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INVESTIGATION OF THE CURRENT STATUS OF POLLUTION AND ITS ROOT CAUSES IN A PORT, WEST OF DAMITTA CITY, EGYPT

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ABSTRACT

The A port is a marine port lying just west of Damietta City on the coast of Nile Delta, Egypt. The port is almost a closed-water basin that is subject to many forms of pollution. To evaluate the extent of pollution problem and propose feasible mitigation, measures, an intensive study was carried out. Water and sediment samples were collected at several localities inside and outside the port's basin, and these were analyzed for the following: Total Petroleum Hydrocarbons Content (surface water, and bottom sediment), Heavy metals (Fe, Cu, Zn, Pb, and Cd) in bottom sediment, and Grain size distribution (bottom sediment). The sediment samples analyzed comprised both the surface layer of bottom sediment, and sediments down two short cores. The total petroleum hydrocarbons contents in surface seawater ranged between 14.54 and 65.46 µg/l with an average of 28.66 µg/l. The surface layer of bottom sediment, exhibited concentrations between 0.156 and 4.163 with an average of 1.443 µg/g. In core No. 1 (station No. 9–General Cargo & Cement Terminal), the total hydrocarbons ranged between 4.16 µg/g at the 0-5 cm level and 80.248 µg/g at the 10-15 cm level. Core No. 2 (station No. 6–Ro-Ro Terminal), showed values between 1.85 µg/g at the 0-5 cm level and 12.432 µg/g at 10-15 cm level. The heavy metals (Fe, Zn, Cu, Pb, and Cd) were detected in surface sediments of all stations with an average of 1780 µg/g for Fe, 40.05 µg/g for Zn, 14.75 µg/g for Cu, 3.1 µg/g for Pb, and 0.014 µg/g for Cd. In core samples, the same metals showed increasing levels with depth in cores. The results point to anthropogenic contributions from different activities in the General Cargo & Cement Terminal (cargo operations and ship activities) to marine environment in the port's basin. The results indicate that the major sources of pollution are the shipping activities, and to a lesser extent the freshwater canal from the Nile branch, agricultural and industrial activities nearby the port and land-based activities inside the port as well. The study also indicates that no surface water transport of pollutants takes place from nearby areas outside the basin. The results of the study provide a useful tool for establishing an environmental management strategy for the port.

1. INTRODUCTION

A port was established in 1982 and is located about 9.7 km west of Damietta Nile branch. The port basin was erected inland and its entrance is protected by two breakwaters. The western breakwater is about 1500 meter long and runs parallel to the navigational channel down to the 7 meter-depth. The eastern one, however, is about 500 m long and is set perpendicular to the shoreline down to 3 m-depth contour. The navigational channel extends offshore to the depth of 15 meter. Since January 1984, the channel is experiencing siltation threatening the navigation activities (Anon, 1998).

Hence, the channel and basin are dredged regularly.

Physically, a port is considered a semi-closed water body that is affected mainly by loading/unloading operations taking place internally. Runoffs from surrounding area are discharged into the port through a 4.5 km-long, 90 meter-wide and 5 meter-deep canal. The port authority applies environmental quality management system to minimize pollution and protect environment inside the port and prevent the surrounding areas from being affected. The present study was undertaken to investigate the levels of pollution by some heavy metals and total petroleum hydrocarbons that will reflect the effectiveness of the quality measures applied by the port authority. Since such measures, however, can be enforced within the limits of the port area only, it was decided to study the potential transport of pollutants from the marine area outside the port.

2. MATERIALS & METHODS

2.1 Pollutants Transport Study

For this purpose, plastic floats were deployed at selected locations outside the port basin as shown in Table (1) and Figure (1). The drifted floats were then collected as they reached the shore and the drift paths of floats relative to their release locations were constructed.

2.2. Water Sampling & Analysis

Surface water samples were collected using 5 L-glass bottle at eight sites for the determination of the Total Petroleum Hydrocarbons Content (THC). Two of the sampling sites were along the navigational channel and the rest were from other parts in the port basin, Table (1) & Figure (1).

Water samples were extracted in the field. One liter-volumes were poured into 2 L-glass separating funnels and extracted twice with 40 ml of methylene chloride each. The extracts of each sample were then combined together and kept in tightly closed glass bottles.

In the laboratory, the extracts were rotary-evaporated at 30°C under reduced pressure, and the residues were then dissolved in 10 ml n-hexane. The Total Hydrocarbons Contents were fluorometrically determined at 415 nm after excitation at 360 nm using a UV Sequoia–Tuner Model 450 spectrofluorometer according to Parsons *et al*. (1985) with Chrysene being used for standardization and n-hexane as diluent.

2.3. Sediment Sampling & Analyses

The surface layer of bottom sediment was collected at ten sites (Table 1 & Figure 1) using a stainless steel Peterson grab sampler. The samples were kept frozen till opened for analysis at laboratory.

Since the harbour is dredged frequently, the surface layer of bottom sediment may not reflect the true conditions in the port. Accordingly, two short cores were obtained by diver from the two main active platforms as shown in Figure (1). The cores were kept frozen till opened for analysis in the laboratory.

Since the particle size of sediment controls the physicochemical processes on the sediment particle surfaces, it was necessary to study the mechanical characteristics of the sediments collected. For this purpose, subsamples of collected sediment taken by quartering were washed, dried and analyzed using the sieve method. The subsamples were placed onto the topmost sieve and the entire column was shaked on a mechanical shaker for about 15 minutes. The sieve meshes give the class intervals 1000, 500, 250, 125, 63 and 31 µm.

