

# **Kuwait Environmental Remediation Program – North Kuwait Excavation, Transportation and Remediation Zone II**

**Muthanna Almumin<sup>1</sup>, Meshari Albader<sup>2</sup>, and Aisha Al-Baroud<sup>3</sup>**

MMomin@kockw.com<sup>1</sup>; MABader@kockw.com<sup>2</sup>

And Abarood@kockw.com<sup>3</sup>

Kuwait Oil Company

PO Box 9758, Ahmadi - 61008, Ahmadi, Kuwait

**Abstract** - The United Nations Compensation Commission (UNCC) awarded numerous environmental claims to fund Remediation and Restoration of environmental damage caused during the Gulf War. Based on Decision 258, all claimant countries were required to establish a National Focal Point. Kuwait National Focal Point (KNFP) was established in 2006 to manage the Funds provided to Kuwait and to liaise with various Government Entities to ensure proper execution of the Kuwait Environmental Remediation Program. Based upon a Memorandum of Understanding signed in 2010 by Kuwait National Focal and Kuwait Oil Company (KOC), Kuwait Oil Company was entrusted with handling the works as stipulated in UNCC Claim Funds 5000259, 5000450 Elements 2&3, and 5000454. The original plan was to Construct 17 landfills and to Excavate and Transport 26 million cubic meters of Contaminates soil to the Landfills and Bio-Remediate residual low level Contamination. Kuwait Oil Company recommended a change in strategy to Kuwait National Focal Point intended to Maximize Treatment and Minimize landfill. As per the new strategy, Tenders were prepared to treat a minimum of 15.5 million cubic meters of contaminated soil and to landfill a maximum of 6 million cubic meters of the estimated remaining oil contaminated soil. Out of a total of eight contracts floated to the market, five contracts have completed preliminary works to assess the quantity and level of contamination, prepare the treatment areas and to conduct treatment trials.

The purpose of this abstract is to shed light on the journey in developing a robust, flexible and attractive Contract and to highlight the achievements in the initial 17 months of work and commencement of full-scale soil treatment for one of the five Zones under North Kuwait Excavation, Transportation & Remediation and South Kuwait Excavation, Transportation & Remediation (Phase I) Contracts.

**Keywords:** Oil lakes, contract strategy, treatment, and TPH

## **1. Introduction**

The State of Kuwait is located in the northeast corner of the Arabian Peninsula. Kuwait is one of the smallest countries in the world in terms of land area. The flat, sandy Arabian Desert covers most of Kuwait. The total area of Kuwait is about 17,818 km<sup>2</sup> includes several offshore islands, the largest of which is Bubiyan, near the Iraqi border. Kuwait contains 10 oil fields in two main areas: Northern Kuwait, which comprises the Ratqa, Raudatain, Sabriya, and Bahra oil fields, and Southern Kuwait, which includes the Greater Burgan, Managish, and Umm Qudair, oil fields (oil wells). Greater Burgan consists of three distinct oil fields, namely, Al-Ahmadi, Burgan, and Maqwa. During the withdrawal of the Iraqi army after the Gulf war of 1990, over 700 oil wells were ignited resulting in black cloud, which extinguished the light for the people of Kuwait, causing the largest environmental disaster in recorded human history.

The experts predicted that it would take over five years to extinguish the fires, but due to the decision to invite multinational fire fighters, the fires were extinguished in approximately 8 months. On 26<sup>th</sup> November 1991, the last oil fire was extinguished but Kuwait was left with the ruins that resulted from Iraq's invasion in the form of Land and Coastal oil contamination as well as the danger of unexploded ordinances and landmines as a result of the actions of the Invading army as well as the ensuing battles. The United Nations Compensation Commission was established in 1991 to manage claims from claimant countries, further to its establishment, an F4 panel was created in 1998 to address claims specific to the environment. Kuwait was awarded six claims by 2005 and decision 258 for the follow-up program provided the framework for the proper management of funds.

