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3D Mapping Technology for Soil Characterization of Kuwait Hydrocarbon Contaminated Sites

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Abstract - In this paper, 3D mapping technology for hydrocarbon contaminated soil a powerful tool for characterizing the soil properties, soil condition, and the extent of Hydrocarbon contamination in the site that been investigated. Furthermore, this innovative 3D soil mapping technology will assist remediation projects managers in developing their remediation strategies, and support their decision in investigating and screening the required technology for specific contaminated sites.
It is observed throughout this research paper that this 3D Soil mapping technology will dramatically reduce the numbers of samples required by the current typical soil site sampling process, which will reduce the sampling costs for any Hydrocarbon contaminated sites. In addition, this sampling method and technology will provide better quality results with reduction in time required for sampling any contaminated site.
Moreover, throughout the literature review, we have identified that there are two interpolation methods that can be realistic to certain data types such as soil chemistry and geology depending on the area being studied, either a single method could be used or a combination of methods that could be integrated from each other to develop the best interpolation technique related to the contaminated area being studied.
The objectives of this research have been achieved by studying a range of petroleum hydrocarbon-contaminated sites in Kuwait, collection of soil data and samples from this related sites location, understanding the spatial variation in soil properties, development of sampling procedure related to our 3D soil mapping technology

Keywords**:** Soil remediation, 3D contaminated soil mapping technology, Soil characterization, Soil sampling, Kuwait oil lakes

1. Introduction

The environmental disaster caused by the Iraqi invasion to Kuwait considered as the worst and biggest environmental damage in all time and history, destroying more than 800 oil wells leading to oil spills in land and sea. As an outcome more than hundreds of oil lakes forms covering the land causing serious threat to human health, ecosystems, and the underground water spills with consequences that are yet to be fully understood. This research paper contributes to the effort of understanding and solving this questions, by the development of 3D soil mapping and characterization technology.

Site characterization, contaminant perspectives and site investigation are the major elements in any site remediation strategy decision and in the process of developing environmental and economical treatment options soil characteristics are a very important element in the remediation technologies selection process as site soil conditions commonly limit the selection of a treatment process. Soils are inherently variable in their physical and chemical characteristics throughout the contaminated site for some extent, and effected by internal and external conditions [1].

In any hydrocarbon-contaminated site the environmental damages require intensive characterization of the impact and spatial extent of the problems. This can be achieved through the formation of comprehensive and inclusive soil maps that define both the spatial and vertical variability of key soil properties. Detailed three-dimensional (3D) digital soil maps can

be readily used and embedded into environmental models, these environmental models will assist in defining the best remediation technology and strategy to tackle complicated hydrocarbon contaminated sites [2].

Our proposed methods to improve the cost-effectiveness of soil characterization include: (a) taking into account the vertical variation in both total petroleum hydrocarbon and various hydrocarbon species; and (b) using 3-D mapping technology to establish models for spatial distribution of petroleum hydrocarbons in oil lake-affected soils with markedly reduced sampling density. The first stage of our research project is to develop 3D soil mapping technology for hydrocarbon contaminated sites, and to investigate the accuracy of different interpolation methods using cross validation errors for interpolating the spatial pattern of soil properties and contamination.

2. Literature Review

2.1. 3D Soil Mapping and Site Characterization Technology for Hydrocarbon Contaminated Sites.

Soil Characteristics is a very important element in any hydrocarbon contaminated sites remediation technology selection process. Site soil conditions frequently limit the selection of a treatment process, Process-limiting characteristics such as pH or moisture content may sometimes be adjusted. In other cases, a treatment technology may be eliminated based upon the soil classification (e.g., particle-size distribution) or other soil characteristics [3]

Analysis and interpretation of spatial variability of soils properties is a keystone in site-specific management [4], 3D soil mapping technology for hydrocarbon contaminated site is a powerful tool for soil characterization and soil maps that describe key soil property and profile, this will support in the decision for the most suitable environmental remediation technology and risk based approach for environmental remediation projects in general, and provide novelty in screening the right technologies for a hydrocarbon contaminated sites.

