrical Conductivity. Like the pH measurement, the conductivity measurement has also been carried out in soil-water mixture of different composition. We have made the conductivity measurement in the sediment-water ratio of 1 : 2. Ten grams of air dry sieved sediment were stirred with 20 ml of water and the mixture was filtered through a filter. The resistance of the filtrate, which was turbid, was measured by using a YSI Model 31 Conductivity Bridge. The conductivity in units of 100 uMhos was calculated from the resistance.

Inorganic Nitrogen Determination in Sediments. For the extraction of inorganic nitrogen (NH_4-N and NO_3-N), 50 g of the wet sediment sample was agitated with 50 ml of 1N KCl solution in a 250 ml flask for about 20 minutes using a wrist-action shaker. The mixture was filtered through Buchner funnel fitted with #5 filter paper and using suction. Washings with 10-ml portions of 1N KCl were continued until 100 ml of the extract was obtained. Fifty ml of the extract was used for the estimation of NH_4-N and the remaining 50 ml was used for determining NO_3-N using steam distillation method described earlier in the analysis of water (4). The inorganic nitrogen content of the sediments has been expressed as ppm N on the basis of air dry soil.

Determination of Water-Soluble and Ion-Exchangeable Cations. It is known that ammonium acetate is preferred over all other extractants for the removal of exchangeable cations from the soil (6). The following procedure was therefore, employed for the displacement of exchangeable metal ions alongwith those that are water-soluble, for subsequent analysis:

Ten grams of air dry soil passed through 1.0 mm sieve were mixed with 25 ml of 1N ammonium acetate in a 100 ml beaker. The mixture was heated on a hot plate for 30 minutes with occasional stirring. The mixture was filtered into a 100 ml flask. The residue was washed several times with the same reagent until the 100 ml filtrate was collected into the flask. This ammonium acetate extract was transferred to a 250 ml beaker and evaporated slowly to dryness. The organic material in the residue in the beaker was then digested with 1 ml of conc. HNO_3 and 3 ml of conc. HCl. Extra portions of these acids were used if necessary to completely destroy the organic matter. The residue finally evaporated to dryness was dissolved in 0.2N HCl and the solution was filtered into a 100 ml volumetric flask. After giving several washings to the filter paper the volume of the soil solution was made up to the mark with de-ionized water. This sample was used for the analysis of reported cations. The use of atomic absorption technique for the analysis of major cations necessitated further dilution of a portion of this sample. Trace elements were determined using the stock solution sample itself.

STUDY OF MICROORGANISMS

Bodies of water are usually in a state of flux while accomodating microorganisms and the products of their interaction with a range of artificial and natural materials. This microbial interaction with living as well as nonliving organic materials may result in the production of a variety of other organic substances (7). Thus the continuous enrichment of aquatic bodies may result in the accumulation of toxic metabolites as well as the occurrence of pathogenic microorganisms. The problem of water pollution has been complicated by the fact that many organic wastes enter a sink such as a river, or a receptor such as fish in the form of complex mixtures. As a result the ultimate composition of microbial flora associated with the sink will be determined to a considerable extent by the nature of waste materials (8).

The studies described in this report were undertaken to (a) isolate, identify, characterize and classify microorganisms, especially pathogenic or pollution indicator bacteria in water and sediment samples collected from Haulover Canal and Mosquito Lagoon by conventional procedures, (b) to correlate the conventional techniques with pyrochromatographic data on the isolated organisms, and (c) to determine the nature of pollution if any in these water bodies and exploring the possible ways of correcting the problem.

Preparation of Samples for Microbial Study. Water samples collected in sterilized polyethylene bottles and temporarily stored in the refrigerator were transferred to cold room maintained at 7 - 8°C. Portions of sediment samples after these were thawed from the frozen state and interstitial water

ORIGINAL PAGE IS

was removed, were used for microbiological examination. Bacteria and actinomycetes were isolated on enrichment, differential and where appropriate selective culture media. Bacteria isolated from enrichment culture media were inoculated into differential and selective media whenever possible.

Culture media were sterilized by boiling or autoclaving at 15 psig for 20 minutes, after which media were cooled, dispensed into petri dishes or test tubes (as broth, agar slope or deep (butt)). Media were inoculated with appropriate water or sediment samples by the surface streak plate method (by means of a hockey stick-shaped glass rod, by pour plating, as stab cultures or as agar shake (9). Anaerobiosis was achieved by overlaying agar stab and shake cultures with vaspar. Cultures were incubated at 15 or 20°C for 7 - 14 days or at 30, 37, 45 and 50°C for 3, 5, and 7 days. Selected colonies were examined morphologically by gram and stain procedures and also biochemically (9, 10). Colonies were then transferred to differential and selective media described as follows:

Media used for Enrichment of Bacteria and Actinomycetes isolated from Water.

Medium #	Ingredients
1.	Yeast extract agar plus carbon sources in lagoon water.
2.	Sodium nitrate agar contains nitrate, carbon sources in lagoon water.
3.	Crystal violet agar, contains peptone and beef extract.
4.	Acetate nitrate agar plus mineral salts and trace elements.
5.	Sodium lactate agar plus carbon sources in lagoon water.

* Selective and Differential Media used in the isolation of Bacteria.

Colony #	Medium	Designated Organism
1.	Mannitol-salt agar	*Staphyloccus* sp.
2.	Pseudomonas isolation agar	*Pseudomonas* sp. and pseudomonads.
3.	Actinomycetes isolation agar	*Nocardia* sp., *Arthrobacter* sp.
4.	Simmons-citrate	*Bacillus* sp.
5.	Oxidation-fermentation (Hugh-Leifson O - F)	Differentiation of oxidative from fermentative pseudomonads.
6.	Motility test medium	Differential medium.
7.	Eosine-methylene blue agar	To differentiate between *Aerobacter* sp., and *Escherichia coli.*
8.	Glucose-casein & glucose-asparagine agar.	Actinomycetes & *Micromonospora*.
9.	Veilonella agar	*Veilonella* sp.
10.	Mineral salts-nicotine.	*Arthrobacter* sp.

* The colonies were selected at random.

RESULTS AND DISCUSSION

Results from the Analysis of Water Samples. The data on the measurement of physical parameters and the analytical results for nitrate-nitrogen and inorganic phosphorus in all the water samples collected during the reporting period are shown in Tables 1-W(a) to 5-W(a). No ammonium-nitrogen was detected in any of the samples. The absence of measurable NH_4-N in all the water samples indicates that the Haulover Canal and Mosquito Lagoon waters are well aerated and the oxidizing and nitrifying bacteria seem to be very active. The NO_3-N levels in the samples where nitrogen was detected are in general accord with the values reported for these water bodies earlier(11). Only one sample, 2L(Table 3-W(a)), was found to contain a significantly high value of 0.98 ppm of NO_3-N. This may be due to a recent localized addition of soem effluent from the adjacent vegitation area. Only the inorganic phosphorus which exists as orthophosphate has been determined in the water samples. The reported values are believed to be within the range normally found in inland water bodies. however, a dramatic increase in the levels of phosphorus in samples collected from all locations was observed during the month of May (Table 3-W(a)). This trend is noticable in the case of other elements also. The salinity and the conductivity also showed marked increase in the month of May.

Tables 1-W(b) to 5-W(b) show the results of analysis of major elements and anionic species including the total solid present in all the water samples. It can be seen from the tables that, in general, there is a gradual increase in the concentration levels of various elements and total dissolved solids in water samples from 1H to 5L and then in 6L and 7L the concentration either levels off or decreases slightly. This observation coincides with the collection of samples in sequence progressing northward and opposite to the direction of flow of water.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 1-W (a)

Data on the Measurement of the Physical Parameters and the Measured Values for Nitrate Nitrogen and Phosphorus

(1st Collection)* - Haulover Canal and Mosquito Lagoon

Sample #	Depth (m)	Temp. (°C)	Salinity (%)	Conductivity (in 100 u Mhos)	pH (Site)	Phosphorus (ppm)	Nitrate-Nitrogen(ppm)
2-H	-	18	3.00	394	7.5	0.033	-
1-L	1.37	17	2.83	380	6.2	0.013	-
2-L	1.37	17	2.94	390	6.5	0.029	-
3-L	1.83	18	3.00	400	7.1	0.124	0.28
4-L	1.83	18	3.13	410	7.2	0.098	-
5-L	1.83	17	3.25	423	7.3	0.066	-
6-L	1.83	17	3.28	430	7.6	0.061	-
7-L	1.83	18	3.07	415	7.6	0 .087	-

---

* Samples collected on December 21, 1974

NASA PROJECT WATER SAMPLE ANALYSIS

Table 2-W (a)

Data on the Measurement of the Physical Parameters and the Measured Values for Nitrate Nitrogen and Phosphorus

(2nd Collection)* - Haulover Canal and Mosquito Lagoon

Sample #	Depth (m)	Temp. (°C)	Salinity (%)	Conductivity (in 100 u Mhos)	pH (Site)	Phosphorus (ppm)	Nitrate-Nitrogen(ppm)
1-H	0.61	20	3.50	430	7.3	0.035	-
2-H	0.61	20	3.50	428	6.0	0.190	-
1-L	-	20	3.55	435	7.3	0.040	-
2-L	-	20	3.68	448	7.8	0.025	-
3-L	1.83	19	3.85	465.5	7.6	0.025	0.14
4-L	-	19	3.82	462	7.8	0.032	0.28
5-L	-	19	3.75	456	7.5	0.025	0.42
6-L	1.52	20	3.80	460	7.5	0.045	0.28
7-L	1.07	19	3.79	460	7.4	0.035	-

* Samples collected on March 8, 1975

NASA PROJECT WATER SAMPLE ANALYSIS

Table 3-W (a)

Data on the Measurement of the Physical Parameters and the Measured Values for Nitrate Nitrogen and Phosphorus

(3rd Collection)* - Haulover Canal and Mosquito Lagoon

Sample #	Depth (m)	Temp. (°C)	Salinity (%)	Conductivity$ (in 100 u Mhos)	pH (Site)	Phosphorus (ppm)	Nitrate-Nitrogen(ppm)
1-H	0.91	28	3.44	427	7.8	2.00	0.14
2-H	1.52	28	3.61	448	7.8	1.90	-
1-L	0.91	27	3.51	436	7.3	1.70	-
2-L	0.91	26	3.81	473	7.3	2.00	0.98
3-L	0.91	27	3.90	484	7.3	2.00	0.14
4-L	0.91	27	3.93	488	7.3	3.20	0.28
5-L	-	26	3.98	494	7.3	2.00	0.28
6-L	-	26	3.90	484	7.3	1.75	-
7-L	-	27	3.92	487	7.3	1.55	-

---

* Samples collected on May 10, 1975

$ Conductivity of the samples was measured in the laboratory

NASA PROJECT WATER SAMPLE ANALYSIS

Table 4-W (a)

Data on the Measurement of the Physical Parameters and the Measured Values for Nitrate-Nitrogen and Phosphorus