For the determination of Total Petroleum Hydrocarbon Content (THC), 10–20 gm portions of sediment samples were freeze-dried, soxhlet-extracted with methylene chloride. The siphon cycle was about 20-30 min. and was repeated at least 10 times. After complete extraction, the extracts were evaporated at low temperature (30°C) to volumes less than 20 ml. The extracts were then transferred to a 25 ml-measuring flasks. The soxhlet extraction flask was then rinsed with methylene chloride and rinse was used to make the volume up to 25 ml. Three milliliters of extracts were then transferred to 10 ml-measuring flasks and volumes were made up to 10 ml mark with n–hexane for spectrofluorimetric analysis. Determinations were made using a UV Sequoia–Tuner Model 450 spectrofluorometer at 415 nm after excitation at 360 nm according to Parsons *et al*. (1985) with Chrysene being used for standardization.

For the determination of environmentally available contents of trace metals in sediment (trace metals admitted by pollution and readily available for re-release into the environment), the dilute acid technique adopted by Rifaat (1990) was applied. One-gram portions air-dried samples were extracted using 50 ml-aliquots of 25% glacial acetic acid at room temperature. The extracts were evaporated to near dryness and cakes were dissolved in 10 ml volumes of deionized water and volumes were brought to 25 ml in volumetric flasks. Fe, Zn, Pb, Cd, and Cu were determined by Flame and Flameless Atomic absorption spectrophotometry (AAS) against relevant standards.

Table (1): Locations of floats, surface water, sediment and core samples.

Position	Station No.	Fieldwork	Floats Group No.	Remarks
Lat.: 31 34.80 N Long.: 31 46.40 E		**F[1]**	Group No. 10	
Lat.: 31 35.70 Long.: 31 46.10		**F**	Group No. 9	
Lat.: 31 35.70 Long.: 31 45.20	St. No. 1	**F, W[2] & S[3]**	Group No. 8	Depth:15m
Lat.: 31 36.20 Long.: 31 44.70		**F**	Group No. 7	
Lat.: 31 36.50 Long.: 31 45.20		**F**	Group No. 6	
Lat.: 31 35.80 Long.: 31 45.80		**F**	Group No. 5	
Lat.: 31 35.50 Long.: 31 46.90	St. No. 2	**F, W & S**	Group No. 4	Depth: 15m
Lat.: 31 34.90 Long.: 31 46.40		**F**	Group No. 3	
Lat.: 31 34.80 Long.: 31 46.40		**F**	Group No. 2	
Lat.: 31 33.90 Long.: 31 46.50		**F**	Group No. 1	
Lat.: 31 33.20 Long.: 31 46.50	St. No. 3	**W & S**		Depth: 15m
Lat.: 31 30.50 Long.: 31 45.90	St. No. 4	**S**		Depth: 14m
Lat.: 31 28.80 Long.: 31 45.30	St. No. 5	**S**		Depth: 14m (Turning Area)
Lat.: 31 28.20 Long.: 31 45.20	St. No. 6	**W & S**		Depth: 14m Part of recently dredged channel
Lat.: 31 28.20 Long.: 31 45.20	Core No. 2 50 cm	**C[4]**		Ro-Ro Terminal
Lat.: 31 27.80 Long.: 31 45.40	St. No. 7	**W & S**		Depth: 14m
Lat.: 31 27.30 Long.: 31 46.00	St. No. 8	**W & S**		Depth: 11m
Lat.: 31 27.20 Long.: 31 46.30	St. No. 9	**W & S**		Depth: 8m Part of recently dredged channel
Lat.: 31 27.20 Long.: 31 46.30	Core No. 1 30 cm	**C**		General Cargo &Cement Terminal
Lat.: 31 28.41 Long.: 31 45.80	St. No. 10	**W & S**		Depth: 14m (Grain Terminal)