2.2. Spatial Interpolation

GIS is all about spatial data and the tools for managing, compiling, and analysing that data Arc GIS Spatial Analysis extension provides a toolset for analysing and modelling spatial data. A set of sample points representing change in landscape, population or environment can be used to visualize the continuity and variability of observed data across a surface through the use interpolation tools. These changes can be extrapolated across geographic space. The ability to create surface from sample data make interpolation both powerful and useful [5].

Interpolation is based on the assumption that spatially distributed objects are spatially correlated; in other words, things that are close together tend to have similar characteristics. Each Method uses a different approach for determining the output cell values [6].

2.3. Interpolation Techniques

Visiting every location in a study area to measure the height, magnitude, or concentration of a phenomenon is usually difficult or expensive. Instead, dispersed sample input point locations can be selected and a predicted value can be assigned to all other locations. Input points can be either randomly, strategically, or regularly spaced points containing height, concentration, or magnitude measurements [7].

A typical use for point interpolation is to create an elevation surface from a set of sample measurements. Each point represents a location where the elevation has been measured. The values between these input points are predicted by interpolation method [7].

3. Methodology and Procedure.

- To assess the feasibility of 3D Techniques for soil mapping and characterization of hydrocarbon contaminated sites and oil lake area.
- A range of petroleum hydrocarbon-contaminated sites in Kuwait selected as case studies during this technology development.
- To investigate the accuracy of different interpolation methods using cross validation errors for interpolating the spatial pattern of soil properties and contamination extent of hydrocarbon contaminated sites.
- Collected soil data and samples from selected hydrocarbon contaminated sites in Kuwait at different locations within the study area and understand the spatial variation in soil properties especially TPH Total petroleum hydrocarbon.

- To develop the most 3D appropriate and distinguished technology integrated form the appropriate interpolation methods and technique for sampling and examining hydrocarbon contaminated soil properties in the specific site.

4. Laboratory Analysis and Methods

Laboratory analyses for physical, chemical properties have been carried out using laboratory protocol related, TPH (Total Petroleum Hydrocarbon) is our concerns for demonstration in this paper.

5. Case Study

Studying a petroleum hydrocarbon-contaminated site at one of the oil Lake in Kuwait Figure 1 below, by collection of soil data and samples from this related sites location, and understanding the spatial variation in soil properties, development of sampling procedure related to our 3D soil mapping technology. Furthermore, we have developed an inverse distance weighting interpolation code using MATLAB (Figure 1), which been used in our 3D soil mapping to provides information related to TPH at this contaminated site (Figure 2).

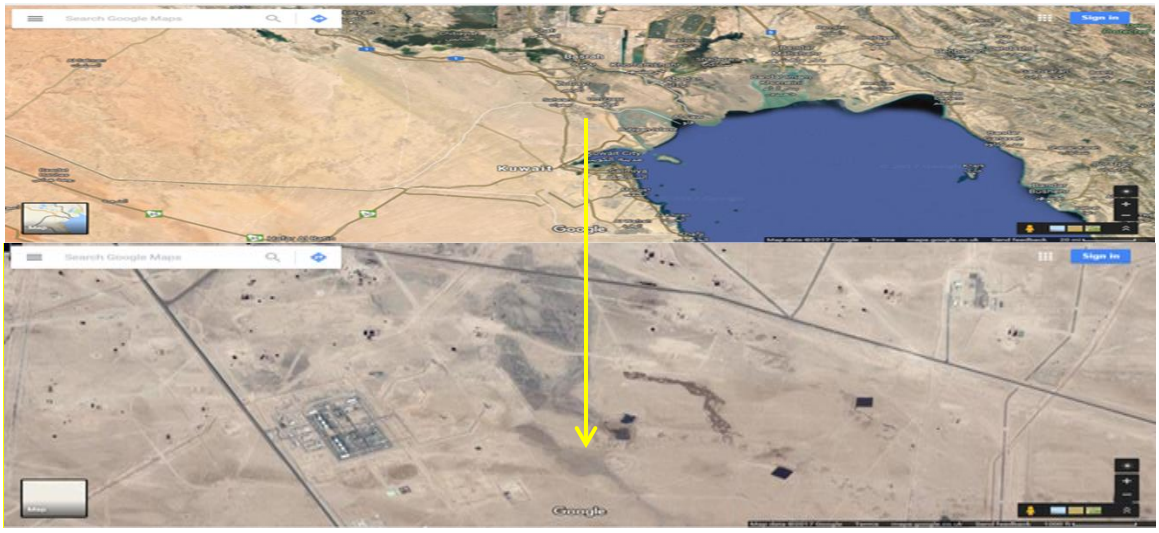

Fig. 1: Project location (Hydrocarbon contaminated site)

