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Impact of Draining of Iraqi Marshes on Sediment Quality of Kuwait's Northern Marine Area

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The Arabian Gulf is a long shallow tectonic depression, trending northwest southeast and separated from the Arabian Sea of the Indian Ocean by the Straits of Hormuz. Its basin has an average depth of about 35m; it slopes gradually from the north of the Shatt Al-Arab river to deeper waters at the Straits of Hormuz and from the shallow waters of the Arabian Peninsula to the deeper Iranian waters. Shatt Al-Arab, the only freshwater source into the Gulf, is formed by the confluence of Tigris and Euphrates rivers, and also receives the Karun River from Zagros Mountains of Iran, and discharges into the northern Arabian Gulf. Thus, the northern marine area of Kuwait is the receiving basin for the influx of sediments and associated pollutants from the Shatt Al-Arab estuary (Fig. 1). Shatt Al-Arab pours about 2 x 10^{10} m^3 nutrient-rich water into the Gulf each year (Al-Saeed et al. 1989). This nutrient input into the northern territorial waters of Kuwait significantly contributes to the marine productivity of that area (Al-Abdul Razzaq et al. 1982; Al-Yamani 1989). Tigris and Euphrates rivers carry 50-100 x 10^6 tonnes/ year of suspended sediments (Milliman and Meade 1981). Much of the suspension load of the Tigris and Euphrates rivers is normally deposited in the marshy delta of the Shatt Al-Arab prior to the discharge into the Gulf (Berry et al. 1970; Al-Saad and Timari 1993). Still it has been estimated that net annual sediment discharge entering the Gulf amounted to about 0.93 million tonnes with high concentrations of hydrocarbon residues at the northern part of the Gulf (Karim and Salman 1987). Douabul and Al-Saad (1985) estimated that Shatt Al-Arab Rivers transport about 48 tons of oil residues to the Gulf annually.

In addition to that connection of Euphrates River by the Al-Basra canal to 35 km long and 1-2 Km wide Khor Al-Zubair estuary in southern Iraq that extend to Khor Abdullah has become the second most important source of freshwater, other than Shatt Al-Arab in the northern territorial waters of Kuwait. The canal is being used by the Iraqi regime to drain the marsh areas called Hor Al-Hammar. The building of the Al-Basra canal and the physical manipulation of the marshlands has been reported to have caused a considerable impact on the environmental characteristics of the Khor such as temperature, salinity and dissolved solids and on the hydrodynamics of the northern Gulf (Al-Mussawi 1989; Al-Mussawi and Basi 1993). Engineering and other developments (such as the construction of dams for hydroelectric power in Turkey and Iraq) have already impacted the wetland resources vital to the maintenance of water quality. Recent studies using satellite imagery have shown that

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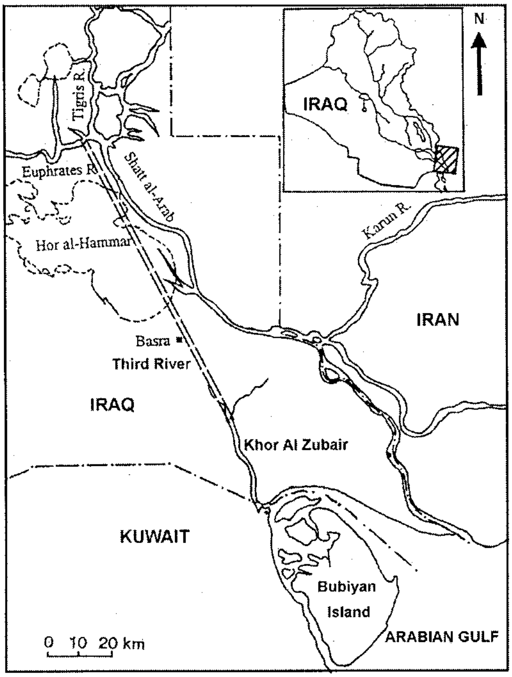

Figure 1. Map showing geographical setting of marshes, Shatt Al-Arab and Kuwait's northern marine area.

water diversion and agricultural reclamation in the marshlands of southern Iraq in 1991/1992 alone have reduced the marsh area by 80% compared with the figures in 1984/85 and have destroyed the integrity of the extensive wetlands complex of the central or Qurnah marshes (Maltby 1994; Al-Yamani and Khan 2002).

The physical manipulation of the environment in the marshlands of southern Iraq is expected to reduce freshwater supply and allow for more evaporation that will increase the salinity. Though, the new source of freshwater supply from Khor Al-Zubair into the northern Gulf is expected to compensate the reduction of freshwater from Shatt Al-Arab, but also expected to increase the input of nutrients and pollutants drained by the Al-Basra canal.