1 F: Floats 2 W: Water sample 3 S: Surface layer of bottom sediment sample 4 C: Core sample

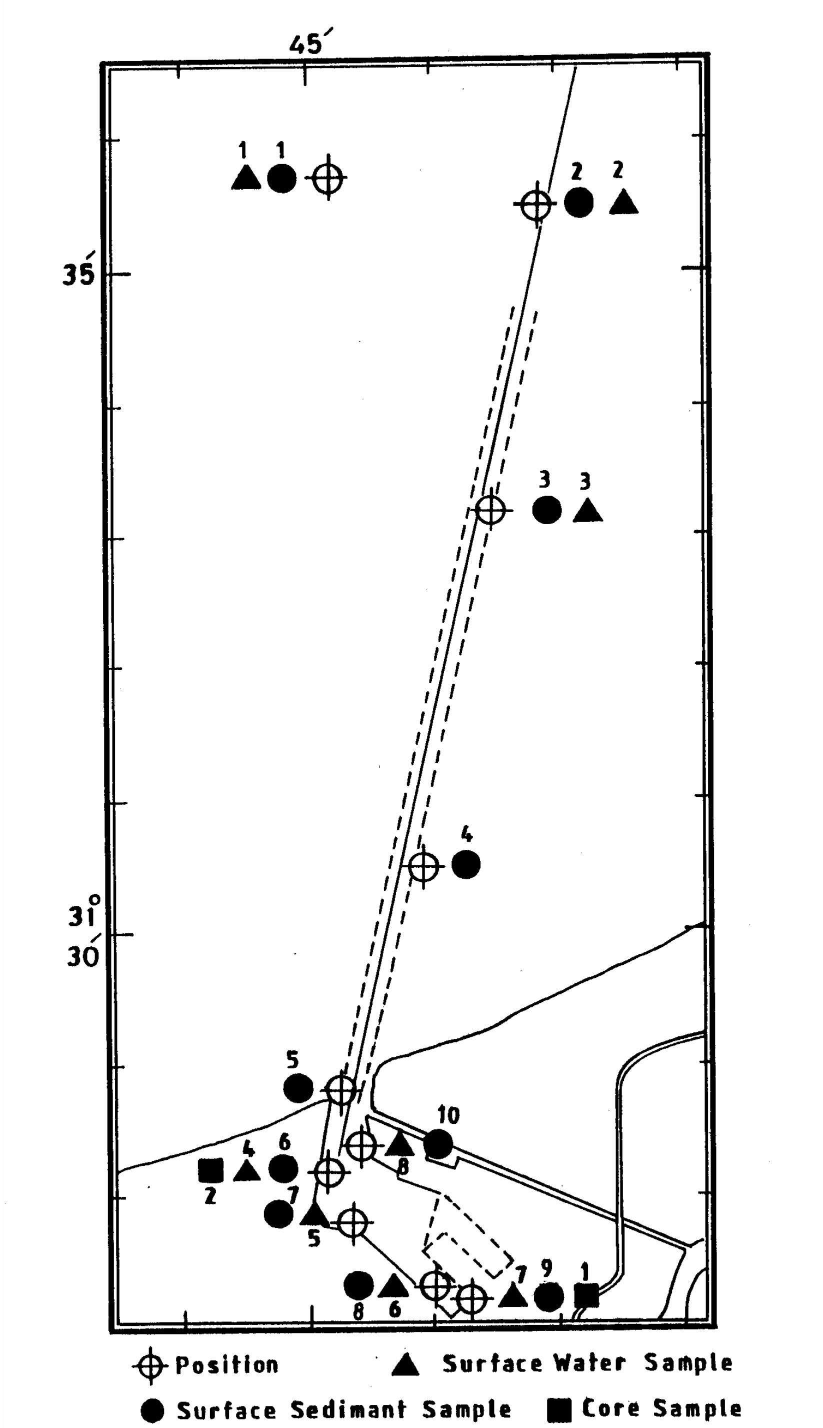


Fig. (1): Location of study area and sampling sites.

3. RESULTS

3.1. Surface water transport

The results of the floats experiment in front of A port showed that 9% of the total deployed floats reached the coast within short time. The locations of these retrieved floats were mainly in Port Said Harbour, A port, and along Port Said coast. The floats were transported by coastal currents that direct the water towards the coast. These currents move southeast with variable speeds between 8.29 cm/sec.: 13.62 cm/sec. The rest of deployed floats (91%), however, traveled far away from the area, and none of them entered the port. This indicates that under the prevailing weather conditions during the present experiment, no surface pollutants might enter the A port from the anchorage and nearby areas.

3.2. Grain Size Distribution

Table (2) gives the results of grain size analysis of samples of surface layer of bottom sediment collected from the A port area in the present study.
Apparently, sediment in the study area are fine to very fine grained; a texture typical of Nile Delta deposits.

3.3. Total Petroleum Hydrocarbon Content (THC)

3.3.1. THC in Seawater

The total hydrocarbons contents of seawater samples are given in Table (3). The values ranged between 14.55 and 65.46 µg/l with an average of 28.66 µg/l. The highest value (65.46 µg/l) was detected at station No. 2 in the waiting area, while the lowest one (14.55 µg/l) was determined at station No. 9 inside the port. These concentrations are much lower than those reported by Lucas and Roux (1975), Dunnimg and Major (1976), and Mazmanidi *et al*. (1976). The THC that induces harmful effects on living organisms in seawater is in the range of 50 µg/l**.**

The highest THC (65.46 µg/l) at station No. 2 is probably related to local pollution from activities of ships in the Waiting Area of the port. The following higher concentration of total hydrocarbons (56.73 µg/l) at station No. 6 is probably connected with the greater number of cargo vessels being loaded and unloaded at the General Cargo Terminal. In general, the results indicate that THC of seawater inside the port is lower than outside it. It's likely that municipal runoffs from Damietta Governorate are contributing to the levels of hydrocarbons in the semi-enclosed water body of the port. Therefore, the THC's recorded in seawater of the port might be reflecting increasing anthropogenic activities in and the near by areas.

Table (4) gives the levels of hydrocarbons in seawater reported from different marine regions. Whaby and El-Deeb (1980) reported hydrocarbons concentrations ranging between 0.60 and 41.40 µg/l in the seawater off Alexandria. In a latter study in the same area, however, Emara & Shridah (1995) reported hydrocarbons concentrations showing wider variations (nil-282 µg/l) with general decreasing trend from El-Max, Eastern Harbour to Abu Qir Bay.

Table (2): Mechanical characteristics of bottom sediment, A port, 2006.

Sample No.	Depth (meter)	Sand (%)	Silt (%)	Clay (%)	Mean grain size (mm)	Sediment Type	Nomenclature
1	15	54.98	28.98	16.05	0.065	Very fine sand	Silty sand
2	15	45.17	38.02	16.81	0.051	Coarse silt	Silty sand
3	15	93.77	4.24	1.99	0.230	Fine sand	Sand
4	14	64.54	15.52	19.94	0.065	Very fine sand	Silty sand
5	14	19.58	11.11	69.31	0.007	Very fine silt	Sandy clay
6	14	58.73	5.67	35.60	0.040	Coarse silt	Clayey sand
7	14	23.21	12.05	64.73	0.009	Fine silt	Sandy clay
8	11	16.51	15.60	67.89	0.007	Very fine silt	Sandy clay
9	8	39.57	3.73	56.68	0.012	Fine silt	Sandy clay
10	14	6.67	13.21	80.12	0.004	Clay	Clay

Table (3): Total Petroleum Hydrocarbons Content (THC) of seawater in A port, 2006.

