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IMPACT OF THE MAP TA PHUT INDUSTRIAL ESTATE ON COASTAL ENVIRONMENTAL CHANGES AND TREND ANALYSIS

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ABSTRACT

This research probes the performance of Map Ta Phut Industrial Estate, with a focus on its compliance with Thailand's environmental safety and standards and its potential environmental impact in the area. Map Ta Phut Industrial Estate is a major industrial estate and the most prominent international port located in Rayong province, eastern Thailand. It started its operation in 1988 and still in use today. Between 2007 to 2012, coastal seawater and sediment samples were collected and analyzed. The samples were collected from various pollution emitting point sources of interest. Coastal environmental changes and marine ecology changes were observed, compared, and analyzed. Contour maps representing several crucial water quality parameters with trend analysis comparing every data with time-series trend and location were also visualized on the system. These parameters were selected based on their impact on the environment and living species and the information they gave when a change in the level of each parameter occurs. The coastal environment in the dry season was generally better than in the rainy season, impacting the amount of land contamination leaking into the coastal areas. This research also studied the level of mercury and arsenic, in sediment and seawater. These pollutions can have severe consequences if not treated properly. However, Map Ta Phut's pollutions mostly stayed within Thailand's standard during the period of this study.

1. INTRODUCTION

Map Ta Phut industrial estate, the largest operating industrial estate on the east coast of the Gulf of Thailand, start its operation in 1988 [1]. Total of 476 plants in the Map Ta Phut Industrial estate produces about 46,500 m^3 of wastewater per day. Additionally, the community of residents and workers of more than 150,000 people generates an additional 8,142.17 m^3 of wastewater per day. The

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impact on the coastal environment can be significant when considering the amount of wastewater from the Map Ta Phut each day. Studies in other countries such as China and Canada have suggested that wastewater that was not treated properly can pose a threat to the environment [2] and the amount of wastewater released into the sea has to be considered as well [3, 4]. Past studies regarding Map Ta Phut industrial estate were either did not to include coastal environmental impact in the research or focus on public participation and comments. This study focuses on the coastal environmental impact and water-related parameters of the Map Ta Phut industrial estate. Two coal fuel power plants, four other pollutant sources of interest, and one reference point are included in this study shown in Figure 1 [5]. Contour maps of each key parameter were created to study the coastal environmental trend between the period of the study. The key parameters were carefully chosen based on their impact on the environment and living species and the amount of information that can be extracted when changes in their level occur.

Figure 1: The Map Ta Phut Deep Seaport with the reference points: Rayong province, Gulf of Thailand.

2. MATERIALS AND METHODOLOGY

2.1 SAMPLE COLLECTION AND SAMPLE ANALYSIS

Seven data-collection points were chosen as a part of this research. These seven points were as follow MP02, MP06, MP09, MP12, MP14, MP20, and MP22 as shown in Figure 1 [5]. Each data-collection point was selected based on its role on the Map Ta Phut area and its potential environmental impact. Seven parameters were chosen to represent the coastal environmental effect of Map Ta Phut with both seawater quality and sediment quality in mind. The seven parameters were salinity, seawater temperature, seawater mercury, seawater arsenic, sediment mercury, sediment arsenic, and total petroleum hydrocarbon. The seawater and sediment quality parameters values are all analyzed with standard methods as stated in the Pollution Control Department of Thailand suggested method for seawater analysis [6] and sediment analysis [7] by the Aquatic Resources Research Institute, Chulalongkorn University. The methods used to analyze for each parameter are as follow. First, there are three certified methods that can be used to analyze salinity level including Argentometric (titrate with AgNO3), Electrical Conductivity Method, density or refractometer. For seawater temperature, there are two, thermometer or Electrical Sensor Method. Both seawater mercury and seawater arsenic have to be pre-concentrated and then analyze. For seawater mercury after pre-concentration, any of these methods can be used including Cold-Vapor/Hydride Generation-Atomic Absorption Spectrometric Method, Cold-Vapor/Hydride Generation-Atomic Fluorescence Spectrometric Method or Inductively Coupled Plasma Method. For seawater arsenic after pre-concentration, there are also three certified methods consist of Hydride Generation-Atomic Absorption Spectrometric Method, Electrothermal Atomic Absorption Spectrometric Method or Inductively Coupled Plasma Method that possesses Chloride interference elimination system. Sediment mercury and sediment arsenic need to go through acid digestion before entering any analysis methods. There are five approved methods for sediment mercury including Inductively Coupled Plasma - Optical Emission Spectrometry (ICP/OES), Inductively Coupled Plasma - Mass Spectrometry (ICP/MS), Cold Vapor-Atomic Absorption Spectrometry (CVAAS), Cold Vapor-Atomic Fluorescence Spectrometry (CVAFS), Mercury in Solids and Solutions by Thermal Decomposition, Amalgamation, and Atomic Absorption Spectrophotometry or other methods approved by the pollution control department. Four methods are available for sediment arsenic consisting of Inductively Coupled Plasma-Optical Emission Spectrometry (ICP/OES), Inductively Coupled Plasma - Mass Spectrometry (ICP/MS), Graphite Furnace Atomic Absorption Spectrometry (GFAAS), Hydride Generation Atomic Absorption Spectrometry (HGAAS) or other methods approved by the pollution control department. Finally, there is only one certified method for total petroleum hydrocarbon which is. pre-concentration followed by Fluorescence Spectrophotometry.