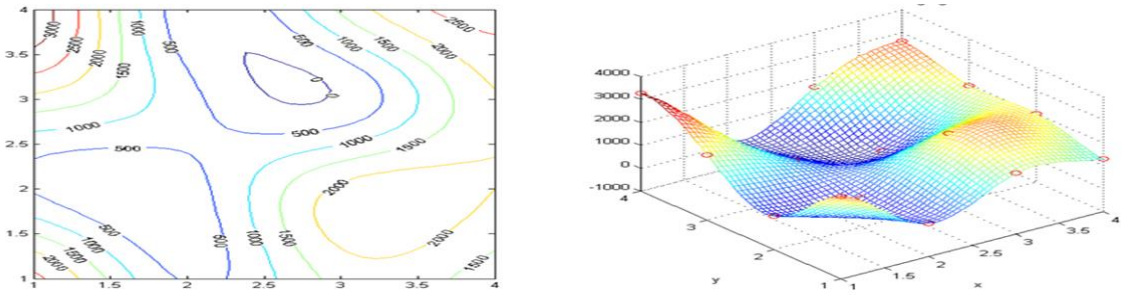

Fig. 2: Predicted contamination degree using innovative 3D soil mapping technology.

Fig. 3: Sampling Methodology.

6. Conclusions

It was observed in the literature review that there are two main groupings of interpolation techniques for generating raster surfaces, deterministic and geostatistical techniques. Deterministic Models use a mathematical function to predict unknown values and result in hard classification of the value of features. Statistical Techniques produce confidence limits to the accuracy of a prediction but are more difficult to execute since more parameters need to be set.

In addition, throughout this study we have identifies that this 3D Soil mapping technology will dramatically reduce the numbers of samples required by the nowadays typical soil site sampling process, this will reduce the sampling costs and time for any Hydrocarbon contaminated sites, adding to that better quality results. "New sampling procedure and Method" for 3D soil mapping for hydrocarbon contaminated sites has been developed and accomplished during this project. Developed interpolation code using MATLAB. Integrated formulas to achieve the best quality values

Cost, Time, and quality: less numbers of sampling, more information provided, cover more distance and areas, with less sampling, following structure procedure and methodologies from sampling collection to data analysis results.

References

[1] Hamad Al-Mebayedh, "Remediation Technology Review and Selection Process for Hydrocarbon Contaminated Sites," in *SPE Annual Technical Conference and Exhibition*, Amsterdam, The Netherlands, 2014, pp. 27–29.

[2] Hamad Almebayedh, Chuxia Lin, Yu Wang, "Improving Management and Technology Selection Process for Petroleum Hydrocarbon-contaminated Sites by Innovation of 3D Mapping Technology for Soil Characterization," in *Fourth European Conference on Sustainability, Energy & the Environment*, 2016.

[3] Environmental Protection Agency (EPA) Federal Remediation Technologies Roundtable (FRTR)

[4] Javed Iqbal, "Spatial Variability Analysis of Soil Physical Properties of Alluvial Soils," *Soil Science Society of America Journal*, vol. 69, no. 4, 2005. [Online] Available: https://www.researchgate.net/publication/43256103_Spatial_Variability_Analysis_of_Soil_Physical_Properties_of_Alluvial_Soils

[5] Esri, Spatial Analysis, Understanding Spatial Relationships and Patterns. [Online] Available: http://www.esri.com/products/arcgis-capabilities/spatial-analysis

[6] Colin Child, (2004), ESRI Education Service, [Online] Available: http://www.esri.com/news/arcuser/0704/files/interpolating.pdf.

[7] MininGeology,(2015). Spatial Interpolation. [Online] Available: http://miningeology.blogspot.co.uk/2015/06/spatial-interpolation.html.