Station No.	THC (µg/l)
1	21.82
2	65.46
3	16.73
4	18.18
5	20.00
6	56.73
7	14.55
8	15.82
Average	28.66 ± 20.28 (S.D)

Table (4): Levels of THC in seawater (µg/l) from different marine regions.

Region	Area	Range	Mean	Reference
Suez Canal	- Suez Canal - Suez Canal	0.17–59.70 0.15–13.75	14.80 2.10	*El-Agroudy, 2001* *El-Samra et al, 1983*
Red Sea	- Saudi Arabia Coast - Saudi Arabia Coast - Suez Gulf - Suez Gulf	18.80–412.00 35.00–612.00 7.00–10.28 4.50–18.00	147.20 174.00 10.28 18.00	*Awad,1990* *Awad, 1988* *Said, 1992* *Said, 1996*
Arabian Gulf	- Saudi Arabia Coast - Saudi Arabia Coast	0.19–3.47 4.30–546.00	0.89 111.00	*Ehrhd & Burns, 1993* *El-Samra et al, 1986*
Mediterranean	- Alexandria Coast - **A** port	0.60–41.40 14.55–65.46	12.00 28.66	*Wahby & El-Deeb, 1980* Present Study

3.3.2. THC in surface sediment

As shown in Table (5), the total hydrocarbons contents in surface sediment samples ranged between a minimum of 0.16 (St.3) and maximum of (St.9) 4.16 µg/g with an average of 1.44 µg/g. The high concentrations of hydrocarbons observed at stations 8 & 9 may be due to shipping activities (cargo gears, general cargo handling, and the relatively long stays of general cargo ships at the General Cargo Terminal inside the port). In addition, the port receives agriculture, industrial, and municipal effluents from the heavily populated surrounding area, and it's likely that contaminants from these effluents are accumulated in bottom sediment particularly during low-flow conditions.

Table (6) gives the levels of hydrocarbons in surface sediments from different marine regions. Awad (1981) investigated the levels of petroleum hydrocarbons in surface sediment samples from 5 sites (15 m in depth) in the vicinity of Alexandria Harbour. The sediments contained comparatively very high levels of total hydrocarbons ranging between 22.02 and 23.42 mg/g of dry sediment.

Table (5): Total Petroleum Hydrocarbons Content (THC) in surface sediment in A port, 2006.

Station No.	THC (µg/g)
1	0.39
2	0.16
3	0.16
4	0.94
5	0.88
6	1.85
7	1.50
8	3.98
9	4.16
10	0.41
Average	1.44

Table (6): Levels of petroleum hydrocarbons in sediments (µg/g) from different marine regions.

Region	Area	Range	Mean	References
Suez Canal	Suez Canal	2.91-127.70 0.04-2.45	32.70 ±62.96	El-Agroudy, 2001 El-Samra et al,1983
Red Sea	Saudi coasts	10.30-803.00	326.90±560.52	Ehrhard & Burns, 1993
Mediterranean	**A** port	0.16-4.16	1.44±2.83	Present study

3.3.3. Total petroleum hydrocarbons in cores

Surface sediment reflects the current and near past condition in an area, while studies of cores reveal the history of the area. As shown in Figure (2), the concentrations of petroleum hydrocarbons in core No. 1 (General Cargo & Cement Terminal) ranged from 4.16 µg/g to 80.25 µg/g with an average of 43.16 µg/g. The highest concentration (80.25 µg/g) was found in the 10-15 cm interval of the core, while the lowest one (4.16 µg/g) was found in the 0-5 cm interval of the core. Core No. 2 (Ro-Ro Terminal), Fig. 3 showed values between 1.85 µg/g and 12.43 µg/g with an average of 6.79 µg/g. The highest concentration (12.43 µg/g) was found in the 15-20 cm interval of the core, while the lowest one (1.85 µg/g) was detected in the 0-5 cm interval of the core. Thus, the older sediments contain higher concentrations of petroleum hydrocarbons which may reflect relaxed environmental policies in the harbour in the near past. Comparing the two cores, however, it is evident that there is reflection of the intensity of activities taking place at each terminal on the petroleum hydrocarbons concentrations; i. e. the highest values are found in the General Cargo Terminal area where greater numbers of ships (1047 ship in 2004) stay alongside the terminal probably dumping their sludges there.

3.4. Heavy Metals

3.4.1. Heavy Metals in Surface Sediment

The concentrations and mean values of heavy metals (Fe, Zn, Pb, Cd, and Cu) are given in Table (7). The iron contents ranged between 0.41 µg/g (near Waiting Area) and 1814.30 µg/g (in front of Grain Terminal). The zinc concentrations ranged between 0.04 µg/g (near Waiting Area) and 64.68 µg/g (Entrance of port). Lead was detected in three of the samples only with contents ranging between 1.84 µg/g near the Waiting Area & in front of General Cargo and Cement Terminal), and 5.51 µg/g at the Ro-Ro Terminal. Cadmium was not detected in all samples except of that from the General Cargo & Cement Terminal whereas a value of 0.14 µg/g was recorded. Copper ranged from 0.01 µg/g in the Waiting Area to 21.9 µg/g at the Ro-Ro Terminal. Jeftic *et al*. (1990) reported total heavy metals contents of 20-425 ppm Zn, 29-280 ppm Cu, and 0.16-2.0 Cd for sediment from Damietta Estuary reveling higher than that of the present study.