Since the marshes act as buffers for sediment and nutrient transport, the draining of the marshes is expected to significantly increase the sedimentation and input of agricultural, industrial and urban pollutants into the northern gulf and change its hydrodynamic regime (Al-Bakri et al. 1984; Al-Ghadban 1990). Therefore, a program has been undertaken in our institute to study the impact of the draining marshes on the topography and sediment budget and associated pollutants in Kuwait's northern marine environment (Al-Ghadban et al. 1999; Saeed et al. 1999). This paper presents the whole sediment toxicity determined by Microtox solid phase

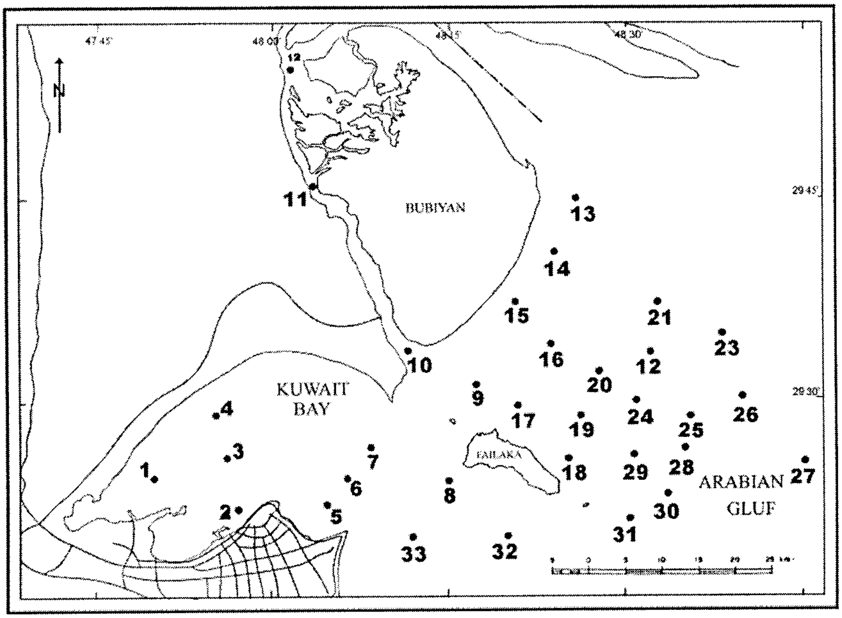

Figure 2. Sampling locations in the study area

toxicity (SPT) assay. The sediment may be contaminated with a variety of chemicals in addition to what is normally determined as priority pollutants. Many contaminants that exist at concentrations below detectable limits may still elicit toxicity. Microtox is a rapid method for the detection of the toxicity in *toto* and has the capacity to differentiate toxic and non-toxic solid samples (Kwan and Dutka 1995; Beg et al. 2001).

MATERIALS AND METHODS

The sampling sites were selected to provide good coverage of the Kuwait's northern waters that possibly impacted by the draining of the Iraqi marshes. Out of 33 sampling sites used in earlier study (Al-Ghadban et al. 1999; Saeed et al. 1999) only 20 were used for toxicity determination. In order to keep the comparability of the results the site number were kept the same and the stations not used in this study were marked as not done. The sediment samples were collected using Van Veen Grab samplers from the sites shown in Fig 2. Fresh sediments were used for the toxicity assay. Microtox Solid PhaseTest (SPT) was used with whole fresh sediment and freeze dried sediment samples from all the locations. In SPT the bacteria is placed directly in close vicinity of solid particles and its response reflect in totality the action of toxicants along with synergists and antagonists present in a given sample (Kawn and Dutka 1995). The assay protocols were as given in Microtox Manual (1992). In Microtox system the difference in light output of luminescent bacteria, *Vibrio fischeri* (Microtox reagent) before and after exposure to test samples is measured using Microtox Analyzer Model 500, that is integrated with a Microtox Data Collection and Reduction System (Data System). Using that EC50 was calculated.