(4th Collection)* - Haulover Canal and Mosquito Lagoon

Sample #	Depth (m)	Temp. (°C)	Salinity (%)	Conductivity (in 100 u Mhos)	pH (Site)	Phosphorus (ppm)	Nitrate-Nitrogen (ppm)
1-H	0.91	30	3.00	455	7.6	0.24	-
2-H	0.91	31	2.85	480	8.1	0.10	-
1-L	1.22	31	2.60	425	7.4	0.89	-
2-L	1.22	30	2.65	430	8.5	0.27	-
3-L	1.22	31	2.70	440	8.0	0.23	-
4-L	1.22	31	2.76	446	7.6	0.24	-
5-L	1.22	31	2.84	458	7.8	0.54	-
6-L	1.22	31	2.86	462	7.3	0.25	-
7-L	1.22	31	2.90	469	7.5	0.33	-

* Samples collected on July 26, 1975

NASA PROJECT WATER SAMPLE ANALYSIS

Table 5-W (a)

Data on the Measurement of the Physical Parameters and the Measured Values for Nitrate Nitrogen and Phosphorus

(5th Collection)* - Haulover Canal and Mosquito Lagoon

Sample #	Depth (m)	Temp. (°C)	Salinity (%)	Conductivity (in 100 u Mhos)	pH (Site)	Phosphorus$ (ppm)	Nitrate-Nitrogen(ppm)
1-H	1.22	25	2.90	360	6.4		-
2-H	1.22	26	2.90	360	6.7		-
1-L	1.22	26	2.85	350	6.7		-
2-L	1.22	27	2.95	360	7.1		-
3-L	1.22	27	2.85	355	7.1		-
4-L	1.22	27	3.05	374	7.2		-
5-L	1.22	28	3.10	380	6.9		-
6-L	1.22	27	3.10	380	7.3		-
7-L	1.22	28	3.10	383	7.0		-

---

* Samples collected on September 27, 1975

$ Phosphorus is yet to be determined in these samples

NASA PROJECT WATER SAMPLE ANALYSIS

Table 1-W (b)

Concentration of Major Ions in Water (1st Collection)* from Haulover Canal and Mosquito Lagoon

Sample #	Site #	Ca	Mg	Na	K	Cl	SO_4	HCO_3	Total Solids
				ppm					
1-H	West of bridge								
2-H	East of bridge	335	1100	6400	600	17519	2350	175.2	35116
1-L	Post 43	360	1100	6800	624	18270	2550	234.0	35432
2-L	Post 37	365	1125	6500	624	20773	2300	204.9	36716
3-L	Post 31	370	1200	6800	640	21524	2850	175.2	37912
4-L	Post 25	400	1150	7000	658	19521	2750	204.9	39100
5-L	Post 19	380	1250	7600	688	19521	3000	175.2	40100
6-L	Post 13 A	378	1225	7300	700	19772	2850	234.0	40036
7-L	Post 10	375	1210	7200	700	19521	2650	204.9	40020

* Samples collected on December 21, 1974

NASA PROJECT WATER SAMPLE ANALYSIS

Table 2-W (b)

Concentration of Major Ions in Water (2nd Collection)* from Haulover Canal and Mosquito Lagoon

Sample #	Site #	Ca	Mg	Na	K	Cl	SO_4	HCO_3	Total Solids
					ppm				
1-H	West of bridge	370	1200	6900	624	18520	2060	175.2	39060
2-H	East of bridge	390	1217	6800	640	21273	2300	161.0	40992
1-L	Post 43	383	1250	7100	624	20523	2320	204.9	40124
2-L	Post 37	400	1250	7300	648	22274	2320	175.2	40724
3-L	Post 31	405	1300	8000	696	21774	2050	161.0	46576
4-L	Post 25	403	1250	8000	696	21273	2100	161.0	44484
5-L	Post 19	407	1242	8000	736	24026	2400	161.0	41944
6-L	Post 13 A	400	1167	7600	696	20523	2300	146.6	41500
7-L	Post 10	393	1183	7500	688	19521	2250	168.1	42044

* Samples collected on March 8, 1975

NASA PROJECT WATER SAMPLE ANALYSIS

Table 3-W (b)

Concentration of Major Ions in Water (3rd Collection)* from Haulover Canal and Mosquito Lagoon

Sample #	Site #	Ca	Mg	Na	K	Cl	SO_4	HCO_3	Total Solids
				ppm					
1-H	West of bridge	492	1300	11500	790	20523	2820	183.0	46752
2-H	East of bridge	480	1333	11250	820	21023	2800	175.7	43016
1-L	Post 43	480	1333	11100	830	21774	2830	190.3	42544
2-L	Post 37	487	1367	11750	830	26029	3020	175.7	46408
3-L	Post 31	472	1389	12250	870	22525	3080	175.7	47028
4-L	Post 25	463	1400	12350	875	27030	2990	183.0	45120
5-L	Post 19	480	1433	12800	865	25028	3200	175.7	47588
6-L	Post 13 A	485	1400	12000	850	23025	3150	175.7	47656
7-L	Post 10	485	1389	12000	840	21524	3150	161.0	45380

* Samples collected on May 10, 1975

NASA PROJECT WATER SAMPLE ANALYSIS

Table 4-W(b)

Concentration of Major Ions in Water (4th Collection)* from Haulover Canal and Mosquito Lagoon

Sample #	Site #	Ca	Mg	Na	K	Cl	SO_4	HCO_3	Total Solids
			ppm						
1-H	West of bridge	335	1015	8300	330	16495	2310	161.04	34148
2-H	East of bridge	345	1035	8350	335	16495	2200	175.68	34608
1-L	Post 43	345	1025	8400	325	15995	2130	175.68	34616
2-L	Post 37	350	1020	8500	333	15995	2530	146.4	34764
3-L	Post 31	355	1065	8600	365	16245	2640	161.04	35160
4-L	Post 25	355	1080	8800	365	15995	2280	175.68	36236
5-L	Post 19	370	1130	9100	380	16995	2470	161.04	36120
6-L	Post 13 A	372	1150	9200	385	20494	2640	175.68	37036
7-L	Post 10	372	1155	9150	375	17744	2530	161.04	37320

---

* Samples collected on July 26, 1975

NASA PROJECT WATER SAMPLE ANALYSIS

Table 5-W(b)

Concentration of Major Ions in Water (5th Collection)* from Haulover Canal and Mosquito Lagoon

Sample #	Site #	Ca	Mg	Na	K ppm	Cl	SO_4	HCO_3	Total Solids
1-H	West of bridge	386	1170	9800	468	17994	3150	161	39452
2-H	East of bridge	378	1150	9440	392	16995	2675	190	39538
1-L	Post 43	378	1150	9720	368	16495	2775	190	39604
2-L	Post 37	384	1200	9400	380	16495	2725	190	39866
3-L	Post 31	389	1145	9320	368	16995	2375	161	40260
4-L	Post 25	384	1210	10000	380	17495	2500	161	41008
5-L	Post 19	374	1240	10280	408	17994	3075	161	41386
6-L	Post 13 A	370	1240	10400	412	17994	2675	161	40568
7-L	Post 10	370	1240	10400	400	17994	3175	161	40592

---

* Samples collected on September 27, 1975

The concentration of trace elements in all the water samples undertaken in this study are presented in Tables 1-W(c) to 5-W(c). The values reported for most of the trace elements, except zinc, may be considered as upper values for possible detection in water samples. The limit of senitivity of detection of Atomic Absorption Spectrometer for some of the trace elements precludes their analyses with a high degree of accuracy. For more accurate analysis the trace elements should be pre-concentrated by extraction or ion-exchange techniques using larger volumes of water. The analytical results show, however, that there are slight variations in the concentration of trace elements we have studied from one location to the other as well as from season to season. In general, Fe, Mn and Zn concentrations in these saline waters are less than the maximum recommended for irrigation waters. However, the Cr and Cd levels are relatively higher in these samples, thus revealing the different chemical composition of estuarine waters (12).

Results of Analysis of Sediment Samples. In Tables 2-S(a) to 5-S(a) are given the results of the measurement of physical parameters and of the analysis of ammonium- and nitrate-nitrogen. In most cases, the upper and lower parts of the soil core have been analyzed, but in few instances only the composite samples were collected and analyzed. The percentage of moisture was estimated in order to compute the concentration of nitrogen per gram of dry sediment (6). The difference in the percentage of shells in the collected samples shows that these samples are not alike in their composition and structure. There is also some difference in the color of the samples as seen from the tables. All the samples (2H) collected from the site labeled "East of Bridge" in the Haulover Canal have darker color than the rest although no such consistency in color was observed for other samples collected from other sites at different times. In general, the pH of the sediment

NASA PROJECT WATER SAMPLE ANALYSIS

Table 1-W (c) : Concentration of Trace Elements in Water (1st Collection)*

from Haulover Canal and Mosquito Lagoon

Sample #	Fe	Mn	Cr	Zn	Cd
		------ ppm ----------			
2-H	2.93	0.050	0.70	0.068	0.062
1-L	2.33	0.088	0.33	0.068	0.062
2-L	3.17	0.088	0.50	0.068	0.070
3-L	3.17	0.106	1.00	0.068	0.075
4-L	4.40	0.050	0.70	0.072	0.044
5-L	4.40	0.050	0.50	0.080	0.056
6-L	3.37	0.088	0.83	0.078	0.044
7-L	3.37	0.106	0.33	0.070	0.056

* Samples collected on December 21, 1974

Table 2-W(c) Concentration of Trace Elements in Water (2nd Collection)*

from Haulover Canal and Mosquito Lagoon

Sample #	Fe	Mn	Cr	Zn	Cd
		------ ppm ---------			
1-H	0.87	0.106	1.00	0.059	0.084
2-H	1.07	0.050	1.00	0.059	0.075
1-L	0.87	0.088	0.50	0.052	0.080
2-L	2.33	0.088	0.70	0.054	0.070
3-L	8.17	0.088	0.33	0.050	0.075
4-L	2.73	0.106	0.33	0.085	0.080
5-L	3.17	0.50	0.70	0.072	0.100
6-L	2.33	0.088	0.50	0.052	0.088
7-L	4.20	0.100	0.50	0.059	0.088

* Samples collected on March 8, 1975

Table 3-W (c) : Concentration of Trace Elements in Water (3rd Collection)*

from Haulover Canal and Mosquito Lagoon

Sample #	Fe	Mn	Cr	Zn	Cd
			ppm		
1-H	0.87	0.040	0.70	0.049	0.080
2-H	0.63	0.050	1.17	0.046	0.056
1-L	0.87	0.088	0.70	0.068	0.088
2-L	1.27	0.106	0.70	0.080	0.070
3-L	1.47	0.050	0.70	0.047	0.070
4-L	1.70	0.050	0.70	0.080	0.062
5-L	2.10	0.106	0.70	0.063	0.075
6-L	2.73	0.106	0.33	0.063	0.070
7-L	2.93	0.088	0.50	0.092	0.070