3.4.2. Heavy Metals in Core Samples

Trace metals analysis was carried out for two short cores collected from A port area. Core No.1 was collected from the General Cargo & Cement Terminal inside the port basin, while core No. 2 was collected from the RO-RO terminal. The contents of environmentally available heavy metals in core No. 1 are given in Table (8) and presented in Figure (4).

Apparently, all metals except that of cadmium show their highest levels in the top 0-5 cm interval of the core with different variation patterns downward. Copper and lead show decreases from their maximum values in top layer of core followed by more or less steady concentration patterns downside the core, while zinc shows a fluctuating pattern downwards. On the other hand, cadmium increases from minimum (0.14 µg/g) at top to maximum (2.60 µg/g) in the 10-15 cm interval after which it drops to almost half value (($\approx$ 1.25 µg/g) in the 15-20 & 20-25 cm intervals that is followed by another drop to 0.50 µg/g in the bottom interval (25-30 cm) of core.

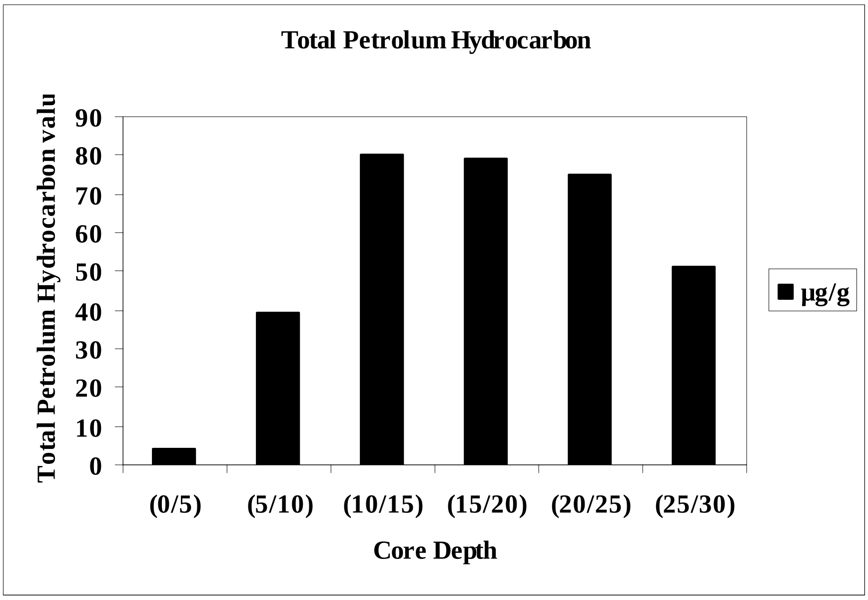


Fig. (2): Total petroleum hydrocarbons in Core No. 1 (General Cargo & Cement Terminal).

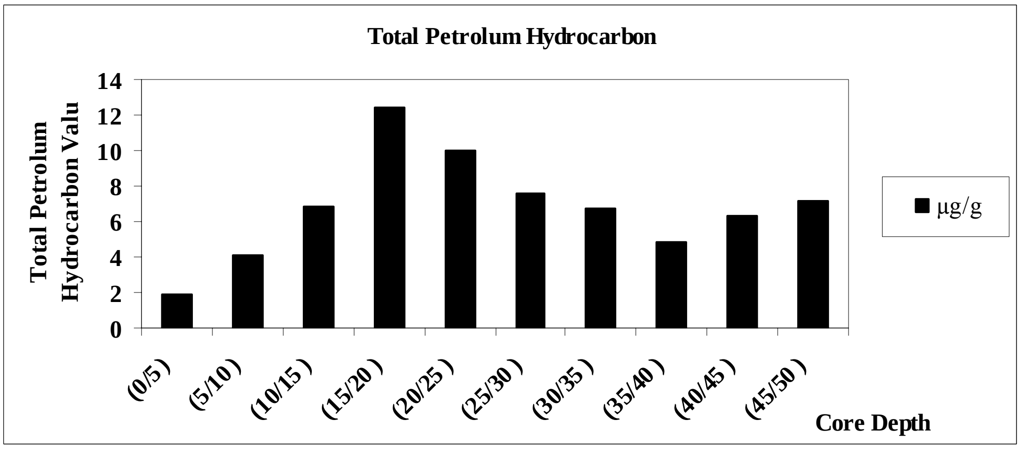


Fig. (3): Total petroleum hydrocarbons in Core No. 2 (Ro-Ro Terminal).