2.2 DATA ANALYSIS AND INTERPRETATION

Each parameter was compared to their respective applicable standard [8, 9, 10]. The seawater temperature standard is to compare the current data to the average seawater temperature from the year before. The standard has three main categories including an increase of less than 1 °C, no change, and an increase of more than 2°C. Salinity standard is that the level of salinity must not change for more than 10% compared to the lowest level from the year prior. The seawater mercury and seawater arsenic standards indicate that the maximum acceptable values of these two parameters are 0.1 µg/l and 10 µg/l respectively. The sediment mercury and sediment arsenic standard are at a maximum of 0.4 mg/kg dry weight and 7.0 mg/kg dry weight respectively. Finally, Thailand's seawater standard for total petroleum hydrocarbon allows a maximum level of 5 µg/l.

2.3 Surfer® 16

The Surfer software is a program used for contouring and 3D surface mapping. The contour maps of each parameter are a product of the surfer program. These contour maps visualize a trend of where each parameter accumulated.

3. RESULTS AND DISCUSSIONS

As mentioned before, the parameters were selected with their impact on the environment and living species and the information they give when changes in their level occur. After carefully determining the best parameters to focus on seawater quality, sediment quality and the above criteria in mind, seven parameters were chosen. The seven parameters were as follow salinity, seawater temperature, seawater, and sediment arsenic, seawater and sediment mercury, and total petroleum hydrocarbon. Samples from Map Ta Phut industrial estate were collected and analyzed throughout this study which was from 2007 to 2012 by the Aquatic Resources Research Institute, Chulalongkorn University. Then, the raw data of these parameters was cleaned, analyzed, and compared to several of Thailand's seawater and sediment standards [8, 9, 10].

The results are as follow. The salinity level is an indication of where the effluent from Map Ta Phut was discharged. The effluent was released in the form of fresh water causing the salinity level to drop so it can be concluded that any significant drop in the salinity level around the Map Ta Phut area was a result of the estate's effluent. The lowest salinity level was usually present at MP14 where Map Ta Phut's main effluent point could be founded as shown in Figure 3.

Both mercury and arsenic are components in byproducts of a number of manufacturing processes in various factories in the Map Ta Phut area.

Figures 4 and 5 display the level of seawater mercury and seawater arsenic. Thailand's seawater standard dictates that mercury and arsenic in seawater should be no more than 0.1 µg/l and 10 µg/l respectively [7]. In the period of this study, the level of seawater mercury stayed below the standard in all but two occasions, in May 2009 at 2.0 µg/l (MP22) and August 2012 at 0.2 µg/l (MP09) and 0.3 µg/l (MP12), as shown in Figure 4. The level of seawater arsenic exceeded the 10 µg/l standard a few times in early 2007 at 14.4 µg/l (MP09) in February and at 11 µg/l (MP06 and MP14) in July but stayed below the standard for the rest of the research period.