* Samples collected on May 10, 1975

Table 4-W (c) : Concentration of Trace Elements in Water (4th Collection)*

from Haulover Canal and Mosquito Lagoon

Sample #	Fe	Mn	Cr	Zn	Cd	Cu
			ppm			
1-H	0.27	0.030	0.033	0.06	0.13	0.31
2-H	0.38	0.030	0.033	0.18	0.14	0.31
1-L	0.31	0.030	0.033	0.11	0.14	0.31
2-L	0.56	0.030	0.033	0.15	0.15	0.31
3-L	0.30	0.030	0.033	0.08	0.16	0.31
4-L	0.44	0.040	0.033	0.11	0.15	0.35
5-L	0.38	0.030	0.033	0.11	0.15	0.35
6-L	0.44	0.100	-0-	0.08	0.15	0.35
7-L	0.30	0.050	0.033	0.10	0.13	0.35

* Samples collected on July 26, 1975

NASA PROJECT WATER SAMPLE ANALYSIS

Table 5-W (c) : Concentration of Trace Elements in Water (5th Collection)*

from Haulover Canal and Mosquito Lagoon

Sample #	Fe	Mn	Cr	Zn	Cd	Cu
		ppm				
1-H	0.24	0.05	0.033	0.032	0.081	0.58
2-H	0.24	0.05	0.033	0.035	0.063	0.58
1-L	0.24	0.03	0.033	0.032	0.081	0.54
2-L	0.30	0.04	0.033	0.023	0.090	0.46
3-L	0.24	0.02	0.033	0.041	0.073	0.50
4-L	0.30	0.05	0.033	0.057	0.100	0.62
5-L	0.18	0.05	0.033	0.027	0.100	0.58
6-L	0.18	0.05	0.033	0.048	0.090	0.54
7-L	0.24	0.05	0.033	0.045	0.110	0.54

* Samples collected on September 27, 1975

samples (1:1 mixture with water) is higher than that of water samples, but the conductivity of the former (1:2 mixture with water) is much less. As seen from the Tables 2-S(a) to 5-S(a) the sediment samples, unlike water samples, contain significant ammounts of ammonium-nitrogen. This would indicate the presence of partial anaerobic conditions in the sediment bed. The nitrifying bacteria may also be less active in this case. Nitrate-nitrogen was also detected in a large number of sediment samples.

Tables 2-S(b) to 5-S(b) show the results of analysis of the interstitial water of the sediment samples for trace elements. The quantity of interstitial water in some of the samples was too small to perform the analysis of all of the chosen trace elements. The concentrations of the analyzed trace elements

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 2-S (a) : Data on the Measurement of Physical Parameters and the Measured Values for Ammonium and Nitrate-Nitrogen

(2nd Collection)* - Haulover Canal and Mosquito Lagoon

Sample #@	Moisture (%)	% Shells in the collected Sample	Color of the Sediment	pH (1:1 Ratio)	Conductivity (in 100 u Mhos)	Nitrogen (ppm) NH_4-N	NO_3-N
1H-C	18.01	23.0	light gray	7.4	35.71	3.97	-
2H-C	13.97	1.3	grayish brown	7.5	34.48	1.60	-
2H-Anchor	22.53	3.0	gray	7.8	50.00	19.04	0.86
1L-T	22.29	26.0	dark gray	-	-	5.13	1.43
1L-B	42.72	6.0	dark gray	7.6	66.67	2.00	2.00
2L-T	27.54	0.9	gray	7.7	58.82	5.71	2.14
2L-B	19.04	9.0	-	7.8	50.00	2.67	1.83
3L-T	22.49	9.6(C)	gray(C)	7.8(C)	50.00(C)	4.8	2.06
3L-B	20.42	-	-	-	-	1.69	2.25
4L-T	23.59	negligible	gray	7.9	50.00	4.85	1.73
4L-B	24.81	6.0	dark gray	8.0	52.63	2.45	-
5L-T	19.49	9.0(C)	gray(C)	8.1(C)	50.00(C)	7.80	-
5L-B	20.90	-	-	-	-	6.09	0.68
6L-T	26.08	10.0	dark gray	8.1	45.45	10.59	0.22
6L-B	26.15	20.0	dark gray	8.5	66.67	7.06	0.53
7L-C	16.21	4.5	gray	8.1	50.00	12.36	-

*Samples collected on March 8, 1975

@ C = Composite; T = Top - upper part of soil core; B = Bottom - lower part of soil core

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 3-S (a) : Data on the Measurement of Physical Parameters and the measured values for Ammonium and Nitrate-Nitrogen

(3rd Collection)* - Haulover Canal and Mosquito Lagoon

Sample #[@]	Moisture (%)	% Shells in the collected Sample	Color of the Sediment	pH (1:1 Ratio)	Conductivity (in 100 u Mhos)	Nitrogen (ppm) NH_4-N	NO_3-N
1H-T	19.77	12.3	gray	8.4	47.62	9.64	-
1H-C	17.57	8.2	gray	8.6	50.00	5.59	-
2H-T	13.94	-	-	-	-	5.59	-
2H-B	22.16	1.5	dark gray	8.4	50.00	2.91	0.68
2H-C	17.25	1.5	dark gray	8.3	50.00	2.63	0.16
1L-T	25.95	13.5	gray	8.1	55.56	3.17	1.23
1L-C	13.33	9.0	light gray	7.5	47.62	16.19	1.11
2L-T	39.44	9.3	gray	8.2	62.50	5.27	1.17
3L-T	17.86	25.3	gray	-	-	2.48	1.32
4L-T	11.59	0.8	light gray	8.2	47.62	5.78	0.78
5L-C	13.94	7.4	gray	8.0	50.00	5.74	-
6L-C	16.21	25.0	gray	8.5	50.00	5.53	-
7L-B	14.71	27.3	gray	8.4	40.00	8.19	-

* Samples collected on May 10, 1975

@ C = Composite; T = Top - upper part of soil core; B - Bottom - lower part of soil core

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 4-S (a) : Data on the Measurement of Physical Parameters and the Measured Values for Ammonium and Nitrate-Nitrogen

(4th Collection)* - Haulover Canal and Mosquito Lagoon

Sample #@	Moisture (%)	% Shells in the collected Sample	Color of the Sediment	pH (1:1 Ratio)	Conductivity (in 100 u Mhos)	Nitrogen (ppm)	
						NH_4-N	NO_3-N
1H-T	20.53	-	gray	8.0	47.85	0.68	-
1H-B	24.61	-	gray	8.2	45.45	0.17	-
2H-T	28.69	-	gray-black	7.9	58.82	-	1.44
2H-B	25.24	-	gray-black	7.9	52.63	2.11	-
1L-T	27.23	-	gray	8.1	64.52	1.25	-
1L-B	34.10	-	gray	8.0	69.44	1.50	-
2L-T	21.17	-	light-gray	8.1	39.84	0.17	0.85
2L-B	26.79	-	gray	8.2	47.85	1.42	-
3L-T	22.14	-	gray	8.2	50.51	0.34	-
3L-B	24.26	-	gray	8.3	54.64	1.04	0.52
4L-T	15.03	-	light-gray	8.1	35.34	-	-
4L-B	21.36	-	gray	8.2	51.02	-	-
5L-T	20.83	-	gray	8.2	50.00	-	-
5L-B	18.71	-	gray	8.1	45.45	0.17	-
6L-T	19.07	-	gray	7.8	43.67	0.83	2.50
6L-B	18.31	-	gray	8.1	45.87	0.67	-
7L-T	16.27	-	gray	8.1	38.31	2.28	-
7L-B	18.00	-	dark gray	8.0	45.45	-	0.17

---

* Samples collected on July 26, 1975

@ C = Composite; T = Top - upper part of soil core; B - Bottom - lower part of soil core

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 5-S (a) Data on the Measurement of Physical Parameters and the Measured Values for Ammonium and Nitrate-Nitrogen

(5th Collection)*- Haulover Canal and Mosquito Lagoon

Sample #@	Moisture (%)	% Shells in the collected Sample	Color of the Sediment	pH (1:1 Ratio)	Conductivity (in 100 u Mhos)	Nitrogen (ppm) NH_4-N	NO_3-N
1H-T	12.88	7.2	gray	8.1	60.24	1.31	1.75
1H-B	11.94	7.6	light gray	8.3	53.48	1.40	0.70
2H-T	15.88	7.2	dark-gray	8.3	66.23	15.29	0.68
2H-B	16.71	3.5	dark-gray	8.3	83.33	6.39	1.13
1L-T	15.70	2.3	dark-gray	8.5	74.07	1.29	1.48
1L-B	17.46	4.6	dark-gray	8.4	76.92	1.12	0.37
2L-T	14.53	13.2	light-gray	8.8	57.80	1.34	0.22
2L-B	19.76	12.7	gray	8.7	98.04	1.98	0.79
3L-T	15.01	9.5	light gray	8.8	68.97	1.07	0.72
3L-B	14.83	13.0	gray	8.6	63.69	0.36	0.36
4L-T	14.81	4.3	light gray	8.6	74.63	1.44	0.36
4L-B	14.86	5.2	light gray	8.8	67.57	1.97	0.18
5L-T	19.06	negligible	dark gray	8.6	48.78	1.65	0.55
5L-B	14.48	19.0	dark gray	8.8	66.2	0.88	0.18
6L-T	9.93	28.4	dark gray	8.7	40.82	4.98	-
6L-B	11.43	6.1	dark-gray	8.7	77.52	2.39	1.90
7L-T	14.35	29.3	gray	8.6	54.35	5.99	2.113
7L-B	11.54	13.0	gray	8.8	50,25	5.77	2.72

* Samples collected on September 27, 1975

@ C = Composite; T = Top -upper partof soil core; B = Botom - lowever part of soil core

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 2-S (b) : Concentration of Trace Elements in Interstitial Water of Sediments from Haulover Canal and Mosquito Lagoon (2nd Collection) *

Sample #	Mn	Cr	Zn	Cd
		ppm		
1H-C	0.12	0.15	0.06	0.24
2H-C	0.12	0.15	0.15	0.10
2H-Anchor	0.14	0.16	0.18	0.25
1L-T	0.11	0.15	0.34	-
1L-B	0.10	0.14	0.25	0.30
2L-T	0.14	0.18	0.21	0.45
2L-B	0.10	0.17	0.20	0.23
3L-C	0.17	0.17	0.26	0.61
4L-T	0.17	0.16	0.20	0.45
4L-B	0.16	0.15	0.25	0.51
5L-B	0.12	0.18	0.21	0.70
6L-T	0.20	0.16	-	-
6L-B	0.16	0.19	0.26	0.57
7L-T	0.19	0.19	0.26	0.76

* Samples collected on March 8, 1975

Table 3-S (b) : Concentration of Trace Elements in Interstitial Water of Sediments from Haulover Canal and Mosquito Lagoon (3rd Collection) *

Sample #	Mn	Cr	Zn	Cd
		ppm		
1H-T	0.15	0.16	0.34	0.83
2H-T	0.13	0.16	0.65	0.79
2H-B	0.17	0.15	0.32	0.23
2H-C	0.13	0.18	0.15	0.46
1L-T	0.14	0.16	0.40	0.37
1L-C	0.16	0.18	0.73	0.43
2L-T	0.15	0.15	0.22	0.40
3L-T	-	0.16	-	-
4L-T	0.11	0.16	0.34	0.43
5L-C	0.12	0.12	0.20	0.24
6L-C	0.16	0.17	0.28	0.42
7L-B	0.14	0.15	0.09	0.33

* Samples collected on May 10, 1975

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 4-S (b): Concentration of Trace Elements in Interstitial Water of Sediments from Haulover Canal and Mosquito Lagoon (4th Collection) *

Sample # $	Zn	Cd	Sample # $	Zn	Cd
	ppm			ppm	
1H-T	0.21	0.30	4L-T	0.15	0.26
1H-B	0.15	0.10	4L-B	0.04	0.09
2H-T	0.14	0.16	5L-T	0.06	0.27
2H-B	0.11	0.42	5L-B	0.03	0.22
1L-T	0.11	0.32	6L-T	0.14	0.42
1L-B	0.15	0.22	6L-B	0.18	0.22
2L-T	0.11	0.11	7L-T	0.03	0.11
2L-B	0.10	0.18	7L-B	0.23	0.11
3L-T	0.09	0.17			
3L-B	0.20	0.37			

* Samples collected on July 26, 1975. $ Mn and Cr were not determined.