RESULTS AND DISCUSSION

The sediment samples were assayed by Microtox solid phase test (SPT), in view of its ability to test sediment in solid phase state avoiding any manipulation during extraction process. In Microtox SPT the bacteria is placed directly in close vicinity of solid particles and its response reflect in totality the action of toxicants along with synergists and antagonists present in a given sample. It is assumed that toxicants with nonspecific modes of action elicit effects by interaction with bacteria. The assay is not sensitive to compounds with very specific modes of action like lindane (Hoke et al., 1992). However, Microtox has been widely applied to discriminate between contaminated and uncontaminated complex samples and has great potential for screening sediments due to its relationship to effects on other aquatic organisms (Sloof, 1985; Hoke et al., 1990; Liu et al., 2002). Kawn and Dutka (1995) standardized the Microtox SPT assay by using incinerator ash as a positive control and clean lake sediment as negative control and found that EC50 varied greatly between the two samples. Based on their observations the same authors rated sediment samples as toxic (EC50, ≤ 0.5 %), moderately toxic (EC50, >0.5-≤ 1%) and non toxic group (EC50, >1%.). Using this classification all the sediment samples exhibited EC50 <0.5% to be categorized as toxic (Table 1). Infact, most of the samples from stations 3,7,8,10,11,15,16, and 33 were extremely toxic. The sediment samples from all other stations though were toxic to the Microtox but the toxicity was 2-10 times less. This difference in toxicity created a distinct zones of extreme toxicity zone-A and lesser toxicity zone-B (Fig. 3).

Table 1. Microtox SPT toxicity of marine sediment from northern area of Kuwait

Sample	EC50	Sample	EC50	Sample	EC50
1	0.016	12	0.047	23	ND
2	ND	13	ND	24	0.102
3	0.016	14	ND	25	ND
4	0.069	15	0.020	26	ND
5	0.053	16	0.016	27	ND
6	ND	17	ND	28	0.058
7	0.010	18	0.063	29	0.103
8	0.012	19	ND	30	0.114
9	0.072	20	ND	31	0.129
10	0.028	21	ND	32	0.110
11	0.020	22	ND	33	0.012

Microtox SPT EC50, % ; ND, not done

If we consider toxicity data with earlier data on textural characteristics and pollutants in the sediment of the area of study a close similarity with the distribution of finer particles and the pollutants is observed. Textural characteristics of the sediment of the study area have shown that that fine grained sediment (clay, silt and mud) covered most of the area (Al-Ghadban et al. 1999). These deposits were found to occupy the deeper areas as well as the sheltered shallow offshore sites. The central

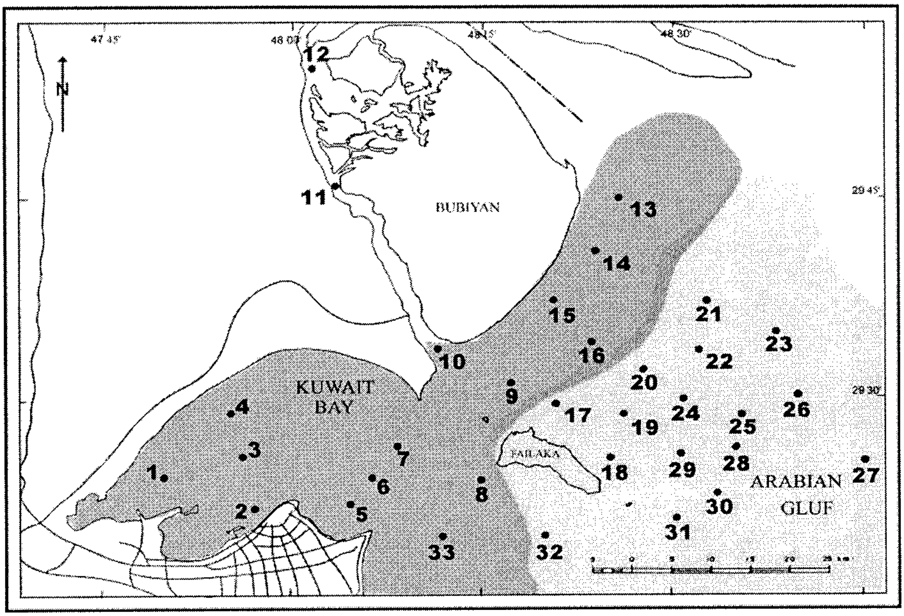

Figure 3. Relative toxicity of sediment in the study area

part of the Kuwait Bay had a zone of of finer material that extends over a large area north and east of failaka Island. This observation in comparison with earlier studies (Abdul Razzaq et al. 1982; Al-Ghadban and Salman 1993) suggested that this area is receiving finer material. The same area showed a zone of extreme toxicity in this study. The finer material was probably carying the contaminants incorporating in the whole sediment as revealed by the chemical analysis of the sediment from this area (Table 2). Average concentration of trace metals in the two identified zones was comparable. However, comparing with interim sediment quality guidelines (ISQGs) for marine sediment (CCME, 1999) the levels of Cd and Ni were higher than probable effect levels (PEL) while other metals were either equal to or higher than ISQG but lower than suggested PEL. TPH in zone A was 2-fold and n-alkanes more than 3-fold higher compared to zone-B. Total PAHs were also found higher in zone-A but were less than the sum of individual PAHs levels of ISQG.The estimated percentage of incidence of adverse biological effects at concentration above ISQGs but below PELs is around 20%; this climbs to 60-80% if PELs are exceeded (Beg et al., 2003).