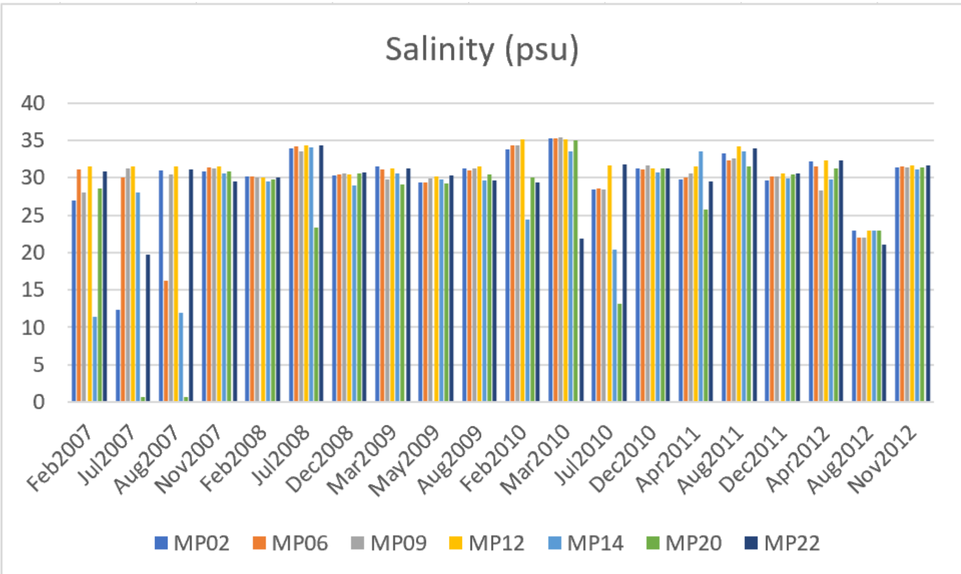

Figure 3: Salinity from seven points of interest between 2007-2012.

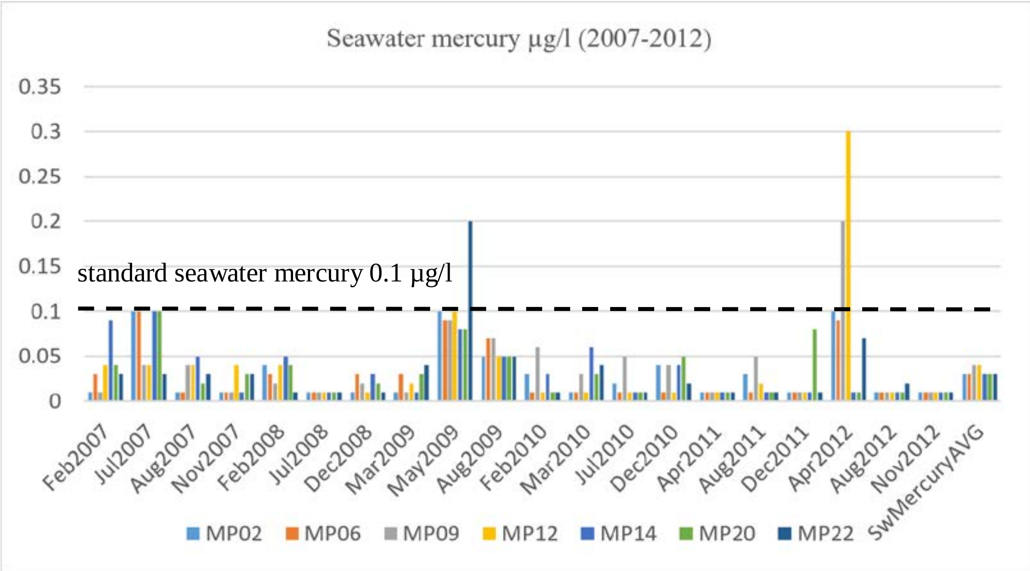

Figure 4: Seawater mercury (µg/l) between 2007-2012.

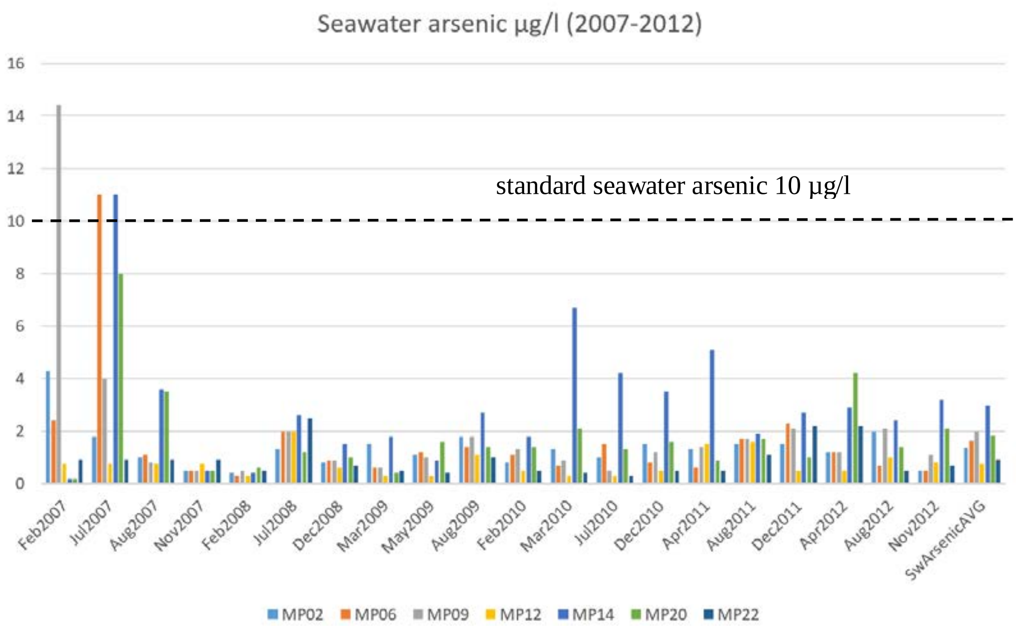

Figure 5: Seawater arsenic in (µg/l) between 2007-2012.