Table 5-S (b): Concentration of Trace Elements in Interstitial Water of Sediments from Haulover Canal and Mosquito Lagoon (5th Collection) *

Sample #	Mn	Cr	Zn	Cd
		ppm		
1H-T	0.050	-0-	0.075	0.165
1H-B	0.100	0.033	0.125	0.165
2H-T	0.967	0.017	0.126	0.222
2H-B	0.300	-0-	0.112	0.245
1L-T	0.150	-0-	0.125	0.198
1L-B	0.167	0.017	0.075	0.210
2L-T	0.100	0.033	0.125	0.178
2L-B	0.100	0.050	0.074	0.178
3L-T	0.083	-0-	0.060	0.089
3L-B	0.117	-0-	0.112	0.189
4L-T	0.100	0.017	0.088	0.198
4L-B	0.100	-0-	0.078	0.198
5L-T	0.183	-0-	0.088	0.178
5L-B	0.133	-0-	0.078	0.232
6L-T	0.117	0.017	0.075	0.178
6L-B	0.167	0.033	0.077	0.189
7L-T	0.133	0.033	0.065	0.189
7L-B	0.100	0.033	0.078	0.165

* Samples cOllected on September 27, 1975.

are in between their respective concentrations in water samples and those of the ion-exchangable trace elements in the sediment. The analytical results do not show any noticable trend in the seasonal or locational variation in the concentration of trace elements.

The results of the analysis of water-soluble and ion-exchangable metals in sediments we have carried out in this study are presented in Tables 2-S(c) to 5-S(c). On comparison of these tables with Tables 2-W(b) to 5-W(b) one can see that the concentrations of Na, K and Mg are much lower in the ion-exchangable fraction of the sediment than in respective water samples while that of calcium is considerably higher in sediment fraction. The concentration levels of all the trace elements are also much higher in the sediment fraction than in the corresponding water samples.

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 2-S (c) : Concentration of Water-Soluble and Ion-Exchangable Metals in Sediments[@] (2nd Collection)[*] from Haulover Canal and Mosquito Lagoon

Sample #	Ca	Mg	Na	K	Fe	Mn	Cr	Zn	Cd	Cu
			-------- ppm in air-dry sediments --------							
1H-C	2667	374	1940	122	1.2	2.25	0.33	2.70	0.70	2.00
2H-C	2400	408	1700	110	1.2	2.05	0.66	3.50	0.70	2.00
2H-Anchor	3267	395	2400	191	1.2	2.10	0.66	5.09	0.50	1.50
1L-T	3867	612	2650	190	1.2	2.30	0.33	2.50	0.50	1.50
1L-B	3067	1088	4800	436	1.8	2.40	0.33	3.00	0.50	2.00
2L-T	4733	510	2700	185	1.8	3.15	0.33	2.50	0.50	1.50
2L-B	5334	748	2300	170	3.6	4.00	0.66	4.50	1.60	3.00
3L-C	3567	476	2650	145	1.2	2.20	0.33	5.05	1.20	2.33
4L-T	4833	476	2350	150	1.8	3.40	0.33	4.00	0.80	2.00
4L-B	5433	510	2350	156	2.1	2.35	0.33	3.62	0.90	2.00
5L-C	2633	408	2200	115	1.2	2.40	0.0	4.25	0.80	2.00
6L-T	4033	748	2960	245	0.6	4.60	0.85	2.50	0.70	2.20
6L-B	3700	850	3320	295	0.6	3.30	0.0	3.00	0.50	2.00
7L-C	2600	442	2130	142	1.2	3.50	0.35	2.87	0.70	1.00

---

[*] Samples collected on March 8, 1975

[@] Sediments extracted by 1 N Ammonium Acetate solution

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 3-S (c) : Concentration of Water-Soluble and Ion-Exchangable Metals in Sediments[@]

(3rd Collection)[*] from Haulover Canal and Mosquito Lagoon

Sample #	Ca	Mg	Na	K	Fe	Mn	Cr	Zn	Cd	Cu
					---------- ppm in air-dry sediments ---------					
1H-T	6200	374	1675	120	1.5	2.00	0.33	10.38	0.33	1.00
1H-C	5900	408	1750	121	2.0	1.00	0.33	8.50	0.33	2.00
2H-C	2300	442	1725	100	2.5	0.67	0.33	8.00	0.33	1.00
2H-B	1767	443	1850	122	1.0	0.67	0.33	14.00	0.33	1.50
1L-T	6250	680	2750	184	1.0	1.83	0.33	10.50	0.50	1.00
1L-C	4700	334	1575	120	2.0	1.50	0.0	7.50	0.0	1.50
2L-T	5333	1428	4000	305	2.0	1.83	0.33	7.50	0.50	3.10
3L-T	4333	518	2475	178	0.5	1.33	0.33	4.87	0.33	2.00
4L-T	2700	334	1725	115	1.0	0.67	0.33	6.88	0.33	2.50
5L-C	4600	443	2200	150	0.5	1.67	0.33	7.88	0.33	3.80
6L-C	6100	525	2100	170	1.0	1.67	0.33	4.38	0.33	1.00
7L-B	4833	342	1575	130	2.0	1.83	0.33	6.00	0.50	1.00

* Samples collected on May 10, 1975

@ Sediments extracted by 1 N Ammonium Acetate solution

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 4-S (c) : Concentration of Water-Soluble and Ion-Exchangable Metals in Sediments[@]

(4th Collection)[*] from Haulover Canal and Mosquito Lagoon

--------- ppm in air-dry sediments ----------

Sample #	Ca	Mg	Na	K	Fe	Mn	Cr	Zn	Cd	Cu
1H-T	5800	374	1500	101	4.4	1.00	0.66	10.13	0.33	2.33
1H-B	5900	408	1825	130	3.8	0.67	0.66	6.25	0.17	2.00
2H-T	3233	748	2500	180	4.7	1.67	1.50	7.00	0.33	2.00
2H-B	1833	731	2350	180	3.6	0.50	1.00	7.75	0.0	2.00
1L-T	7000	697	2700	250	1.5	1.83	0.66	6.50	0.33	2.00
1L-B	9200	884	3350	300	2.0	2.67	0.33	3.13	0.17	2.00
2L-T	7600	408	1650	122	1.5	1.67	0.33	9.38	0.33	3.10
2L-B	7400	544	2100	200	2.0	1.00	0.33	2.50	0.66	2.20
3L-T	4533	578	2350	204	1.0	1.50	0.33	1.50	0.66	1.00
3L-B	5800	680	2625	255	0.5	2.17	0.33	1.13	0.33	1.00
4L-T	3700	323	1450	85	1.0	0.83	0.33	1.25	0.33	1.00
4L-B	3850	476	2025	164	2.5	0.83	0.33	1.00	0.17	1.00
5L-T	7600	530	2250	165	3.0	2.33	0.33	1.25	0.33	1.00
5L-B	9134	408	1850	121	2.5	2.50	0.33	1.25	0.33	0.50
6L-T	9400	1292	2350	228	3.8	4.50	0.33	3.13	0.17	0.50
6L-B	7200	697	2550	230	2.8	2.50	0.0	1.68	0.17	0.50
7L-T	6266	578	2700	154	3.3	2.67	0.33	1.66	0.0	1.00
7L-B	3333	612	2250	234	3.6	3.17	0.0	2.13	0.0	1.00

---

[*] Samples collected on July 26, 1975

[@] Sediments extracted by 1 N Ammonium Acetate solution

.. NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 5-S (c) : Concentration of Water-Soluble and Ion-Exchangable Metals in Sediments@

(5th Collection)* from Haulover Canal and Mosquito Lagoon

Sample #	Ca	Mg	Na	K	Fe	Mn	Cr	Zn	Cd	Cu
			------- ppm in air-dry sediments --------							
1H-T	11600	612	2500	200	3.0	1.83	0.33	5.50	0.50	1.00
1H-B	11600	544	2400	154	3.0	1.67	0.33	8.63	0.-0	5.40
2H-T	4650	612	2400	180	3.0	8.34	0.0	5.05	0.50	1.00
2H-B	3867	833	3100	250	4.4	3.34	0.0	9.63	0.17	1.00
1L-T	4600	782	3200	248	2.5	1.33	0.0	4.25	0.33	0.50
1L-B	5400	953	3300	332	1.5	1.67	0.0	3.75	0.17	0.50
2L-T	10200	510	2325	170	1.5	1.17	0.33	3.75	0.33	1.00
2L-B	8274	926	4100	300	1.0	1.00	0.0	3.13	0.33	1.00
3L-T	6334	519	2900	165	2.5	0.83	0.33	7.88	0.17	1.00
3L-B	9200	646	2875	218	1.5	1.50	0.0	3.63	0.33	1.50
4L-T	7066	576	3075	184	1.5	1.17	0.33	4.38	0.17	0.50
4L-B	5330	748	2800	188	1.0	0.67	0.0	4.87	0.33	1.00
5L-T	4960	571	2350	200	1.0	1.50	0.0	4.37	0.17	0.50
5L-B	3700	697	2825	260	2.0	0.83	0.33	4.38	0.33	1.00
6L-T	3533	374	1650	121	1.5	1.17	0.0	2.50	0.33	1.00
6L-B	4333	748	3250	270	1.5	4.50	0.0	3.15	0.17	1.00
7L-T	3400	969	2275	174	1.0	0.67	0.0	3.38	0.17	1.00
7L-B	3333	442	2025	164	1.5	0.67	0.0	4.37	0.33	1.50

* Samples collected on September 27, 1975
@ Sediments extracted by 1 N Ammonium Acetate solution

Results of Microbiological Studies. The results of microbial studies are presented in the following tables numbered 6 - 12. In achieving these data, the large number of biochemical tests required to establish the identity of individual bacteria were not carried out. Instead, groups of heterotrophic bacteria have been isolated except in instances where selective procedures were available for obtaining pure cultures of bacteria.