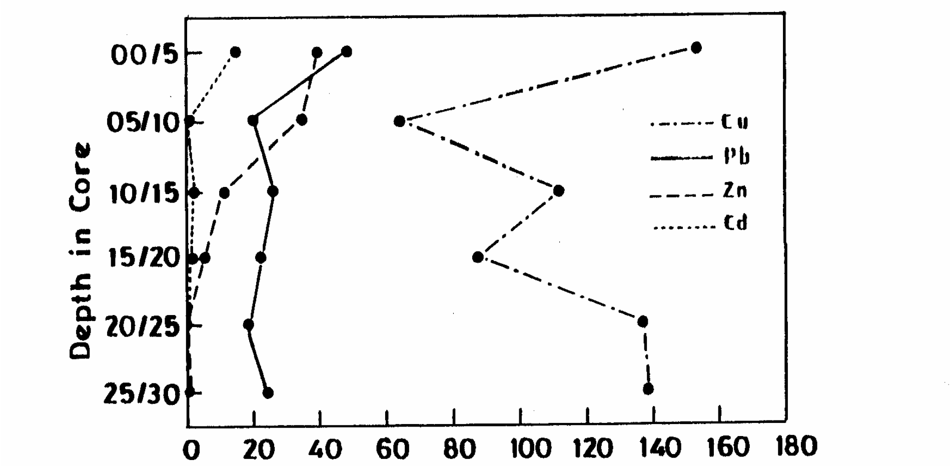
Table (7): Heavy metals (µg/g) in surface sediment in A port, 2006.

Station No.	Fe	Zn	Pb	Cd	Cu
1	0.65	0.04	ND	ND	0.01
2	0.41	0.04	ND	ND	0.02
3	1779	31.53	1.84	ND	11.88
4	1769	42.26	ND	ND	13.36
5	1774	64.68	ND	ND	13.73
6	1779	56.56	ND	ND	21.9
7	1799	50.71	5.51	ND	17.81
8	1749	42.91	ND	ND	14.85
9	1779	23.08	1.84	0.14	8.16
10	1814	56.56	ND	ND	16.33
Average	1780 +/- **750.59** (S.D)	40.05 +/- **22.94** S.D	3.10 +/- **2.11 S.D** (3 samples)	-	14.75 +/- **7.19** S.D

ND Not Detected

Table (8): Heavy metals (µg/g) in Core No. 1 (General Cargo & Cement Terminal), A port, 2006.

Interval (cm)	Cu	Pb	Zn	Cd
0-5	48.80	39.00	154.00	0.14
5-10	19.85	34.50	63.05	0.50
10-15	26.25	10.50	112.00	2.60
15-20	22.05	5.50	86.50	1.25
20-25	18.45	0.50	137.00	1.20
25-30	24.10	1.50	138.00	0.50



Concentration in ppm

Fig. (4): Heavy metals in Core No. 1 (General Cargo & Cement Terminal).

Table (9) and Figure (5) show the concentrations of Cu, Pb, Zn and Cd in core No. 2 from the Ro-Ro Terminal area.

Copper increases from minimum (2.25 µg/g) in the top 0-5 cm interval to maximum (13.85 µg/g) in the 10-15 cm interval after which it maintains a more or less steady concentration pattern downside the core. Lead increases from nil in the top 0-5 cm interval to attain maximum (39.50 µg/g) in the 30-35 cm interval after which it drops remarkably downside the core.

Zinc and cadmium show more or less steady concentration patterns downside the core.

In general, lower concentrations of heavy metals (Cu, Pb, Zn and Cd) are recorded in the top 0-5 cm interval of core No. 2 from the Ro-Ro Terminal area compared with the same interval in core No. 1 collected from the General Cargo & Cement Terminal area.

Table (9): Heavy metals (µg/g) in Core No. 2 (Ro-Ro Terminal), A port, 2006.

Interval (cm)	Cu	Pb	Zn	Cd
0-5	2.25	ND	23.40	0.65
5-10	12.05	29.00	27.10	0.45
10-15	13.85	28.00	28.25	0.50
15-20	13.55	27.50	24.30	0.50
20-25	10.45	26.00	20.95	0.74
25-30	10.55	32.50	28.30	0.50
30-35	10.80	39.50	28.55	0.50
35-40	13.20	35.00	27.10	0.55
40-45	12.80	14.00	26.75	0.50
45-50	11.25	15.00	26.90	0.50

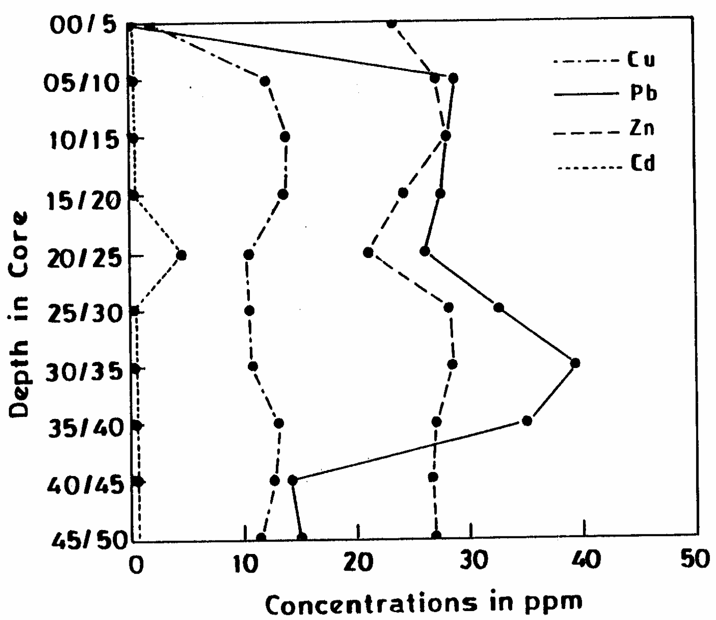


Fig. (5): Heavy metals in Core No. 2 (Ro-Ro terminal).