The amount of sediment mercury and sediment arsenic is shown in Figure 6 and 7 respectively. Thailand's standard set a maximum level of sediment mercury and sediment arsenic at 0.4 mg/kg dry weight and 7 mg/kg dry weight respectively. Throughout this study, as shown in Figure 6, the level of sediment mercury exceeded Thailand's standard on a number of occasions in the following months, in July 2007 at 0.8 mg/kg dry weight (MP20), in November 2007 at 0.84 mg/kg dry weight (MP14), in February 2010 at 0.81 mg/kg dry weight (MP14), in July 2010 at 0.46 mg/kg dry weight (MP14), and in December 2010 at 0.43 mg/kg dry weight (MP12). On the other hand, sediment arsenic was the only parameter to regularly exceeded Thailand's sediment standard usually at collection point MP14 and at collection point MP20 in three separate occasions as shown in Figure 7.

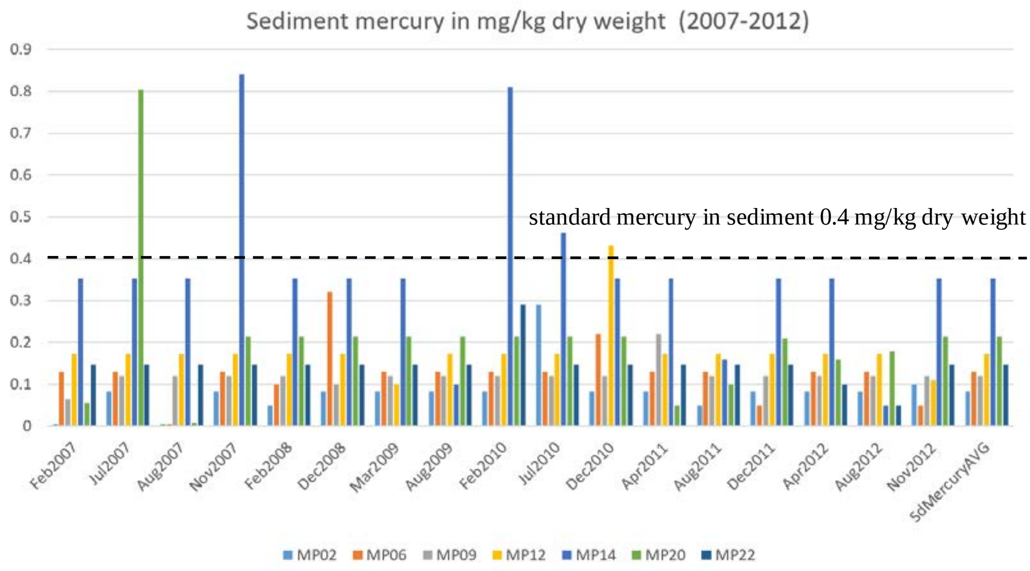

Figure 6: Sediment mercury (dry weight, mg/kg) between 2007-2012.