Table 6 : Bacteria isolated from Water samples of Haulover Canal and Mosquito Lagoon (1st Collection)*

Medium No.	Water Samples	Microbial Group expected	Remarks - Colony Characteristics
1.	1L, 2L, 3L, 4L, 6L, 2H.	Actinomycetes Nocardia Streptomyces ? Micromonospora Arthrobacter	Wrinkled white or pigmented colonies, some embedded in agar.
2.	1L, 3L, 4L, 6L, 2H, 2L,7L.	Bacillus sp.	Spreading colonies; small pinpoint colonies.
3.	2L, 5L, 6L.	Slight growth Pseudomonas. Alcaligenes	Aerial mycelia absent in 2L; no proteolysis in 5L; aerial mycelia present in 6L.
4.	2L, 4L, 2H, 3L, 5L, 6L, 7L.	Moraxella Acinetobacter	Pinpoint white colonies; colorless small (< 1 mm) colonies in 6L & 7L.
5.	1L, 2H.	Cytophaga	White and yellow colonies embedded in agar; small purple colonies Micromonospora.
	7L	---------	Spreaders on agar surface, Bacillus ?
	2L, 3L, 4L, 5L, 6L.	----	Moist glistening large colonies; off-white 'haloed'colonies.

---

* Samples collected on December 21, 1974

Table 7 : Bacteria isolated on differential-selective media after Enrichment.

Medium	Sample	Reaction	Remarks
Simmons citrate agar	2H	discoloration	Ammonia released from inorganic $(NH_4)_2HPO_4$ small moist glistening colonies also present.
Actinomycetes isolation agar	2H	isolated colonies from 1, 2, and 4.	Rough, wrinkled with raised edges, probably Mycobacterium sp.

Table 7 : (continued)

Medium	Sample	Reaction	Remarks
	Colonies transferred from crystal violet agar to medium 3	Slow growing at first, then rapid	Large moist, brown colonies on pseudomonas F agar; organisms motile gram negative, *Pseudomonas* sp.
	and glucose-asparagine agar	Mycelia fragmented white cottony mycelia on crystal violet agar	*Nocardia* sp.
Mannitol salt agar	2H, 5L	Moist, golden yellow colonies, small pinpoint colonies	Gram positive cocci in clusters, *Staphylococcus* sp., pellicle on agar surface in tube, *Micrococcus* sp. ?
Yeast extract mineral salts and 0.2% nicotine	2H, 1L, 7L	Colonies transferred from actinomycetes isolation agar crystal violet agar	Short gram +ve rods (young cultures) → gram variable cocci, (old cultures)-- *Arthrobacter* sp.
Veilonella agar	2H, 2L	Slight growth	Probably not Veilonella, still under study

Table 8 : Some bacteria isolated on different media at 30°C after 5 days of incubation (Samples selected at random from 2nd, 3rd, 4th, and 5th collections) - Water.

Sample No.	Fluid thioglycollate broth	Actinomycetes isolation agar	Pseudomonas isolation agar	Crystal violet agar	Methyl red Voges Proskauer medium	Indole nitrate broth	Koser citrate broth
4L-5th	+++		-				
6L-3rd	+	-					
6L-5th	++	++		+			
5L-5th	++	+			⊕/ -	+	-
2L-5th	+	+					
5L-5th	+	+		-			
3L-5th	+	+					
2H-5th	++	+		+	⊕/ -	+	_
3L-5th	+	+		+			
7L-5th				+			
1L-5th				+			
3L-2nd	+			+			
2L-2nd			+	+			

\+ Indication of bacterial growth. - No bacterial growth.

⊕ Methyl red/Voges Proskauer test inconclusive.

Table 9 : Isolation of some heterotrophic bacteria from water samples on various media after incubation at 37°C for 5 days.

Sample No.	Fluid thio-glycollate broth	Eijkman lactose broth	Nitrogen free medium	Brilliant green agar	Heart infusion agar
1H-1st*			+		
2H-2nd					+
2H anchor*-2nd					+
2H-5th				+	
5L-5th	+	+			
7L-5th				+	
4L-5th				⊕, gas	

* anaerobic cultures. + indication of growth. ⊕ gas produced.

Table 10 : Isolation of some heterotrophic bacteria from selected water samples on various media after 5 days of incubation at 45°C.

Sample No.	Phenol red lactose broth	Bassal nitrate medium	Eykman lactose broth	Enteroscoccus confirmatory agar	Methyl red Voges proskacur	Urea broth	Peptone Nitrate broth	Uric Acid
5L-5th	+	-	+	-		-	-	
1L-5th		-	+	+	⊕	-		-
7H-5th		-	+					
4L-5th			+					-
7L-5th	+	-	+	+				
2H-5th	+		+			-	+@	-
6L-5th			+	+	⊕	-		-
3L-5	+	-	-	+		-		-
2H-1st	x		+			-	$	-
1H-1st	*		+				$	-
2L-5th				+	-	-		-

$ grawn at 42°C, produced bluish-gree pigment, green in presence of ethanol,

@ green in presence of tartrate.

Table 11 : Isolation of some heterotropic bacteria from selected sediment samples on various media after 5 days of incubation at 37°C

Sample No.	Fluid thioglycollate medium	Ejkman lactose broth	Peptone nitrate broth	DRCM* + polymixim	RCM*	Brilliant green agar	N_2-free* medium	Baars-* lactate sulfate	Heart infusion agar
4L-B *		+		+	+		+		+
3L-T*			-	+,H_2S					+
1L-B*							+		+
3L-B*				+	+,H_2S			-	+
6L-B*			+		+		+		
1L-T*							+	+	
5L-T*		+		+, H_2S			+	-	
5L-B*	+	+							
7L-T*	+	+							
2L-B	+			+	+				
4L-T*	+	+							

RCM - reinforced clostridial medium; DRCM- differential reinforced clostridial medium; * anaerobic cultures

Table 12 : Isolation of some heterophic bacteria from selected sediment samples on various media after 5 days of incubation at 45°C

Sample No.	Basal nitrate medium	DRCM + polymixim	Peptone nitrate broth	Uric Acid medium	Baars lactate sulfate broth	Urea* agar	Urea bath
1L-T/B	+				+		
2L-B				-	+		-
3L-B		-		-	+		-
4L-B	+	-	-	-	-	-	-
5L-T		-					-
6L-B		+, H_2S				-	-
7L-T		-				-	-

* for testing the presence of alkaline-tolerant bacteria; [illegible]

Discussion of Results of Microbiological Studies. The first phase of this study has been devoted to the isolation of bacteria and actinomycetes from selected water and sediment samples. Because the extensive testing is usually involved in the confirmation of a single genus, the characterization and identification at the specific level is even more involved. Consequently, only a few pure cultures have been isolated at this time. These include organisms isolated from samples 7L-5th, 2H-1st, and 1H-1st at 42°C on media containing ethanol or tartarate (Table 10). These bacteria were gram negative, motile rods, oxidative in their metabolism and produced water-soluble pigments or light brown pigment (2H, Table 7). The fluorescent pigment producing bacteria that grew at 42°C were *Pseudomonas aeruginosa*; those that produced a buff or light brown pigment were *P. stutzeri* (13). *Arthrobacter* species (2H, 1L, & 7L, Table #7) have not been identified to the specific level.

Table #6 shows the occurrence of aerobic actinomycetes (coryneform bacteria) in water samples 1L, 2L, 3L, 4L, 6L and 2H. Of the many coryneforms expected, only *Nocardia* sp. has been confirmed because actinomycete morphology varies with the medium as is shown in Tables 7 & 8 (14). Thus *Nocardia* species recovered from 2H (Table 7) had white cottony mycelia on crystal violet agar while appearing as fragmented rods on actinomycetes isolation agar. Further growth on nutrient gelatin and antibiotic-forming tendencies are among several more tests required to establish the identity of individual actinomycetes. Screening media such as fluid thioglycollate broth (without indicator) yield a variety of aerobic and facultatively anaerobic bacteria (Tables 8, 9, 11) such as Enterobacteriaceae, although it can also be used for primary isolation of Clostridia (9). Crystal violet agar nutrient enriches for pseudomonads yet is also used for differentiation of Staphylococci (Table 7) which also grow on brilliant green agar (9, 10, 14).

The extensive tests required for pure culture isolation has prompted us to isolate groups of bacteria, store them in stock culture agar for later pyrochromatographic analysis. It would appear that pure cultures would serve as 'reference'organisms whereas mixed cultures would be preferred in correlation studies of microbial interaction with organic and inorganic materials in water and especially sediment samples (8, 15, 16). Since media such as malonate broth, Koser citrate broth, indole nitrate broth and heart infusion agar will support the growth of a variety of bacteria, the large number of tests required to differentiate these organisms will lend support to the development of alternative rapid procedures for bacterial isolation. We feel that pyrolysis-gas-liquid chromatography will be such a procedure, especially if bacterial components are also analyzed.

Other workers (17) have adapted gas chromatography to the presumptive identification of coliform bacteria. We have used traditional methods to establish the presence of fecal coliform bacteria at 45°C in Eijkman lactose broth (Tables 9, 10, 11). The identity of fecal streptococci requires more stringent procedures (18, 19a) and organisms suspected to be fecal streptococci (growth on enterococcus confirmatory agar , Table 10) will be further analyzed biochemically later on.

There seems a preliminary indication of correlation between physico-chemical parameters and microbial activity. The occurrence of facultative and anaerobic bacteria, possibly denitrifying bacteria and/or Clostridium pasteurianum, on nitrogen-free and peptone-nitrate media (Table 9, 10, 11) may explain the low levels of nitrate nitrogen recorded in some samples (18, 19,b 20). These samples also contained fairly high amounts of ammonia nitrogen. RCM and DRCM media were used to isolate clostridia especially Cl. perfringens. The production of hydrogen sulfide may account for the pungent smell encountered in sampling site 6L (Tables 11, 12) near the village

Oak Hill. However, sulfate reduction per se does not suffice to explain the possible contamination of the Mosquito Lagoon by domestic waste, especially since some non-fecal indicator organisms can also produce hydrogen sulfide (8, 9,). Two sites,6L-B and 4L-B, yielded positive cultures on tellurite glycine agar, and although this suggests the presence of non-typhoid Salmonella species, confirmation of these salmonellae will be achieved only through serological and other tests (9, 21).

EVALUATION OF RESULTS AND CONCLUSIONS

General Trends in the Concentration of Major and Minor Constituents of Water Bodies. One of the significant findings in this study is a spring maximum in slainity, electrical conductivity and in the concentration of most of the elements in samples collected from each site as a function of time. Figure 2 is a plot of percent salinity versus periodic time of collection starting the time of first collection as zero. It is obvious from this figure that the salinity at a given site increases progressively from december onwards showing a maximum during the month of May after which it decreases and then begins to increase slightly. Furthermore, Tables 1-W(a) to 5-W(a) and Figure 2 show that, in general, the salinity of water samples at each collection time increases from 1H to 5L (from West end of Haulover canal onwards) and drops of slightly in 6L and 7 L. The latter observation may be the result of dilution of ocean water with less saline water from the land near the village Oak Hill. The seasonal variation in salinity may be the result of precipitation and temperature changes and possibly due to the difference in the influx of water from the ocean to the estuary. The phosphate concentration of the water samples collected from each site also shows a remarkable increase in the month of May while nitrate-nitrogen is hardly detectable at this time.

