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Original Research

A study of Persian gulf pollution by PAH Compounds and heavy metals in Bandar Abbas

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ABSTRACT:

The purpose of this study was to examine Persian Gulf pollution by PAH compounds and heavy metals in Bandar Abbas. In this project, after identifying polluting sources in upstream and downstream of the Bandar Abbas refinery, eight sampling stations were selected to examine physical, chemical, oil, microbial and biological pollution. Sampling water, deposits and aquatics were taken during different seasons. The results indicated that in the stations studied, the annual mean values of wastewater output from the refinery, water in the Haghani Pier and wastewater output from the Power Plants are more polluted than those in other stations in terms of oil and grease; in general, they are higher than the national standards of oil grease in wastewater to discharge into surface waters. According to the results from PAH compounds in different stations like oil grease, they are the highest in fall; and the amount of PAH in the dewatering station is higher than those in other stations. Also, the annual mean values of nickel and lead in deposits in all stations are higher than their world values; values of copper are lower than its world value. The highest diversity, density and distribution of phytoplankton are observed in the stations 1, 2, 7 and 8, and lowest in the stations 3, 4, 5 and 6.According to the results, the highest diversity, density and distribution of zooplankton are observed in the stations 1, 2, 7 and 8, and lowest in the stations 3, 4, 5 and 6.

Keywords:
Persian gulf, pollution, PAH, heavy metals, Bandar Abbas

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INTRODUCTION

Over recent decades, development in industry, excessive profiteering, and the improper and profligate use of natural sources by industrial human have caused strong marine pollution, exposing it in serious danger. In recent years, seas-especially the Persian Gulf, have seriously been polluted by a variety of pollutants including oil, chemicals, heavy metals, pesticides, and plant pest control sprays. One of the main pollution sources in the Persian Gulf is oil industry; the entry of oil grease to the seas resulted in serious water pollution and wide aquatic deaths. Considering the restriction of water sources in the country and that most industries related to oil, gas and petrochemical are placed around water sources (rivers and seas), pollution, especially chemical and oil pollution, results in the loss of main source of core part of protein in the country in addition to result in the destruction of water required for drinking and industry. Since presence of various polluting industries in coastal waters in Bandar Abbas, such as refinery, power plant, and steel piers, Shahid Rajaee and Shahid Bahonar. research on pollutants resulting from the above industries and the impacts of each of them on water and food chains in this vital ecosystem is very critical and important. The objectives of this work are as following: (Abbaspour, 1992) a study of polluting sources in upstream and downstream of the Bandar Abbas refinery; (Bayat *et al.,* 2009) a study of physical, chemical, oil and microbial pollution in the coastal waters at Bandar Abbas (8 stations); (RCJS, 1973).) a study of physical, chemical, oil and microbial pollution in the water and coastal deposits; (Sari, 2002) identification of planktonic organisms; (Nezhad, 1995) a study of negative effects of pollution on food chains; (Karakoc, 2002) identification of benthic organisms, and a study of negative effects of pollutants; and (Mills and Chicheter, 2005) a study of Sulfate Reducing Bacteria (SRB) and the Total heterotrophic Bacteria Count (TBC) in the eight stations studied.

Table 1. Stations studied

Station Number	Sampling Stations
1	Shahid Haghani Pier
2	Power plant opposite (500 meters)
3	Power plant out put
4	Fouladi Pier
5	Refinery opposite
6	Refinery out put
7	Control
8	Dewatering

MATERIALS AND METHODS

To examine environmental pollution around coastal waters in the Bandar Abbas refinery, in a beginning study for determining study stations, sampling and the identification of polluting sources, first five study stations were determined; after water samples were examined, it was recognized that in some stations (Power Plant and Refinery) the range of pollution, especially thermal pollution, extends to a very long distance from the output of the above industries. Therefore, three stations were determined to carefully examine the range of pollution, and in total eight stations were selected.

The study area starts from the Shahid Haghani Pier (Station 1), which is the place for the gathering of passenger boats, motor boats, and fishing and commercial dhows, and extends to the north. Given that there are different polluting industries (Thermal Power Plant and Steel Pier) before the Refinery, which discharge a wide range of pollutants (a variety of chemicals and hot wastewater) to coastal water ecosystem, three stations were selected with in these industries. Finally, as the Bandar Abbas Refinery is one of polluting industries around coastal waters, three stations were selected in the area, and the last station, which is far from polluting industries, was selected as a control station (Table 1).