In line with decision 258, every claimant country was required to establish a national focal point, and so Kuwait established the Kuwait National Focal Point (KNFP) in 2006. KNFP liaises with a number of stakeholders for the execution of the "Kuwait Environmental Remediation Program" (KERP) related to the six claims. In 2010, a memorandum of understanding (MOU) was signed between KNFP and Kuwait Oil Company (KOC). Kuwait Oil Company is managing three claims [1] either in part on whole:

- Claim 5000259 Funds for Remediation of Damage to Marine and Coastal Resources.
- Claim 5000450 Funds for Damage to Terrestrial Resources (Element 2 – Well Head Pits and Element 3 – Tarcrete).
- Claim 5000454 Funds for Oil Lakes remediation.

Upon signing of the MOU, KOC immediately commenced tender preparation and signed four contracts; two to construct two engineered landfills and two for excavation and transportation of the more heavily contaminated soil in ecologically sensitive location to the landfills. As part of the above 4 contracts, all physical works related to Claims 5000259 and Claim 5000450 element 2 were completed in 2018. These works entailed clean-up of well head pits which were pits created by the firefighters to store seawater to fight the oil fires and Coastal Oil Deposits which oil depositing on part of Kuwait's Coast and a Coastal Oil trench created by the Iraq army to defend against a perceived amphibious attack.

As per the technical experts the contamination, which covered a combined area of 114 km<sup>2</sup>, was estimated at 26 million cubic meters. With a plan to construct 17 landfills and to bio remediate limited residual low-level contamination. However, in 2005, Kuwait Oil Company proposed a more sustainable solution named "Total Remediation Solution" (TRS) [2] that was approved by KNFP at the end of that year. In 2017 and 2018, commenced with preparation of tenders to address the largest Claim Fund (5000454 Element 1) for the treatment of Dry Oil Lakes, Wet Oil Lakes and Oil Contaminated Piles. One tender made up of two contracts in North Kuwait for treatment of 4 million cubic meters of Oil Contaminated Soil and another tender for three contracts in South Kuwait.

The focus of this paper is to discuss the strategy implemented and the reasoning behind the contracting arrangement as well as the achievements, which were realised in the first phase (Preliminary Works) of the Contracts. We will be focusing on one of the five contracts presently under physical execution – North Kuwait Excavation, Transportation & Remediation Contract (Zone II) presently being executed by the Joint Venture of KCPC (Kuwait Company for Process Plant & Contracting) and ETC (Environmental Technologies Management Company).

## **2. Tender Preparation & Execution of Preliminary Works**

### **2.1. Location & Feature Description**

North Kuwait Asset Area (Al-Rauthatain, and Al-Sabriya Oil Fields), was split into two zones, Zone I and Zone II and the two zones were not to be awarded to the same entity (Single contractor or Joint Venture/Consortium (JV/C) to mitigate risk of full suspension of operations in any Asset area due to failure of the Contractor. An 11 km<sup>2</sup> area was assigned for the establishment of a treatment area southeast of the contaminated areas and the intention is that each contractor was to manage approximately 2,000,000 m<sup>3</sup> of oil-contaminated soil.

The total area of the contaminated feature were designated as Wet Oil Lakes (WOL) and Dry Oil Lakes (DOL) and Oil Contaminated piles (OCP). However, Wet Oil Lakes and Dry Oil Lakes consist of three layers; a top layer (Layer 1) of highly contaminated soil, which is black and highly viscous, a second layer (Layer 2) of low to medium contaminated soil and the third layer (Layer 3) is the clean soil as per site soil characterisation report [3]. The approximate remaining contamination areas in North Kuwait and assigned the two contractors was more than 14 km<sup>2</sup> and the areas were split into fourteen sub-zone and each contractor was required to handle seven sub-zones.