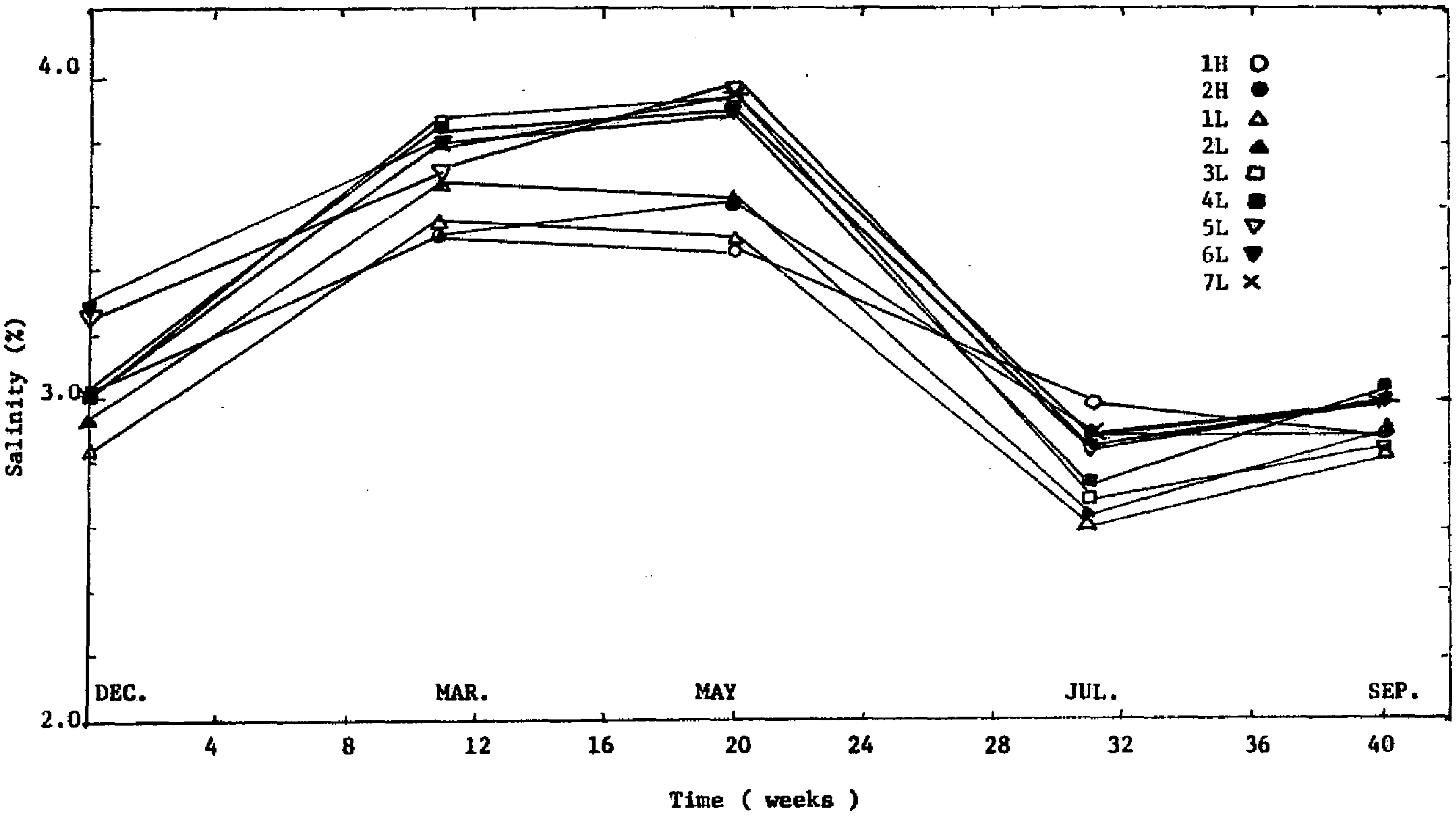

FIGURE 2 . SEASONAL AND LOCATIONAL VARIATION OF SALINITY IN ANALYZED WATER SAMPLES

Examination of Tables 1-W(b) to 5-W(b) and 1-W(c) to 5-W(c) for water samples will clearly show that the concentrations of both major and minor constituents vary location-wise as well as from season to season. Such variations in the elemental composition of samples collected from different locations have been observed elsewhere by previous workers (22). The concentrations of major cations and anionic species on water samples collected at each time increase location-wise from 1H to 5L and then decrease slightly in 6 L and 7L. There is a strong corelation between the salinity variation and the variation in the concentrations of major ionic specieis in water.The variation in electrical conductance also parallels that observed in salinity and elemental distribution in samples. Although the seasonal variation in concentration of major constituents is remarkable, it cannot be attributed to environmental pollution. We are interested in the concentration pattern of trace elements including the phosphate. The results presented in Tables 1-W(c) to 5-W(c) do not reveal the presence of any spring maximum in the concentration levels of the trace elements we have studied, similar to what we observed in the concentration levels of major constituents. However, iron and chromium show relatively larger concentration gradients over the rest throughout the sampling area at each collection. Furthermore, there is an inverse relation between the seasonal vafiation in the concentration of these two elements and that of the major constituents. Iron and chromium concentrations seem to decrease as a function of time from the begining (Dec. 21) to the end (Sept. 27) of the collection period. Partial removal of these two heavy transition metals from water during the sampling period may be attributed to either precipitation at the measured ph of 7 or more of the costal water or uptake by organisms of various kind. Marlini et al (23) have reported that fresh-water plants which fall in the family of Macrophytes have the highest concentration of iron among heavy metals and the fish population (especially the Alburnus) also absorb substantial amounts of iron from water. It is possible that during the spring and summer months the iron content of water gets depleted by its assimilation by various marine organisms. The accumulation and metabolic activity of chromium in fish and water-plants is less known than some of the other trace elements so that its removal from water can, at this time, be attributed mainly to sedimental process. The concentrations of all the trace elements, given as upper values, are believed to be within the permissible limits for esturine waters.

General Trends in the Concentration of Major and Minor Cations in Interstitial Water and Ion-Exchangable Fraction of Sediment Samples. The results of analysis of the interstitial water of the sediment (Table 2-S(b) to Table 5-S(b)) do not shed much light on the distribution pattern of the trace element except the fact that zinc and chromium levels show a gradual increase from March to May and then decrease.. In general, the concentrations of trace elments in the interstitial water of sediment seem to be higher than those obtained from surface water samples collected from the same sites. The trace elements in the interstitial or mechanically removable fraction may be considered as elements resulting from recent sedimentation and sticking to the surface loosely in ionic or combined state with ligands. This may account for the larger concentration of these elements in interstial water than in surface water bodies. The more tightly held cations in the sediment samples are removed by the cation-exchange mechanism with ammonium acetate extraction. This fraction of the trace elements may have been accumulated in the sediment as a result of precipitation for a long period of time. Comparison of Tables 2-S(c)-to 5-S(c) with Tables 2-w(b) to 5-W(b) and 2-W(c) to 5-W(c) clearly shows that there is large difference in concentration of both major and minor elements between these sediment fraxtions and water samples. If one can assume that the ratio of the concentrations of a given element in the ion-exchangable fraction of the sediment to its concentration in water is indicative of long range sedimentation our results suggest that out of four metals, Na, K, Mg and Ca, calcium has the strongest tendency to precipitate than the rest. It is to be pointed out that the concentrations of the four major elements in the sediment samples as shown in the tables are of the order: $Ca > Na > Mg > K$. On the other hand the concentration order of these elements in water is $Na > Mg > Ca \cong K$. The sedimentation of a given ion is governed by several factors some of which are: (a) the charge , (b) mobility and diffusion coefficient of ion, (c) speed of the water current, (d) pH of the solution, (e) presence of organic ligands, (f) direction of wind etc. Since some of these factors are common to all ionic species it was felt that the concentration of elements relative to that of a chosen reference element in water and sediment fraction will give a better picture for the corelation study. Tables 13, 14 and 15 show Ca/K, Mg/K and Zn/K ratios, respectively, in water and sediment fraction of all samples collected during the reporting period. It can be seen from these tables that the values for $(C_{Ca}/C_K)_W$ and $(C_{Mg}/C_K)_W$ remain almost constant at each collection period while that for $(C_{Zn}/C_K)_W$ varies significantly. This observation leads us to conclude that we can expect large concentration gradients for trace elements such as zinc while major elements do not show significant variations in their relative concentrations over the collection area.

It is obvious from these tables that the values for (C_{Ca}/C_K) in sediment fractions are much higher than those for (C_{Mg}/C_K) and (C_{Zn}/C_K). There is also considerable variation in the respective values at each collection time. These ratios, however, do not reveal the relative sedimentation rate between collection periods. A more suitable indicator will be the ratio of concentrations of a pair

Table 13

Ca/K Ratios in Water and Ion-exchangable Fraction of Sediment

(a) Second Collection

Sample #	$(C_{Ca}/C_K)_S$	$(C_{Ca}/K)_W$
1H@	21,86	0.593
2H	21.81	0.609
1L	11.07	0.614
2L	28.35	0.617
3L	24.60	0.581
4L	33.55	0.579
5L	22.90	0.553
6L	14.32	0.574
7L	18.31	0.571

(b) Third Collection

Sample #	$(C_{Ca}/C_K)_S$	$(C_{Ca}/C_K)_W$
1H@	49.16	0.623
2H	23.00	0.585
1L	39.16	0.578
2L	17.48	0.587
3L	24.34	0.542
4L	23.48	0.529
5L	30.66	0.555
6L	35.88	0.571
7L	37.17	0.577

(c) Fourth Collection

Sample #	$(C_{Ca}/C_K)_S$	(C_{Ca}/C_K)
1H@	50.65	1.02
2H	14.07	1.03
1L	29.45	1.06
2L	46.58	1.05
3L	22.51	0.97
4L	30.32	0.97
5L	58.51	0.97
6L	36.24	0.97
7L	24.74	0.99

(d) Fifth Collection

Sample #	$(C_{Ca}/C_K)_S$	$(C_{Ca}/C_K)_W$
1H@	65.54	0.83
2H	19.80	0.96
1L	17.24	1.03
2L	39.31	1.01
3L	40.56	1.06
4L	33.32	1.01
5L	18.83	0.92
6L	20.07	0.90
7L	19.92	0.93

@ The values for the upper and lower parts of the soil core, if available, have been averaged to give the listed values, S=Sediment, W=Water