RESULTS

Examinations on planktonic organisms

Phytoplankton

The results from the examinations on phytoplankton in the eight stations of sampling coastal

waters during four seasons (eight round of sampling) showed that diversity, density and distribution of each of species were not the same during seasons and even different months in the eight sampling stations. The results indicated that the highest diversity, density and distribution of species could be seen in spring, fall and almost early winter. During summer and late winter, diversity and density were reduced.

Zooplankton

The results from the examinations on zooplankton showed that diversity, density and distribution of zooplankton are not the same during seasons and even different months. The examinations indicated that diversity, density and distribution of zooplankton are the highest in late spring, summer and winter; they had the lowest diversity, density and distribution in summer and fall.

Examinations of benthic organisms

The results from the examinations on benthos in the eight stations of sampling coastal waters during different seasons (eight round of sampling) showed that diversity, density and distribution of species were not the same in the eight stations studied. The results indicated that in Station 2,Station 3, Station 5 and Station 6 diversity and density of benthic organisms were low due to the presence of silty and sand beds with oil grease as well as because of a reduction in dissolved oxygen.

Microbiological examinations

The results from the examinations on Sulfate Reducing Bacteria (SRB) and aerobic heterotrophic bacteria in the eight stations showed that in winter Station 1, Station 4, Station 6, Station 7 and Station 8 are normal; Station 2 and Station 3 are high; and Station 5 is very high. The presence of Sulfate Reducing Bacteria (SRB) in all the stations were negative in winter. The results indicated that in spring aerobic heterotrophic bacteria were normal in Station 1, Station 3, Station 4, Station 5, Station 6, Station 7 and Station 8, and were very high in Station 2; that was positive in Station 2, Station 3 and Station 4. According to the results from the aerobic heterotrophic bacteria count, Station 2, Station 4, Station 7 and Station 8 are in a normal state, Station 3 high, and Station 1, Station 5 and Station 6 are very high; in terms of the presence of Sulfate Reducing Bacteria (SRB) all stations, except the control one Station 7 being negative, are positive in summer. In fall, the heterotrophic bacteria count is very low in Station 2 and Station 3, normal in Station 7, high in Station 1, Station 4 and Station 5, very high in Station 6 and Station 8. The presence of Sulfate Reducing Bacteria (SRB) in water is positive in only Station 1, and negative in other stations. The presence of Sulfate Reducing Bacteria (SRB) in the deposits are positive in Station 1, Station 5, Station 6 and Station 8.

Physical parameters

Salinity increases from the East to the West and from the North to the South in the Persian Gulf; it varied between 37.5 and 36 per liter in different seasons on the coasts in Bandar Abbas. Water temperature in the Persian Gulf varied between 17 and 35 during a year. The results indicated that salinity and electrical conduction were higher in winter than those in summer, which these changes were observed (Rissato, 2004). Also, salinity and electrical conduction were higher in the output of the power plant than those in the refinery in all seasons; finally, their effects were observable in Station 2 and Station 5. In addition, the output temperature of the power plant is different from the temperature of sea water up to 3 to 4 degrees during different seasons.

Chemical parameters

pH

Sea water usually has alkaline pH; it ranges from 7.5 to 8.4.Sea water alkalinity resulted in calcium carbonate fixation in water. The range of pH measured in different stations is from eight to eight and half.

Table 2. The annual average of oil contaminants in the sediments of coastal region of Bandar Abbas

Station number	Total hydrocarbons	PAH (Polycyclic Aromatic Hydrocarbons)		Total phenolics
		ROPME	Chrysene	
1	24.47	13.33	0.83	1.83
2	0.61	6.05	0.38	0.53
3	14.30	35.10	2.19	0.85
4	0.22	4.33	49.22	1.28
5	24.81	3.00	0.19	14.73
6	0.85	74.20	4.64	1.65
7	4.19	11.43	0.71	1.33
8	0.29	3.2	0.20	1.08

Phosphorus

The phosphate concentration in the middle part of the Persian Gulf was reported as 0.3-0.60 mg/L (1) and on average, its measured amount in different stations were about 0.03mg/L. Amounts of ammonia in the eight stations fluctuated between 0.01 mg/L and 0.09 mg/L during different seasons. The results indicated that amounts of silica at different stations were measured, which is lower than 0.01 mg/L to 0.06 mg/L during different seasons; higher amounts of silica were usually observed in Stations 3, 4 and 6.