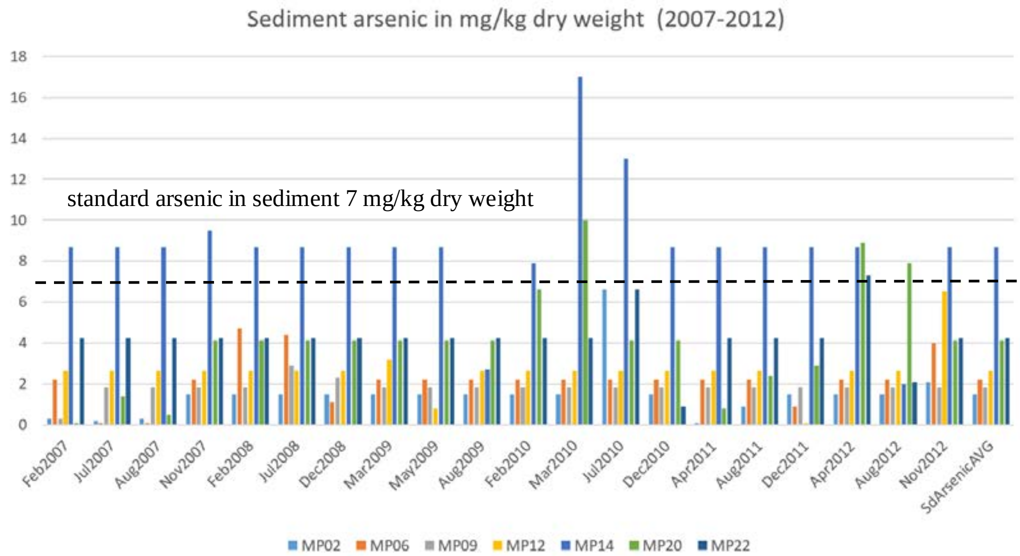

Figure 7: Sediment arsenic (dry weight, mg/kg) between 2007-2012.

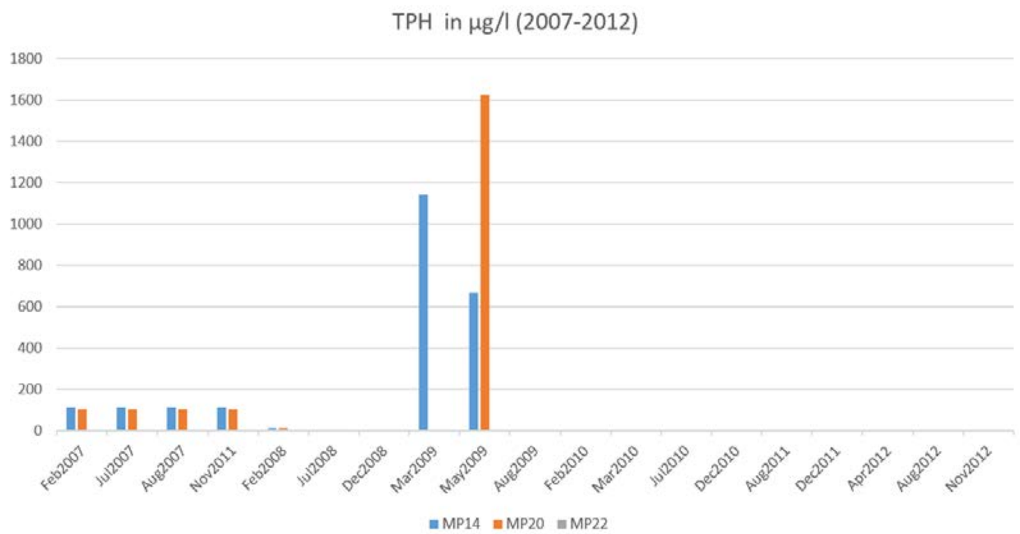

Figure 8 Amount of TPH (µg/l) from three points of interests between 2007-2012.