Table 14

Mg/K Ratios in Water and Ion-exchangable Fraction of Sediment

(a) Second Collection

Sample #	$(C_{Mg}/C_K)_S$	(C_{Mg}/C_K)
1H@	3.07	1.92
2H	3.71	1.90
1L	2.72	2.00
2L	3.54	1.93
3L	3.28	1.87
4L	3.22	1.80
5L	3.55	1.69
6L	2.96	1.68
7L	3.11	1.72

(b) Third Collection

Sample #	$(C_{Mg}/C_K)_S$	$(C_{Mg}/C_K)_W$
1H@	3.37	1.64
2H	4.42	1.63
1L	2.78	1.61
2L	4.68	1.61
3L	2.91	1.60
4L	2.90	1.60
5L	2.95	1.66
6L	3.09	1.65
7L	2.63	1.65

(c) Fourth Collection

Sample #	$(C_{Mg}/C_K)_S$	$(C_{Mg}/C_K)_W$
1H@	3.39	3.07
2H	4.11	3.09
1L	2.69	3.15
2L	2.96	3.06
3L	2.74	2.92
4L	3.21	2.96
5L	3.28	2.99
6L	3.03	2.99
7L	3.07	3.08

(d) Fifth Collection

Sample #	$(C_{Mg}/C_K)_S$	$(C_{Mg}/C_K)_W$
1H@	3.27	2.5
2H	3.36	2.93
1L	2.99	3.13
2L	3.06	3.16
3L	3.04	3.11
4L	3.56	3.18
5L	2.76	3.04
6L	2.87	3.01
7L	4.17	3.10

@ The values for the upper and lower parts of the soil core, if available, have been averaged to give the listed values; S=Sediment, W= Water

Table 15

Zn/K Ratios in Water and Ion-exchangable Fraction of Sediment

(a) Second Collection

Sample #	$(C_{Zn}/C_K)_S$	$(C_{Mg}/C_K)_W$
1H@	0.022	0.000095
2H	0.032	0.000092
1L	0.009	0.000083
2L	0.020	0.000083
3L	0.035	0.000072
4L	0.025	0.000120
5L	0.037	0.000098
6L	0.010	0.000075
7L	0.020	0.000086

(b) Third Collection

Sample #	$(C_{Mg}/C_K)_S$	$(C_{Mg}/C_K)_W$
1H@	0.078	0.000062
2H	0.080	0.000056
1L	0.059	0.000082
2L	0.026	0.000096
3L	0.027	0.000054
4L	0.060	0.000091
5L	0.053	0.000073
6L	0.026	0.000074
7L	0.046	0.000109

(c) Fourth Collection

Sample #	$(C_{Zn}/C_K)_S$	$(C_{Zn}/C_K)_W$
1H@	0.071	0.00018
2H	0.041	0.00054
1L	0.0175	0.00034
2L	0.0369	0.00045
3L	0.0057	0.00032
4L	0.0090	0.00029
5L	0.0087	0.00021
6L	0.0105	0.00021
7L	0.0097	0.00027

(d) Fifth Collection

Sample #	$(C_{Zn}/C_K)_S$	$(C_{Zn}/C_K)_W$
1H@	0.0399	0.000068
2H	0.0341	0.000089
1L	0.0138	0.000087
2L	0.0146	0.000060
3L	0.0300	0.00011
4L	0.0248	0.00015
5L	0.0190	0.000066
6L	0.0144	0.000116
7L	0.0458	0.000112

@ The values for the upper and lower parts of the soil core, if available, have been averaged to give the listed values ; S=Sediment, W=Water of elements in sediment fraction and water. Figures 3, 4 and 5 are plots of such ratios, $(C_{Ca}/C_K)_S/(C_{Ca}/C_K)_W$, $(C_{Mg}/C_K)_S/(C_{Mg}/C_K)_W$ and $(C_{Zn}/C_K)_S/(C_{Zn}/C_K)_W$, respectively, versus time. These plots also show, in general, that maximum sedimentation occurs in the month of May. The sedimentation rate, which is determined by the magnitude of ratios, is of the order Zn Ca Mg. This order follows the same pattern as the stability order of the respective chelates or complexes with organic ligands (24). This may lead to the conclusion that organic molecules including microorganisms play an important role in the sedimentation or removal of trace elements from water.

The presence of both NH_4-N and NO_3-N in the sediment indicates a partially anaerobic environment. Due to continuously flowing water, the upper layers of sediments are supplied with dissolved oxygen of water and a limited amount of nitrification (conversion of ammonia to nitrate) must be going on. This situation also correlates with the appreciable concentrations of iron and manganese. Both Fe and Mn are more available in soil after treatment under reducing conditions (25). In the sediment samples studied Mn concentrations, in many instances, are greater than Fe.

WORK PLANNED FOR THE SECOND YEAR

During the second year of this project we plan to study the aquatic area of Indian river extending southwards from Haulover Canal. At present, it is contemplated that about eight sampling sites will be chosen for the collection of water and sediment samples. Sampling will be initiated in the month of January and repeated periodically until Septembet, 1976.

The physical, chemical and biological aspects of the collected samples will be studied as in the previous year. Further attempts will be made to improve the precision of measurement of trace elements in the samples. The study of some of the toxic elements which could not be determined in last year will also be taken up during the next year. The study on the characterization of