Pollution analysis by oil and heavy metals

According to world statistics, 95.4% of oil pollution results from tanker transport and 4.4% from marine operations. According to experiments performed indifferent stations during different seasons, it was noted that amounts of oil grease indifferent stations fluctuated between < 0.01 mg/L and 96.8 mg/L. The annual mean values of oil grease in water at different stations ranged from 0.01 mg/L in Station 8 to 24.81 mg/L in Station 6. Amounts of oil grease in the deposits of different stations were measured, which the lowest amount of dry weight 624was observed in Station 7 and the highest (27490) dry weight in Station 5.

PAH compounds in water

These compounds are quickly attracted by particles in sea water, and finally they are deposited in the bottom of the sea. The PAH concentration in the river water highly polluted industrial areas is 1-5. Total PAH in sea water and unpolluted rivers are lower than 0.1.The results showed that the lowest and highest amounts of PAH during seasons and stations measured were < 02 and 282, respectively, and its annual mean values in different stations fluctuated between 0.2 and 74.2; the highest pollution rate was observed in Station 8, which is near the place of ship traffic and petroleum discharge from ships and affected by output wastewater of the power plant and refinery (Table 2).p

PAH compounds in the deposits

According to the results, minimum and maximum PAH in the deposits of the stations at different seasons were 5.5 and 123.9, respectively, and its annual mean values fluctuated between 25.7 and 77.98; maximum pollution was recorded in Station 2 that is influenced by pollutants exited by the Power Plant, and oil spills from petroleum discharge. It is reported that the total amount of PAH on Penobscot coasts ranged from 286 dry weight to 8794 dry weight. In New York Bay, the amount of PAH in the deposits of the Kristians Basin is raised to 6000 nanograms per gram, and in sludge, it is reached to 20400nanograms per gram (Table 3).

Phenol compounds

The presence of phenol compounds in water represented water pollution by oil grease. Amounts of phenol compounds in different stations over various seasons in water fluctuated between < 0.3 and 30.4; their annual mean values ranged from 0.53 to 14.73. The highest amounts of phenol compounds were measured in Station 6.

Heavy metals in water and deposits

Heavy metals are deposits and aquatic pollutants, which are associated with the discharge of

Table 3. The annual average of heavy metals in the sediments of the coastal region of Bandar Abbas

Station Number	Cd	Pb	Ni	Cu	V
1	2.85	26.83	57.1	18.63	51.8
2	2.36	23.48	62.42	17	50.26
3	-	-	-	-	-
4	2.6	28.06	89.54	27.38	60.58
5	-	-	-	-	-
6	2.63	24.88	54.95	11.4	47.10
7	2.73	26.95	76.95	15.4	57.68
8	2.42	23.46	59.68	16.2	47.2

municipal and industrial sewage. Also, oil and oil product leaks and its discharge into the sea are among important factors increasing the concentration of some heavy metals.

Copper

Copper concentration in ocean waters is 0.1. The results indicated that copper concentration in water in all stations in all the seasons are more than ocean waters, which the highest amount is associated to summer due to the discharge of municipal, industrial sewage and transport. The concentration of copper in global deposits are about 33 dry weight (8). The amount of copper in different stations during different seasons ranged from 6.3 in Station 8 to 56.4 in Station 4. A higher amount of copper in Station 4 is due to the mineral transportation from the prier.

Cadmium

Cadmium concentration in oceans varied from about 0.2 nanogram/L to 60 nanogram/L; the lowest amount is usually observed in tropics. The results showed that cadmium concentration was higher than that in open seas and even that in industrial coastal areas during all seasons. Cadmium concentration in the deposits of different stations over various seasons fluctuated between 2.42dry weight and 2.85dry weight. The highest amount of cadmium associated with winter was resulted from the deposition of oil grease leaked by the Tabriz tanker accident.

Nickel

Nickel concentration indifferent stations and various seasons ranged from 0.1 in Station 7 to 15.4 in Station 4, which 15.4 is associated with the winter in 1999, i.e. two years after the Tabriz tanker accident in the Steel Prier site. The highest amount of nickel in winter was associated with Station 4 because of oil leaked by the Tabriz tanker.

Lead

Lead concentration in water at different stations ranged from 0.1 to 9.4, which is very higher than that in the surface waters. The highest was related to Power Plant outputs. According to the experiments performed, the amount of lead in the deposits of different stations fluctuated between 16.3 dry weight in Station 5 and 34.4 dry weight in Station 4. Its annual mean values varied from 23.46 dry weight to 28.06 dry weight, which in total is very higher than that in the deposits of the world. Like nickel and vanadium, it was the highest in Station 4. In comparison with the results obtained from other areas in the Persian Gulf, lead in deposits was higher than that on Oman coasts and lower than that on Iraq coasts.