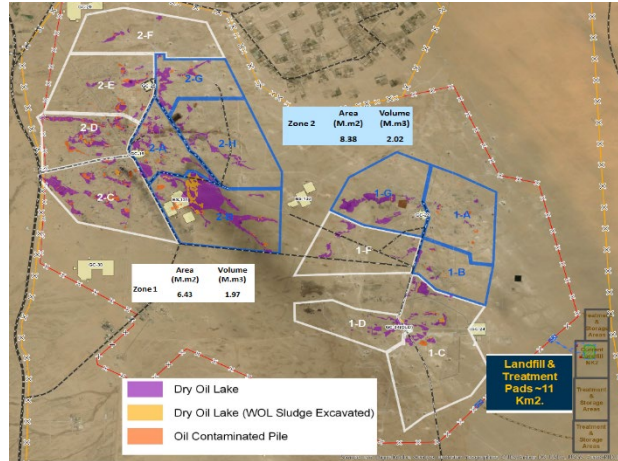


Fig. 1: North Kuwait Oil Fields Gulf War Fires Contamination distribution and designated treatment area

## 2.2. Risk Based Approach (RBA)

The RBA approach adopted is in accordance with internationally recognized Risk Based Corrective Action (RBCA) methodology. This approach had been agreed with Kuwait Environment Public Authority (KEPA). The Risk Based Assessment study [4] & [5] mainly covered wet oil lakes, dry oil lakes, contaminated soil piles and tarcrete for contaminated features. The main objective of this study was to derive risk based remediation target criteria (RTC) for historical contaminants resulting from the damaged oil wells that can be used to inform clean up criteria. Moreover, this study was designed to help minimize unnecessary remediation on marginal contamination that does not pose an unacceptable risk to receptors. A key part of establishing the treatment criteria is the assessment of the risk involved to the ecosystem and the Risk Based approach assessed the risks on wildlife and selected the following species of local fauna and flora to identify their tolerance to various hydrocarbon chains mentioned in table 1 [6] & [7].

In combination with the above tolerance limits data was collected from over 70 samples of varying contamination concentrations from North Kuwait identifying the concentration of carbon chains (Aromatic and Aliphatic) C<sub>6</sub>-C<sub>10</sub>, C<sub>10</sub>-C<sub>16</sub>, C<sub>16</sub>-C<sub>35</sub> and C<sub>35</sub>-C<sub>90</sub> and based on the below formula, the treatment target for each sample was calculated:

$$F1 = C6 - C10 \quad (1)$$

$$F2 = C10 - C16 \quad (2)$$

$$F3 = C16 - C35 \quad (3)$$

$$F4 = C35 - C90 \quad (4)$$

$$Treatment\ Target = \frac{Initial\ TPH\ level}{\left(\frac{F1}{F2Limit} + \frac{F2}{F3Limit} + \frac{F3}{F4Limit} + \frac{F4}{F4Limit}\right)} \quad (5)$$

Based upon the Table 1 and formula (5), the below graph was developed showing consistence in TPH treatment targets.

Table 1: Site Specific Assessment Criteria for Individual and Fractionated TPH for valued ecological constituents in the South Burgan Oilfield (mg/kg)

TPH Fractions	Desert Hedgehog	Lesser Jerboa	Crested Lark	Soil invertebrates	Terrestrial plants
DOL Layer 1					
Aromatic (C10-C12)	325	757	399	240	200
Aliphatic (C10-C12)	1584	1365	8874	240	200
Aromatic (C12-C16)	1695	757	399	240	200
Aliphatic (C12-C16)	1584	1365	8874	240	200
Aromatic (C16-C21)	2676	2445	444	2711	2711
Aliphatic (C16-C21)	3362	2602	9298	2711	2711
Aromatic (C21-C34)	2676	2445	444	2711	2711
Aliphatic (C21-C34)	3362	2602	9298	2711	2711
Aliphatic and Aromatic (C>34)	4481	4481	4481	4481	4481
Total Petroleum Hydrocarbons	4440	4440	4265	4370	4355
DOL Layer 2					
Aromatic (C10-C12)	325	NR	NR	240	200
Aliphatic (C10-C12)	1584	NR	NR	240	200
Aromatic (C12-C16)	1695	NR	NR	240	200
Aliphatic (C12-C16)	1584	NR	NR	240	200
Aromatic (C16-C21)	2676	NR	NR	2711	2711
Aliphatic (C16-C21)	3362	NR	NR	2711	2711
Aromatic (C21-C34)	2676	NR	NR	2711	2711
Aliphatic (C21-C34)	3362	NR	NR	2711	2711
Aliphatic and Aromatic (C>34)	4481	NR	NR	4481	4481
Total Petroleum Hydrocarbons	4325	NR	NR	4040	3985
NR – not required					

Based on the RBA outcomes, RTC (TPH 1%) has been considered as new remediation standard which will be implemented for entire Remediation Projects in Kuwait [8]. Moreover, 1 % TPH will result in the significant reduction of remediation treatment durations and appropriate cost savings, thereby providing scope to employ additional technologies to achieve the target remediation goal more efficiently on fast track while realising the ecological benefits of the previous standard. The 1 % TPH has adopted on the KERP remediation mega projects in South & North Kuwait oil fields.