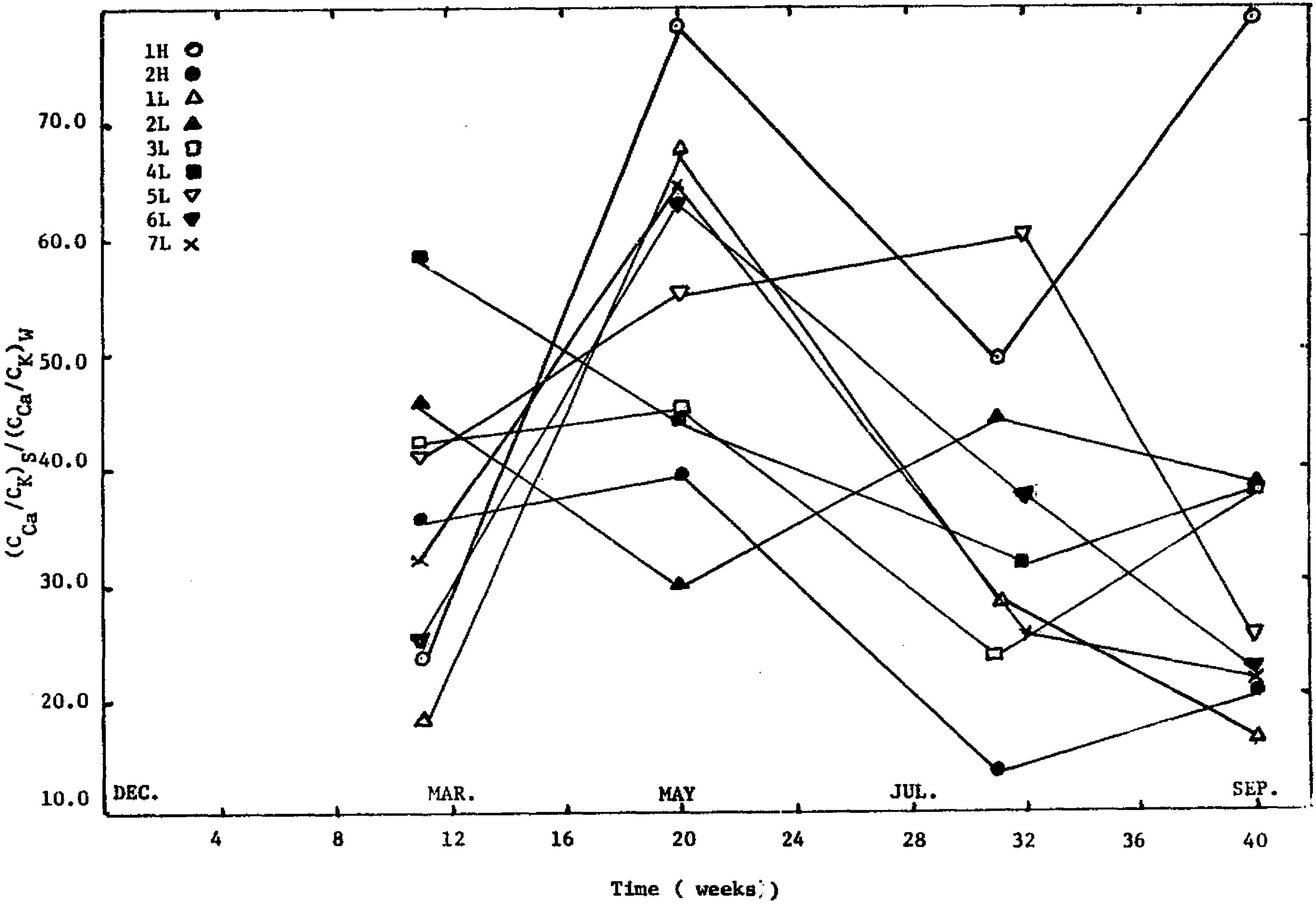

FIGURE 3 . SEASONAL AND LOCATIONAL VARIATION IN SEDIMENTATION OF CALCIUM RELATIVE TO POTASSIUM

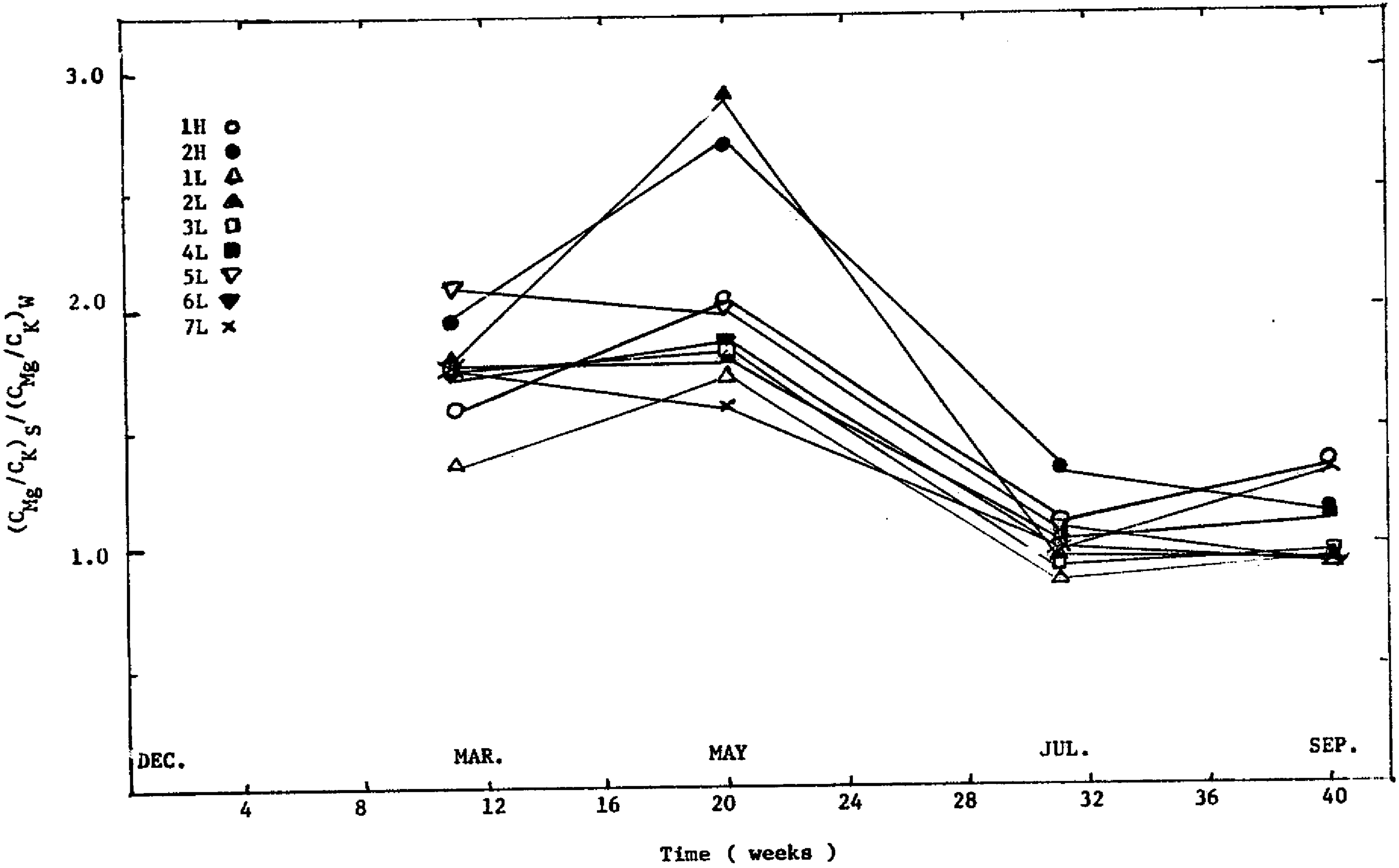

FIGURE 4 . SEASONAL AND LOCATIONAL VARIATION IN SEDIMENTATION OF MAGNESIUM RELATIVE TO POTASSIUM

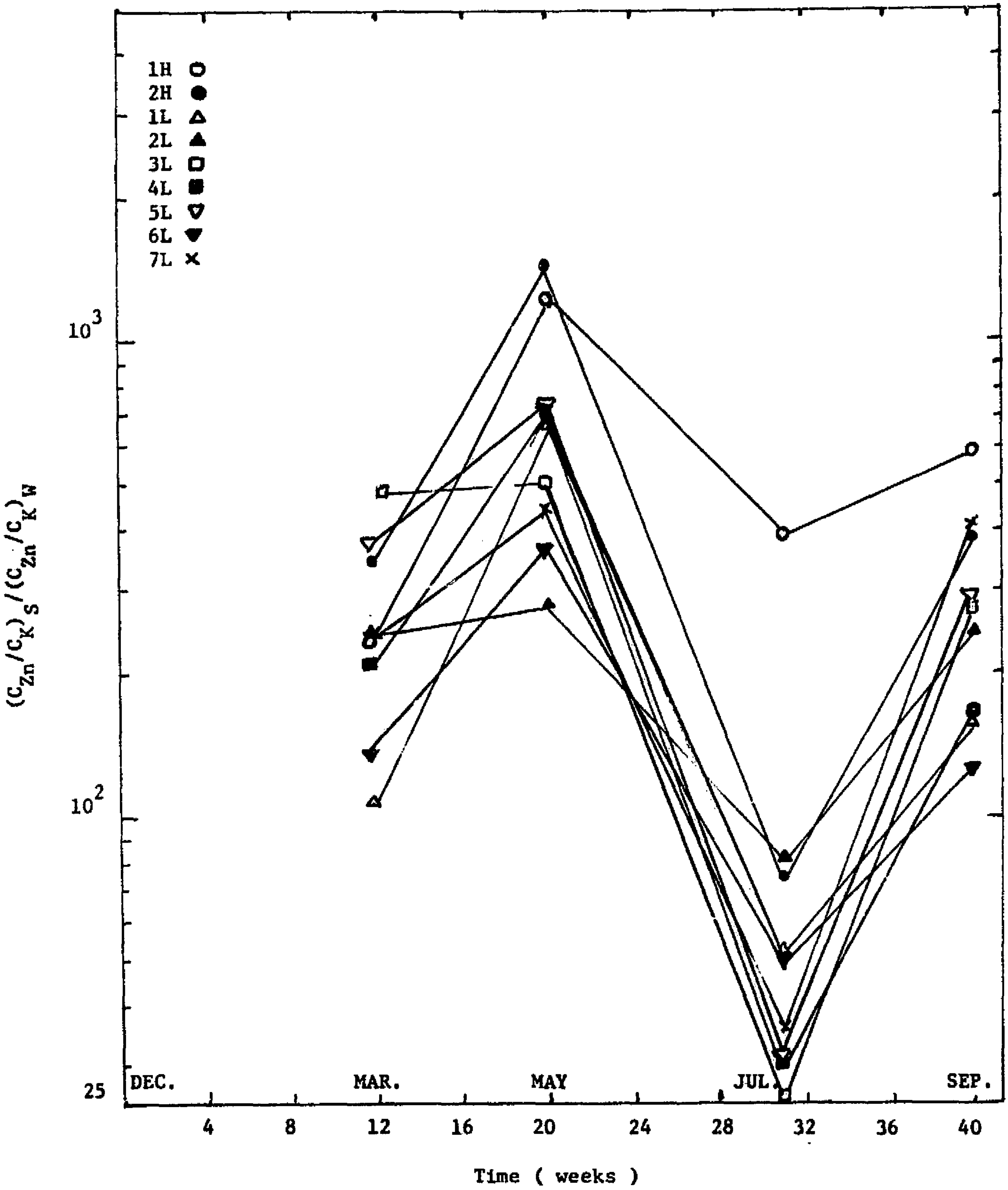

FIGURE 5 . SEASONAL AND LOCATIONAL VARIATION IN SEDIMENTATION OF ZINC RELATIVE TO POTASSIUM

micro-organisms using pyrolysis gas-liquid chromatography will be initiated.

We also plan to collect samples at least once during the second year from the previous sampling sites in Haulover Canal and Mosquito Lagoon. The purpose of this sampling is to study further the changes that might occur in the aquatic environment.

REFERENCES

1. American Public Health Association. 1971. Standard methods for the examination of water and waste water. 13th ed. New York.

2. Crowe, R. E. 1974. Methods for chemical analysis of water and wastes. U. S. Environmental Protection Agency Handbook, Washington, D. C.

3. American Society for Testing and Materials. 1975. Annual Book of ASTM Standards. Part 31 Water, Philadelphia. p. 472.

4. Bremner, J. M., and D. R. Keeney. 1965. Steam distillation methods for the determination of ammonium, nitrate and nitrite. Anal. Chim. Acta, 32:485-495.

5. Kenney, J. E., and M. P. Menon. 1972. Determination of traces of phosphorus by a radiomolybdenum method. Anal. Chem. 44:2093.

6. Hesse, P. R. 1972. A textbook of soil chemical analysis. Chemical Publishing Co., Inc. New York.

7. Carney, J. F., C. E. Carty, and R. R. Colwell. 1975. Seasonal occurrence and distribution of microbial indicators and pathogens in Rhode River of Chespeake Bay. Appl. Microbiol. 30:771-779.

8. Mitchell, R. 1972. Water pollution microbiology. Wiley Interscience, New York. p. 1-10; Sources of water pollution; p. 119-151, Stream purification; p. 305-331, Biochemical oxygen demand.

9. Skerman, V. B. D. 1967. A guide to identification of genera of bacteria. 2nd ed. The Williams and Wilkins Co., Baltimore, p. 291.

10. Gibbs, B. M., and F. A. Skinner eds. Part A; Gibbs, B. M., and A. D. Shapton eds. Part B. 1966-8. Identification methods for microbiologists. The Soc. Appl. Bact. Technical Series 1 & 2. Academic Press, London.

11. Lasater, J. A. 1972. Water quality parameters of the lagoonal complex surrounding KSC. Second Annual Report to the John F. Kennedy Space Center. NASA Grant No. NGR 10-015-008, V-10p.

12. Branson, R. et. al. 1975. Water quality in irrigated watersheds. J. Environ. Qual., 4(1):33-40.

13. Gilardi, G. L. 1975. Identification of pigmented gram negative bacilli. Health Lab. Sci., 12:311-315.

14. Cure, G. L., and R. M. Keddie. 1973. Methods for the morphological examination of aerobic coryneform bacteria. p. 123-136, in 'R. G. Board & D. W. Lovelock (eds.)-Sampling-microbiological monitoring of environments. Academic Press, London.

15. Sampling and estimation of bacterial populations in the aquatic environment. 1973. In Sampling-microbiological monitoring of environments. p. 77-106. Academic Press, London.

16. American Chemical Society. 1969. Cleaning our environment, the chemical basis for action, Washington, D. C. p. 95-164, The water environment.

17. Newman, J. S., and R. J. O'Brien. 1975. Gas chromatographic presumptive test for coliform bacteria in water. Appl. Microbiol. 39:584-588.

18. Hobbs, G., K. Williams, and A. T. Willis. 1971. Basic methods for the isolation of clostridia, p. 1-24. In D. A. Shapton and R. G. Board eds. Isolation of anaerobes, Technical series, 5. Academic Press, London.

19a. Daoust, R. A., and W. Litsky. 1975. Pfizer selective enterococcus agar overlay method for the enumeration of fecal streptococci by membrane filtration. Appl. Microbiol. 29:584-589.

19b. Sutton, R. G. A., A. C. Ghosh, and B. C. Hobbs. 1971. Isolation and enumeration of Clostridium welchu from food and feces, p.39-48. In Isolation of anaerobes., Technical series 5. Academic Press, London.

20. Freame, B., and B. W. F. Fitzpatrick. 1971. The use of differential clostridium medium for the isolation and enumeration of clostridia from food. p. 49-56. In D. A. Shapton, & R. G. Board eds. Academic Press, London.

21. Lindell, S. S., and P. Quinn. 1975. Use of bile-esculin agar for rapid identification of enterobacteriaceae. J. Clin. Microbiol. 1:440-443.

22. Dams, R., J. A. Robbins, K. A. Rahn, and J. W. Winchester. 1971. Nuclear techniques in environmental pollution. Proc. Symp., Salzburg, Oct. 1970. IAEA, p. 139.

23. Merlini, M., C. Bigliocca, A. Berg, and G. Pozzi. 1971. Trends in the concentration of heavy metals in organisms of mesotropine lake as determined by activation analysis. Ibid: p.447.

24. Martell, A. E., and M. Calvin. 1962. Chemistry of metal chelate compounds. 5th ed., Prentice-Hall, Englewood Cliffs, N.J. p.514.

25. Ghuman, G. S., and L. D. Whittig. 1969. Significance of mangano-calcite in soil chemistry. Agronomy Abs., 61st Annual Meeting. p.75.