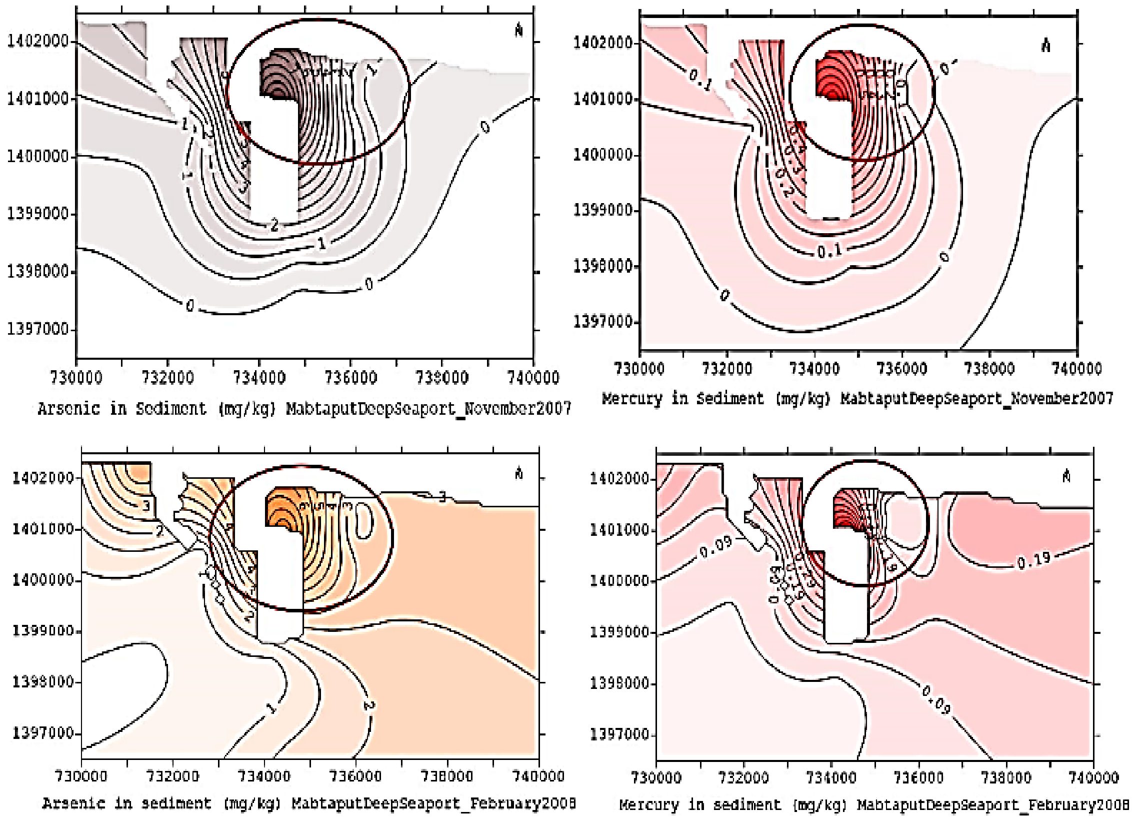

Figure 9: Arsenic and Mercury in sediment contour of Map Ta Phut November 2007 and February 2008.

Another concern regarding water pollution in the Map Ta Phut area is total petroleum hydrocarbon or TPH which came from sea-based transportation. Out of seven sample-collection points, only three showed meaningful amounts of total petroleum hydrocarbon as shown in Figure 8. Thailand's seawater quality standard allows up to 5 µg/l of TPH [8]. The amount of TPH at MP14 and MP20 exceeded the standard easily earlier in the period of this study but drastically improved and stayed below the requirement after reaching their peak levels in 2009.

Both sediment mercury and sediment arsenic came from the effluent used to clean plants or byproducts of several production processes. The mercury and arsenic then settled down to the seabed. As shown in Figure 9, the amount of sediment mercury and sediment arsenic concentrated around the area where the effluent from Map Ta Phut was released.

If the mercury and arsenic didn’t settle, they would be carried further by the current. From figure 10, the highest amount of both seawater mercury and seawater arsenic usually can also be found around the area where the effluent is released. In 2012, the amount of seawater mercury in the southwest of Map Ta Phut drastically increased due to coal shipments began delivering through a port in the area. Salinity around the effluent point in the northeast and west of the estate showed the effluent point of both the estate and the community, resulting in less salinity in the areas as mentioned above as shown in Figure 11. The quantity of TPH in seawater around Map Ta Phut comes from the effluent used to clean a plant or several processes in a plant production process and sea-based transportation. In this research, TPH in some areas near the effluent point of Map Ta Phut regularly exceeds Thai’s standard at 0.5 µg/l as shown in Figure 12.