It is to be noted, that assessment of target Initial and Target TPH were assessed using CWG (Criteria Working Group) method and a comparison was made based on 21 of the same set of samples where both TPH level assessment (CWG & HEM) were made to provide a ratio which was averaged to 1:1.256. i.e. a TPH HEM of 1% will equate to 1.256 CWG (for this data set only).

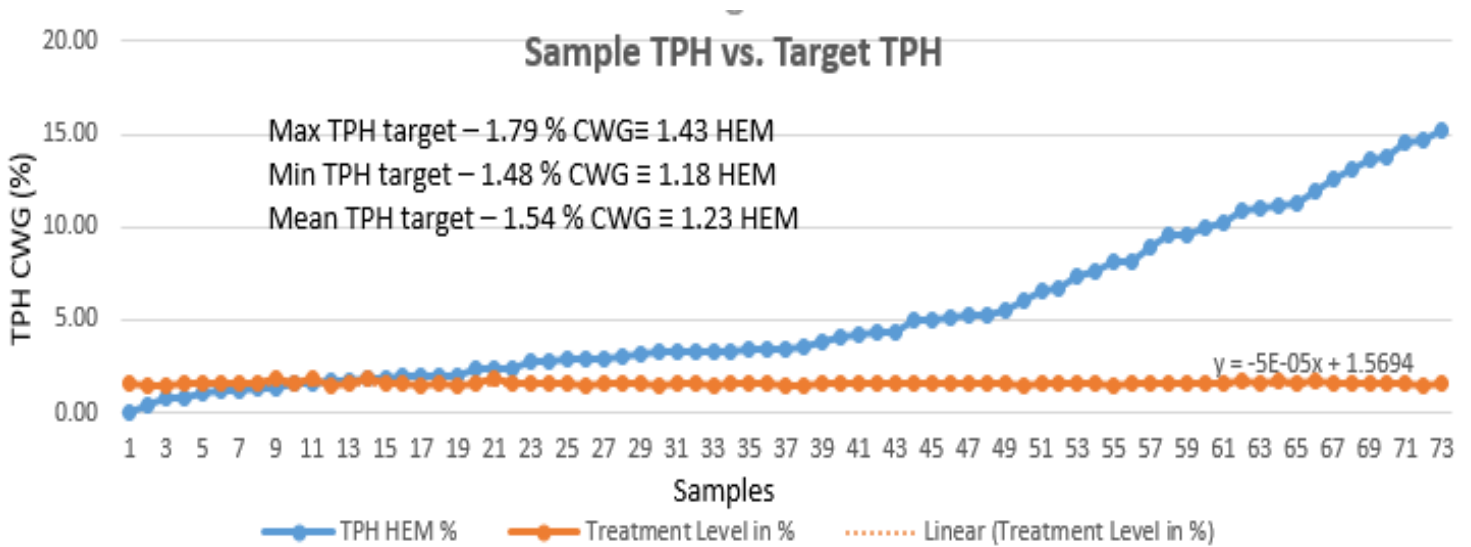


Fig. 2: Initial vs. Target TPH levels

### 2.3. Contracting Strategy

Contracting strategy and contract preparation can make or break a project. It was important to ensure clarity not only in the requirement of the contract but also having a common understanding of how things are to be quantified. Furthermore, considering the cost, quality and time aspect, it was important to manage our expectations especially considering that the original funds were intended for construction of landfills and the excavation and transportation of oil contaminated soil to those landfills. We had a number of lessons learnt from previous contracts where we expected the contractors to treat a hundred percent of the contamination but none of the contractors achieved these goals and it became economically impractical even though some of the contractors had reached over 90% treatment, contractually they had failed to achieve the contractual objectives set out in. Another issue which led to adjustment orders in previous contracts, was the concept of providing limited site soil characterisation data which may not be completely representative of the detailed investigation to be carried out by the contractor and asking for a single treatment cost per quantity and which therefore had to be addressed.