DISCUSSION

Pollution in Water

In the stations studied, the annual mean values of output wastewater from the refinery, water in the Haghani Pier and output wastewater from the power plant were more polluted than those in other stations in terms of oil grease. In general, they were higher than the national standard of oil grease in wastewater to discharge into surface waters (10). In the case of refinery outputs, it was caused by oil grease spills, oil grease leaks from corrosion of cooling systems, and the dysfunction of systems related to separation and collection of oil grease from refinery wastewater in fall in 2000 and in other seasons it was lower than the standard set by Environment Protection Organization; In the case of the Haghani Pier, it was caused by the discharge of burned

oil by vessels, oil grease spills when supplying fuel for vessels, etc.

In the case of the marine stations, amounts of oil grease was several times more than that in the Gulf water in Bahrain, the United Arab Emirates and Oman, which was primarily caused by oil grease from the refinery and power plant, oil grease spills, discharge of oil by vessels, and accidents in the area. The highest oil grease is found in Station 7, compared to other stations, it was resulted from excessive pollution of outputs from the refinery, power plant and Haghani Pier, and water direction in the area.

Like oil grease, PAH compounds in water at different stations were the highest in fall, compared to those in other seasons. PAH in the dewatering station was higher than that in other stations, which was caused by Power Plant output, ship traffic, petroleum discharge in the Steel Pier. Refinery outputs did not have considerable role in sea water pollution in terms of PAH compounds.

Pollution in Deposits

The results from the amounts of oil grease in deposits at different stations in summer showed deposit pollution rate in the beginning of the project. Plenty amounts of petroleum entered the sea in the Steel Pier due to the Tabriz tanker accident. The results from the experiments performed on oil grease in the deposits in winter indicated deposition of oil grease in different deposits; during other seasons oil grease concentration was gradually decreased considerably, which was caused by new deposits in the bottom of the sea, and oil grease dispersion in the area. In the case of PAH compounds, pollution in deposits at different stations are more visible in winter compared to that in summer (due to the Tabriz tanker accident).

There were rather high amounts of copper in the control station due to mineral spills in the Steel Pier. Also, the amount of nickel was higher in all stations in fall than that in other seasons, which was associated with oil leaks by the Tabriz tanker to the sea; the highest amount of nickel was related to the Steel Pier station (accident location). The annual mean values of heavy metal concentrations in deposits in all stations were lower than those reported in Khark Island, which is logical because oil grease spills are higher on Khark coasts than those in Bandar Abbas, in comparison with mean values of heavy metals in the deposits on Kuwait coasts. Amount of cadmium and lead are higher in Khark than those in Kuwait, and amounts of nickel and copper are lower in Khark than those in Kuwait. In general, the annual mean values of nickel in deposits in all stations were higher than its world values (52 dry weight), in the case of copper it was lower than its world amount (33 dry weight), and in the case of lead it was higher than its world amount (19 dry weight).

CONCLUSION

The results from the physicochemical examinations as well as studies on planktonic organisms (phytoplankton and zooplankton) and on the benthic organisms in coastal waters at Bandar Abbas over four seasons indicated which three loops of food chains in different aquatic ecosystems are considered as the most sensitive and vulnerable organisms because of the lack of active motion organs, and are quickly destroyed by pollution, especially oil pollution, chemical pollution and thermal pollution. The highest diversity, density and distribution of phytoplankton were observed at Station 1, Station 2, Station 7 and Station 8, and the lowest at Station 3, Station 4, Station 5 and Station 6. According to the results, the highest diversity, density and distribution of zooplankton were observed at Station 1, Station 2, Station 7 and Station 8, and the lowest at Station 3, Station 4, Station 5 and Station 6. The highest diversity, density and distribution of benthos can be observed in winter with eight live species at Station 1, Station 4, Station 5 and Station 7, and the lowest in summer with five live species at Station 1, Station 2, Station 4, Station

7 and Station 8. Increased diversity, density and distribution of benthos during spring and winter can be caused by improvement in their environmental conditions, reproduction seasons, decreased water temperature etc., Decreased diversity, density and distribution of benthos in the eight stations during summer and fall are caused by increased water temperature, the presence of inappropriate beds for life of benthos at Stations 2, 3, 5 and 6, decreased food etc.

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