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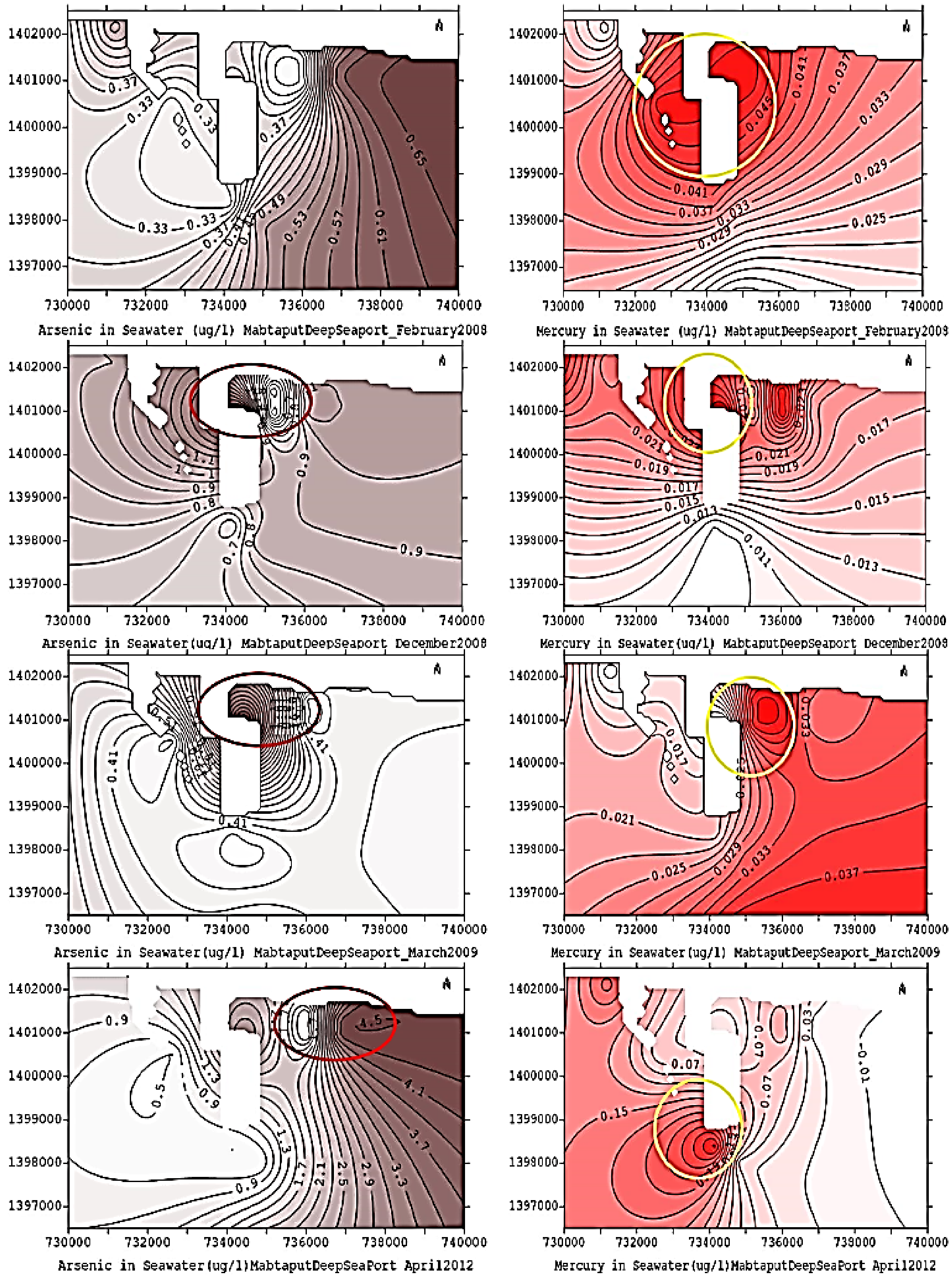

Figure 10: Arsenic and Mercury in seawater contour of Map Ta Phut Seaport February 2008 to April 2012.

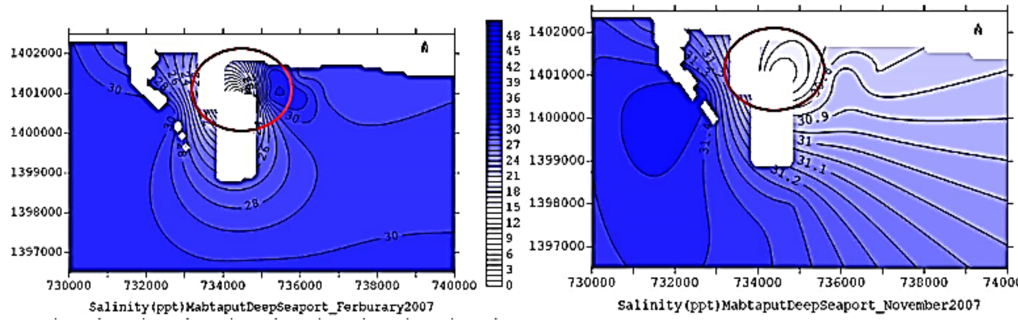

Figure 11: Salinity contour of Map Ta Phut February 2007 to April 2012.