The Total remediation strategy (TRS) followed the standard model for waste management; first assess the hydrocarbon content in the soil and the hydrocarbon constituents to assess the ecological risk and identify the acceptable threshold (the remediation target criteria (RTC)) through the Risk Based Approach (RBA) for the specific oil to be treated. Then, remediate the soil down to below the threshold. The TRS identified that contamination below 7% should be treated through Bioremediation and soil with a contamination level between 10% to 5% maybe treated through treatment technologies or a treatment train and for contamination beyond 10%, Company will consider oil recovery or reuse before opting for landfill.

### 2.4. Payment Structure

Considering Client/Contractor relationship and contention in terms of payment especially when assessing volumes and the change during excavation and transportation, one of the first steps was to identify the pre-treatment mass in Tons as the unit of measure and all measures are to be identified through regularly calibrated weighbridges. Payments for Excavation and transportation would be in increments of 10 km hauling distance and all vehicles would require the installation of GPS tracking systems to identify hauling distance. To ensure cost effective and timely treatment, contractors had to price treatment not in terms of technology used but rather in contamination level with a minimum treatment percentage for each contamination band:

Table 2: Treatment payment structure

Contamination Level in TPH %	Minimum Treatment	Estimated Quantity in Tons	Unit Price in dollars (\$)
1-5%	> 90%	2,609,200	\$
	> 90% & < 100%**	288,800	\$\$
5-7%	> 80%	144,400	\$\$
	> 80% & < 90%**	18,050	\$\$\$
	> 90% & < 100%**	18,050	\$\$\$\$
7 and above*	< 70%	379,050	\$\$\$
	> 70% & < 80%**	54,150	\$\$\$\$
	> 80% & < 90%**	54,150	\$\$\$\$\$
	> 90% & < 100%**	54,150	\$\$\$\$\$\$

\* Considering minimal initial sampling were above 10% the treatment percentage was not broken down further unlike contracts for North Kuwait

\*\*Contractor may dispose to landfill

The above pricing bands were central to the method of measurement and payment strategy, which provided the flexibility to allow contractors to include any risk pricing on the higher treatment bands and yet stay competitive. Whilst, for the company, if funds were limited, we may opt to limit treatment to the minimum treatment percentages. Costing was split between preliminary works portion such as Unexploded Ordnance, Topographical and ground survey and site soil characterisation as well as HSE studies, which were required to be executed within the initial 17 months whilst treatment trials were to be paid as part of the Treatment portions to prevent compensation in case initial treatment trials (paid based on success).

### 2.5. Quantification of volumes and Level of Contamination

The JV/C of KCPC & ETC conducted ground truthing and topographical surveys of approximately 5.66 million m<sup>2</sup> and, collected 1,061 samples for site soil characterization in order to develop 3D models of the contamination distribution and concentration. Below is an example of a feature, which was modelled:

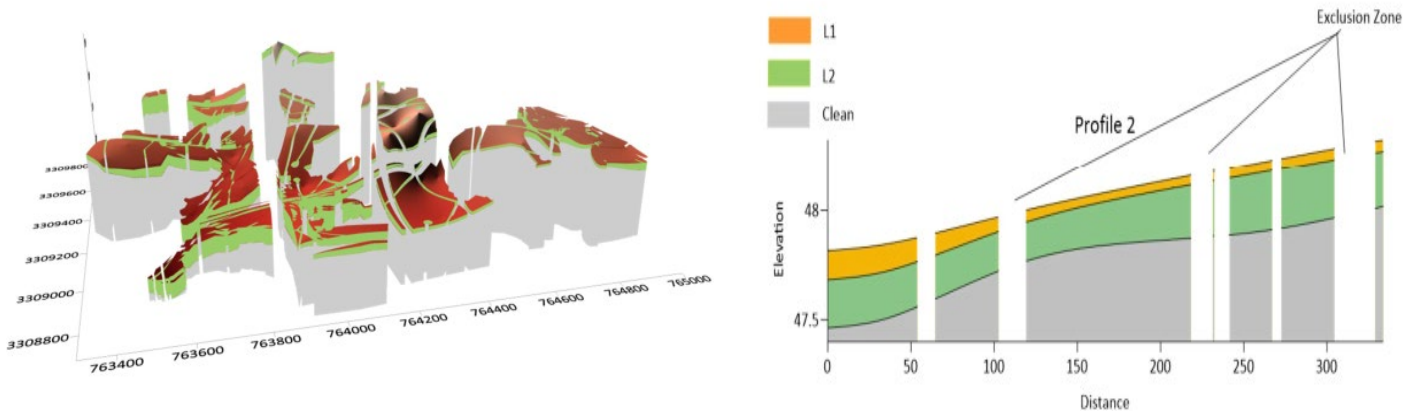


Fig. 3: 3D Model of contaminated feature

Based upon Contractors detailed assessment, the following quantities were refined:

Table 3: Treatment payment structure

Contamination Level in TPH %	Minimum Treatment	Bill of Quantity (Ton)	Final Bill of Quantity (Ton)
1-5	> 90%	2,609,200	2,429,056
	> 90% & < 100%	288,800	268,861
5-7	> 80%	144,400	325,281
	> 80% & < 90%	18,050	40,660
	> 90% & < 100%	18,050	40,660
7 and above	< 70%	379,050	325,139
	> 70% & < 80%	54,150	46,448
	> 80% & < 90%	54,150	46,448
	> 90% & < 100%	54,150	46,448
Total tonnage		3,620,000	3,569,003

## 2.6. Treatment Pad design

Each contractor of the five employed to treat the contaminated soil developed a methodology for both their Bioremediation activities as well as their treatment technologies. The JV/C of KCPC & ETC designed a unique treatment pad design with a complete infrastructure of piping to transport water from constructed lagoons to a Land farm as well as windrow area. For the Land farm, they constructed a pivot system with a radius of 500 meters and the system can be controlled to provide different water and nutrients for each quarter of the Land farm and a set of quick coupling pipe risers every 200 m along the windrows.

Below is a layout of the stock pile area where the soil is sifted and pulverised, as required to ensure easy treatment of the soil, identifying the locations of the weighbridges used to weigh and log each load in the bar code system and treatment area showing the location for the Soil wash system, Land Farm and Windrow areas:

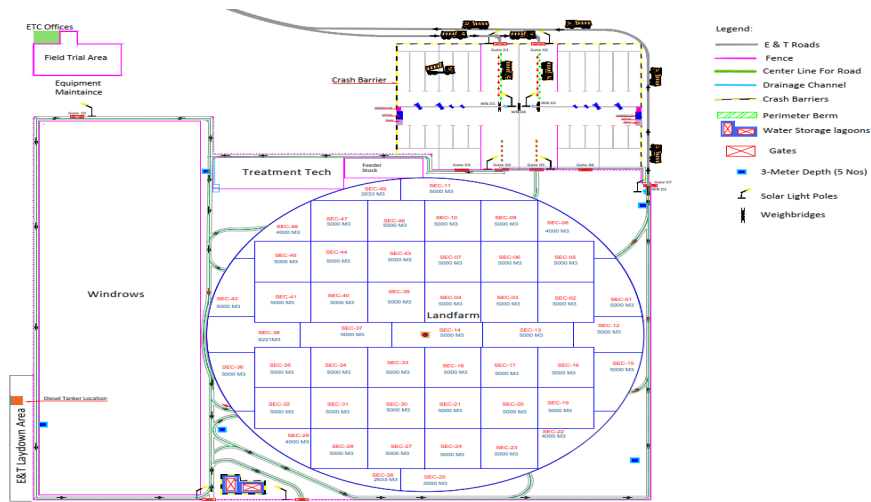


Fig. 4: Treatment area and stockpile area

It is important to highlight that the barcode system records the source location of the contamination, the average contamination level prior to treatment and the treatment location.