4. DISCUSSION

In recent years, there has been growing concern that pollutants from anthropogenic sources are incorporated into sediment accumulating in the aquatic environment. Sediment plays a major role in the pollution scheme of an aquatic system because they act as sink for various contaminants. They further reflect the current quality of the aquatic system and can be used to detect the presence of contaminants that become insoluble after discharging into surface water. Moreover, they might act as pollutant-carriers and possible source of pollution as some pollutants; e. g., heavy metals, are not permanently fixed by them and can be released back to the water column through changes in physico-chemical conditions of the environment.

Wooldridge *et. al*. (1999) stated that "cogent management of the relation between a port and its environment requires practicable assessment techniques that do more than merely define the *statues quo* but also provide appropriate data for checking compliance and for auditing the components that affect the sum total impact of port activities on the environment".

The higher THC in surface seawater near the Waiting Area out of the port is probably connected with the large numbers of ships waiting there for relatively long time with most of these ships being old-aged and raising flag of convenience.

On the other hand, the higher total total hydrocarbons contents downside sediment cores, particularly from the General Cargo & Cement Terminal area, reflect historical contaminations.

In general, the concentrations of heavy metals (Cu, Zn, Pb and Cd) are higher in the surface layers of core sediment than in surface sediment samples collected from the navigation channel or the waiting area outside the port. These lower concentrations of metals in sediment from the navigational channel and waiting area could be attributed to dredging operations regularly conducted there. On the other hand, the higher concentrations of metals in core No. 1 obtained from the General Cargo Area relative to those in core No. 2 obtained at the Ro-Ro Terminal are mostly a reflection of the higher intensity and quite different nature of operations conducted in the first area relative to the second one. Copper, zinc and cadmium are found in high concentrations in cement (Pytkowicz, 1972) that is handled in large volumes in the General Cargo and Cement Terminal area (EMDB, 2004). Copper, lead and cadmium are also known to be active ingredients in many insecticides and pesticides.

Heavy metals are known to be usually most enriched in the fine-grained fractions of sediment (silt and/or clay fractions) due to the high surface properties of these fractions. Since the metal ions extracted by the method described in the present study are of non-detrital origin; i. e., mostly adsorbed on surfaces of sediment particles, it is expected that they will be mainly concentrated in finer fractions of sediment. Thus, to eliminate the effect of particle size on the concentrations of metals, the concentration values were normalized to the highest silt content in each core. Tables (10 & 11) give the normalized values of metals. From these tables, it's clear that the high concentrations of metals in the surface layer of core 1 confirm the anthropogenic origin of these trace metals in sediments. In core No. 2, however, the whole sediment column seems to be contaminated to variable degrees.

Table (10): Normalized values of heavy metals in core No. 1, A port, 2006.

Interval (cm)	Cu	Pb	Zn	Cd
0/5	56.85	45.44	179.41	16.95
5/10	21.87	38.02	43.03	0.55
10/15	32.31	12.93	137.87	3.20
15/20	19.27	4.81	75.60	3.20
20/25	14.78	0.40	109.74	0.96
25/30	19.93	1.24	114.13	0.41

Table (11): Normalized values of the heavy metals in core No. 2, A port, 2006.

Interval (cm)	Cu	Pb	Zn	Cd
0/5	2.43	0.00	25.27	0.70
5/10	11.76	28.30	26.45	0.44
10/15	14.30	28.92	29.18	0.52
15/20	9.27	18.81	16.62	0.34
20/25	13.85	34.45	27.76	6.23
25/30	7.66	23.59	20.55	0.36
30/35	8.99	32.86	23.75	0.42
35/40	14.24	29.12	29.24	0.59
40/45	16.74	18.31	34.99	0.65
45/50	10.70	14.27	25.58	0.48

The present study indicates that pollution is affecting water (THC) and sediment (heavy metals) qualities in the case study port. Fig. 6 shows the the pollution sources, causes and its relation with the port operation. The IAPH (International Association of Ports and Harbours) has conducted a survey covering 183 ports. This revealed some critical areas that need particular considerations. These include:

1. Hazardous substances,
2. Water pollution, and
3. Dredging & dumping of dredged wastes.

As a result of this survey, IAPH made recommendations to be considered in environmental policies such as:

1. Managing oil residues,
2. Managing dredging disposal areas, and
3. Developing quality programs and areas.

As observed by Perman *et al.* (1996), a major problem is related to the quality of port's natural environment itself. Soin (1999) and Wooldrige **(**2004) state that quality is becoming an important concept in dealing with environmental problems in seaports.

In the present study, it's apparent that environmental policy, approaches and mechanisms existing and being applied in **A** port are not fully effective protecting the environment there. AAST (1998) stated that Egyptian seaports have always suffered shortages in controlling-combating equipments and human resources as well. These coupled with delays in decision-taking in pollution combating incidents due to bureaucratic complications weigh badly on environmental management plans and policies. EMDB data (2004) showed that **A** port has the highest record of pollution incidents (82 incidents) in 2004.

Fig. 6 shows the pollution sources which may be eliminated through reducing the time of ships waiting in the anchorage area, controlling the quality of allowed trucks inside the port, using standard bunker barges, preventing the fishing boats from using the port and its borders, and using suitable and standard cargo gears for loading and unloading the cement and general cargo. To overcome the causes of pollution the monitoring system to the ships alongside and in the anchorage area, bunkering operation, terminals cargo gears maintenance and selection of the appropriate location for disposal of dredging are very important and applying the local and international regulations is essential. It is clear from figure No. (6) that the port operation and shipping activities affect the environmental aspects especially the pollution.