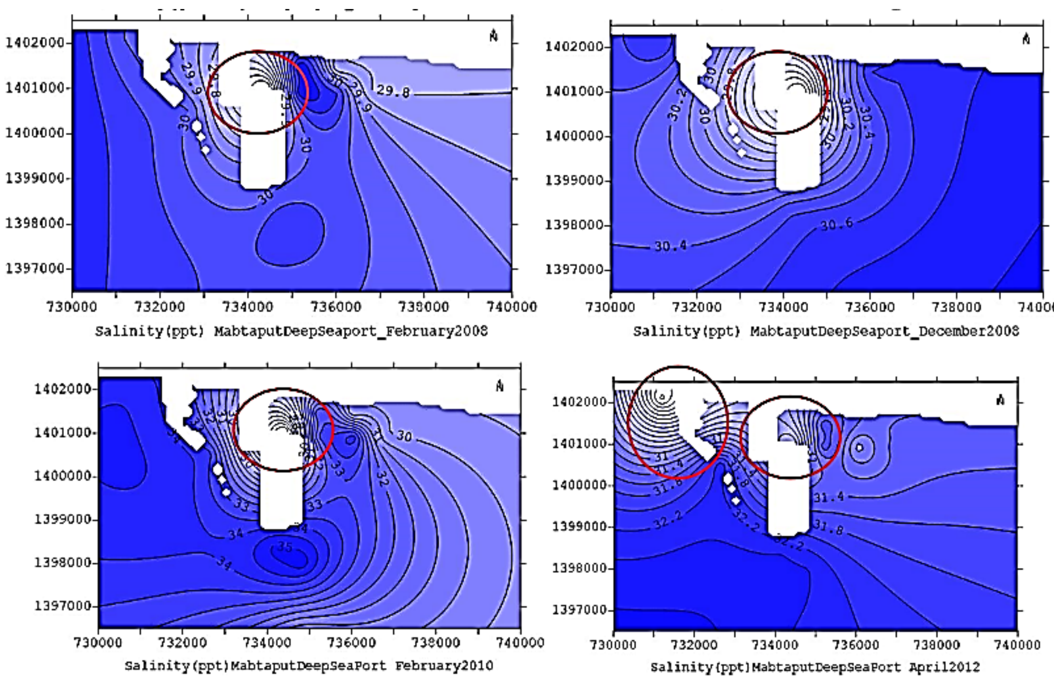

Figure 11: Salinity contour of Map Ta Phut February 2007 to April 2012 (continue).

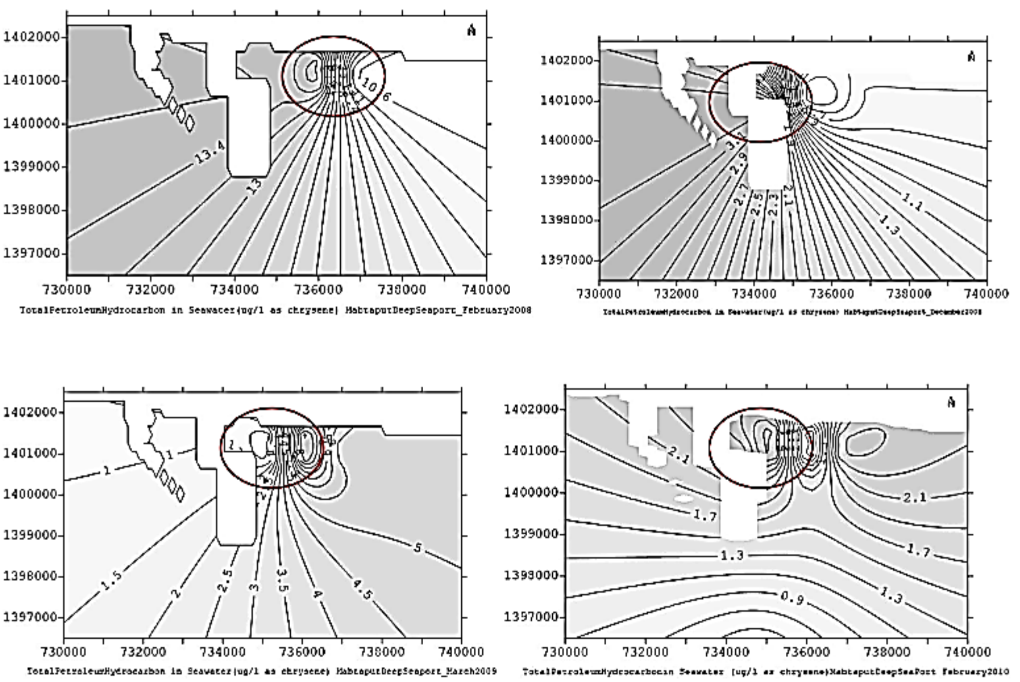

Figure 12: TPH contour of Map Ta Phut February 2008 to February 2010.

4. CONCLUSION

Map Ta Phut Deep Seaport has been in operation for over 26 years. It has twelve piers, two public piers and ten private piers, all of which are related to the petrochemical industry with a loading of about 43 million tons per year. Long term marital environment monitoring shows that Map Ta Phut's coastal environment, despite some occasional downfall, is usually up to Thailand's standard, and the amount of pollution produced has a decreasing trend in the period of this study (2007-2012). The results of this research can be used as a foundation for further study. The analyzed parameters can also be used as a guideline for improving the wastewater treatment system in Map Ta Phut. A lot more data is needed to better understand Map Ta Phut's impact on the nearby coastal environment. A continuing effort to collect and analyze samples from Map Ta Phut is required.

5. ACKNOWLEDGMENT

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