## 2.7. Treatment Trials

For contamination between 1% to 5%, 5% to 7% and a mix of the two contamination levels, 18 trays were prepared by ETC for each of the three mixtures with varying nutrient, inoculum and water levels to identify the most efficient treatment

combination. Once targets were met, the most effective lab test was taken to the field for treatment field trials. Below, is figure 6 shows degradation levels of some of the treys:

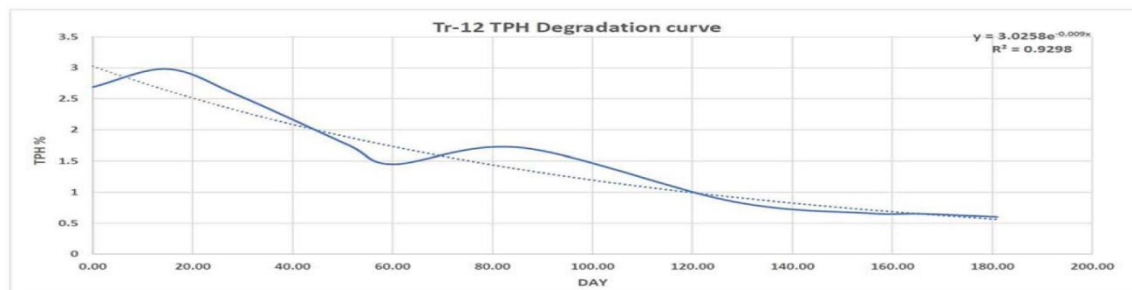


Fig. 5: Degradation of contamination as a function of time.

KCPC and ETC showed great success and worked ahead of schedule and in November 2022 commenced with full scale treatment on its Land Farm and has filled the whole of the Land Farm with more than 400,000 tons of contaminated soil. We expect to reach the treatment targets for a quarter of the Land Farm Area by the end of May 2023 and remaining Land Farm Area is expected to reach RTC by July 2023.

### 3. Conclusion

The oil fires of Kuwait represented the largest inland manmade environmental catastrophe in living memory and its solution (the Kuwait Environmental Remediation Program) had to be the largest inland environmental program and in the very near future, we will have 8 contractors handling approximately 38 million tons of contaminated soil. We believe the contracting model, which was developed, provides a suitable framework of this extremely large-scale remediation program, which has allowed competitive pricing allowing Kuwait Oil Company to realize the TRS strategy.

Furthermore, similar to the international contribution during the extinguishing of the oil fires, this contract has allowed the involvement of a Saudi Company and the other JV/Cs have involved countries such as Finland, China, Italy, the Czech Republic and Germany which will contribute in enhancing the remediation field especially considering the high wreathing of KERP oil contaminated soil. All the Contractors are showing promising early results and are creating a sense of positive competition in order to achieve the remediation target criteria i.e. less than 1% TPH of contaminated soil . Moreover, this project can be a model, globally, for large-scale treatment of contaminated soil utilising multiple remediation technologies.

### References

- [1] <http://uncc.ch/home>.
- [2] KERP Total Remedial Solution (TRS) Strategy [report], AMEC, Dec, 2014, pp 1-63.
- [3] Limited Scope Site Soil Characterization - summary report, Project Management Consultancy Services For Kuwait Environmental Remediation Projects (KERP), 2014, pp 1-17.
- [4] KOC & AMEC Foster Wheeler, "KERP – overview of RBA, "July 2015.
- [5] AMEC Foster Wheeler 050669-0050-DV00-RPT-0004, Rev. A1 Report- Ecological Risk Based Approach Part 1: Risk Characterization Report,2017.
- [6] A.S.Al-Barood; Kuwait Environmental Remediation Program (KERP) Risk Based Approach Process, 22nd International Petroleum Environmental Conference, November 2015, Denver, CO.
- [7] Aisha Al-Barood; Kuwait Environmental Remediation Program (KERP) : Roadmap to Benefits of Remediation Standard Revision, 512th International Conference on Science, Engineering & Technology (ICSET-2019), October 18 -19, 2019 in Seoul, South Korea.
- [8] API Publication Number 4709: Risk-Based Methodologies for Evaluating Petroleum Hydrocarbon Impacts at Oil and Natural Gas E&P Sites. Washington, 2001.