Adoption of an EMS program is necessary to improve the quality of environment in **A** port area. The effectiveness of such a program can further be enhanced through it's integration into a TQM (Total Quality Management) program to be applied for the whole management of the port. TQM considers techniques specifications, inspection and testing as well, and such an approach would help greatly reducing environmental impacts of port's operations and port management as a whole. Bery and Ronandinelli (1998) state that the implementation of TQM in any organization in perfect view has less problems related to environmental compliance and improves their operating process.

Developing and implementing a quality management system is expected to help in managing major environmental problems such as those revealed by the ESPO survey in 2003; e. g., garbage/port waste, water and sediment contaminations, air quality, waste management, dredging and dredge disposal, noise, ship loading/unloading.. Furthermore, the adoption of an environmental monitoring program would help greatly identifying and manning environmental issues such as in the case of the present study. According to Eng (1999) *"periodic monitoring of the status of the marine environment at a given site can provide valuable information pertaining to environmental quality changes caused by natural disaster or human activities"*.

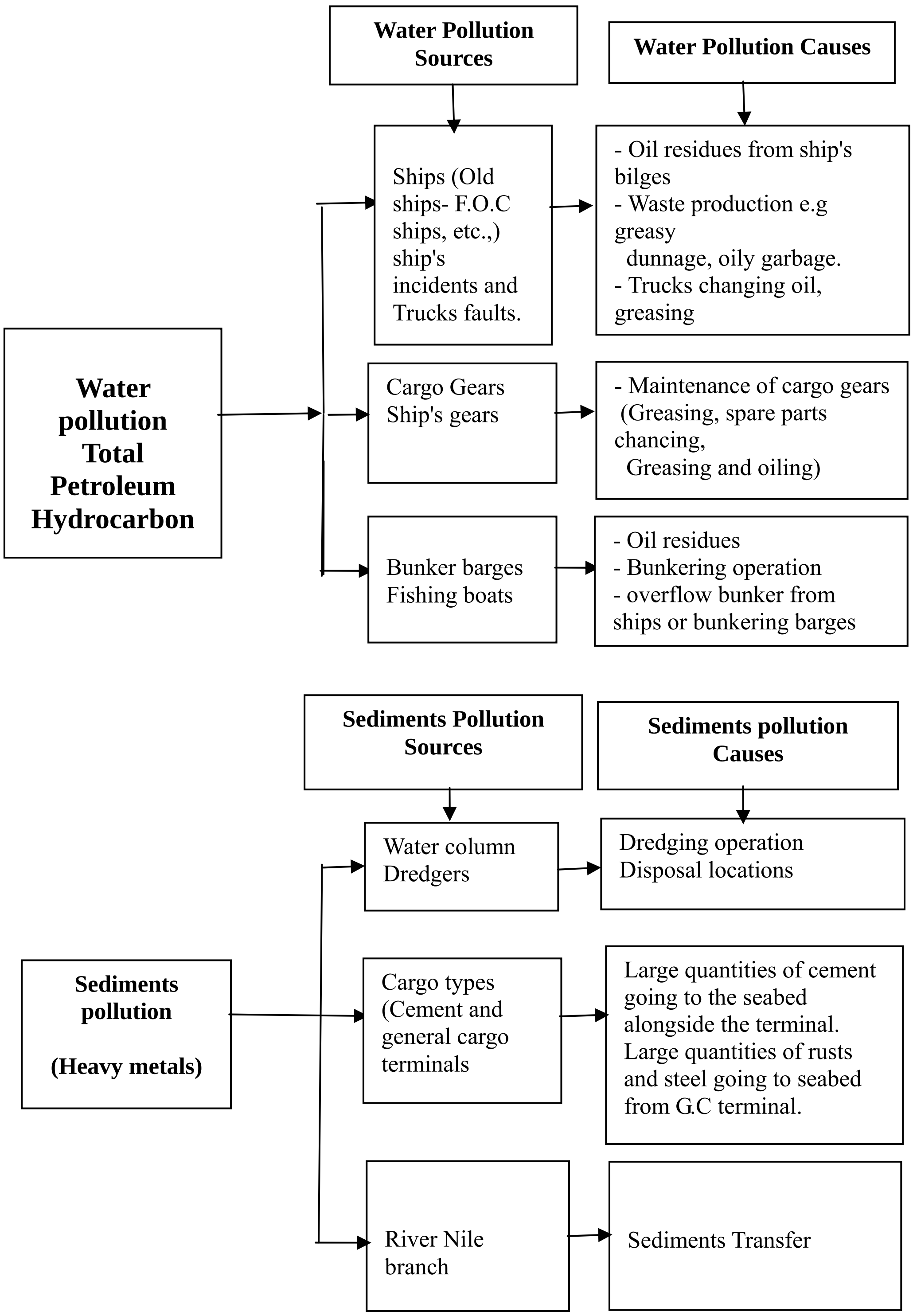


Fig. (6): water and sediments pollution sources and causes.

5. CONCLUSIONS

There is minimum transport of pollutants from outside the port to port's basin. Pollution from ships in the Waiting Area needs intensive surveillance and enforcement of applicable laws and regulations on ships waiting there.

Cement, General and Grain Terminals (General Cargo Area) are the most contaminated by heavy metals. Special attention must be given to cement cargo ships and loading/unloading system there. Better management for dredging disposals is required to avoid increasing environmental hazards at dumping sites.

In general, although an environmental quality management system does exist for the port, refinement and upgrade of this system deem necessary in view of the results of the present study. These might include:

1. Tightening of surveillance and law-enforcement on ships & activities in port's area,
2. Development of an environmental monitoring system for the port, and
3. Integration within a TQM system.

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