The Microtox toxicity could not be correlated with any specific trace metal but petroleum hydrocarbons were distinctly higher in high toxicity zone-A (Table 2). It is to be mentioned here that the distinction between the higher and lower toxicity zones was relative otherwise the sediment even from the zone-B showed very low LC50 to be categorized as toxic according to suggested classification of sediment (Kawn and Dutka 1995). In our earlier studies with sediment collected from the coastal region in south of Kuwait receiving industrial effluents extreme toxicity hotspots in Microtox assay were found in samples from the depositional zone whereas the samples distant

Table 2. Trace metals, petroleum hydrocarbons and toxicity of marine sediment from northern area of Kuwait

Sample	Cd	Cr	Cu	Mn	Zn	Ni	Pb	V	TPH	n-alk.	PAHs	EC50
Zone A												
Av.	8.1	52	29	470	52	93	35	26	270	503	61	0.031
Min.	7.5	47	21	368	41	79	6	22	30	82	5	0.010
Max.	10	61	39	551	72	112	68	34	1450	932	209	0.069
Zone B												
Av.	8.9	52	24	446	50	107	41	28	140	140	53	0.097
Min.	8.2	47	22	415	40	86	11	23	40	6	4	0.058
Max.	9.2	56	26	488	55	108	52	32	300	505	87	0.129

Trace metals, mg/kg; TPH, n-alkanes, PAHs µg/kg; Microtox SPT EC50, %

to this area were non toxic (Beg et al. 2001). In the current study none of the sample was found non-toxic in Microtox assay probably because of the abundance of finer particles deposited in the area owing their origin to Shatt Al-Arab. The distribution of pollutants implied the possible role of the general water current circulation that acts as a driving force for pollutant transport from the offshore zone to the northern territorial waters of Kuwait (Fig 4). It has been shown that the sediment from this area and Tigris-Euphrates recent sediments have some resemblance in their classic heavy mineral suite suggesting that the sediment in the present study area had been transported to the area as a wind-borne and river borne sediment and as a consequence of the draining of Iraqi

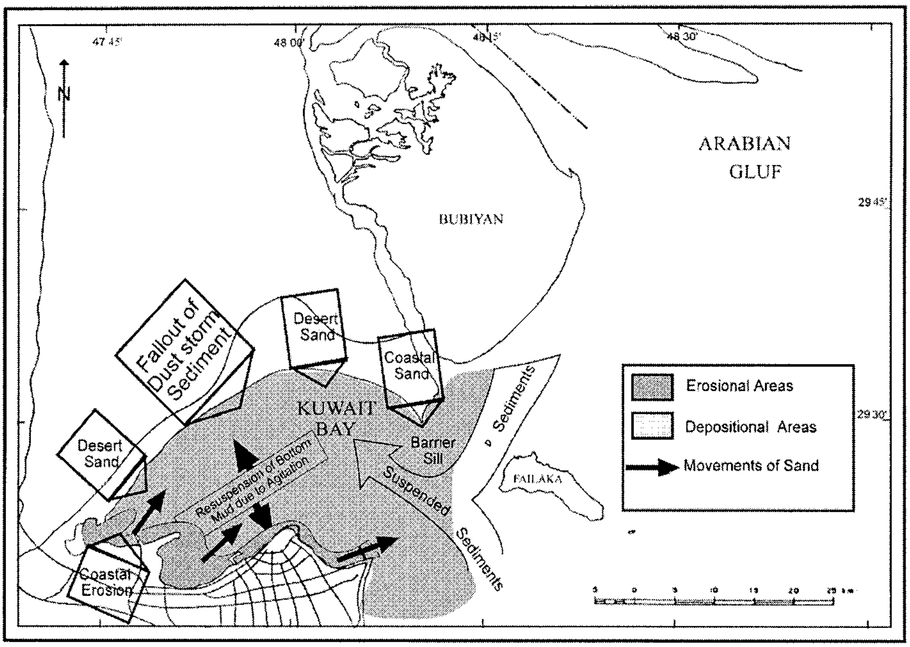

Figure 4. Mode of transport of suspended sediment in Kuwait bay (after Al-Ghadban and Salman, 1993).

marshes (Ali 1976; Darmoian and Lindqvist 1988; Saeed et al. 1999, Al-Ghadban et al. 1999). As pollutants could be adsorbed on or complexed with the sediment mineral grains, full knowledge of the sediment source and genesis would greatly help in understanding of the pollutant distribution and transportation. The results of this study implies the necessity for an action plan to reduce the ecological impacts of pollutant approaching from Iraq due to several activities including draining process of the marshes.

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