Hisham M.J. Al Sharaa

Geomatics Eng. Div., Civil Eng. Dept., University of Technology Baghdad, Iraq.
hishamalsharaa@live.com

Abdul Razzak T. Ziboon

Geomatics Eng. Div., Civil Eng. Dept., University of Technology Baghdad, Iraq ‘

Abdul Hameed M.J. Al Obaidy

Environmental Research Center, University of Technology, Baghdad, Iraq.
10929@uotechnology.edu.iq

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Toxic Soil Contamination in Al Muthanna Storage Site Using Geospatial Analysis Technique

Abstract- *The Iraqi past chemical program was destroyed by the military operations or destructed by the UNSCOM/CDG teams during the early 90s. Both operations lead to a large number of scattered remnants of contaminated areas. The quantities of hazardous materials, incomplete destructed materials and toxic chemicals were sealed in two well-protected bunkers. Lack of appropriate destruction technology, led to spread the contamination around the bunkers .since 2009 the Iraqi experts have been working to develop a practical plan for decommissioning the contaminated area. This paper introduces the hazard contamination in the storage site using geospatial analysis technique. The contamination level of two main chemical compounds (Copper Cu and cyanide Cn) have been evaluated and analyzed, taken from different soil samples of the site, surrounding areas have investigated and analyzed compared to the reference points. The storage area divided into 30 sector major sectors level of soil samples from soil surface all samples collected from acquires 10 samples from each sector. The results showed The Cn level exceeds the permitted level by (55000) times and for copper by (1050) times over the permitted level very high Contamination activity was found in the storage area.*

Keywords- *Al Muthanna Storage site, Geospatial techniques and visual interpretation, Toxic.*

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1. Introduction

Al Muthanna has been used as the key facility for production of chemical weapons in Iraq last century. It is located 90 km northwest of Baghdad as shown in figures 1 and 2. According to the Security Council Resolution 678 (1991). Iraq accepted to declare and destroy its weapon of mass destruction (**WMD**) program.

Al Muthanna State Establishment (**MSE**) production facilities were converted to destroy the chemical agents and the precursors under the supervision united nation special commission (UNSCOM). Due to the high-risk and the lack of appropriate destruction technology, the UNSCOM has select two well-protected bunkers to secure and isolate the remnants resulted from the destruction process from the population. [1]

Iraq declared the contents of two bunkers according to the Chemical Weapons Convention (**CWC**) in June 2009 and committed to submit the destruction plan to the Technical Secretariat [2,3]. The contaminated area was investigated and analyzed by using the integration of Geospatial Information Systems and statistical software.

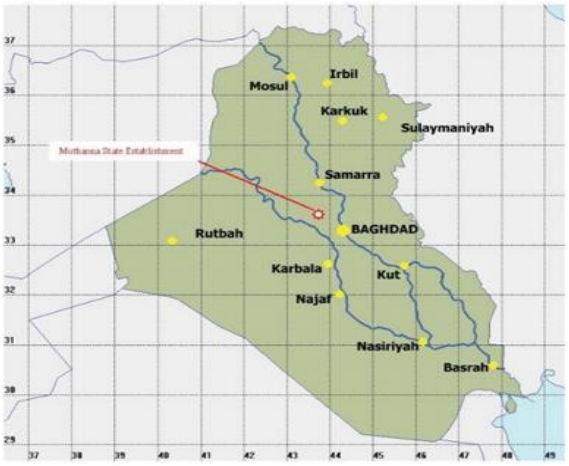

Figure 1 Al-Muthanna storage site location

2. Al Muthanna Storage Site Description

Al Muthanna storage site, located 90 km northwest Baghdad on Tigris river arm between Samara and Fallujah Was Iraq's main chemical weapons research, development, and a production facility. It is located in Saladin Governorate The geographical coordinates shown in Table 1 and figure 2.This facility covering an area 1 km², This site was operated continuously from 1983 to 1991, produced thousands of tons of precursors

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2412-0758/University of Technology-Iraq, Baghdad, Iraq

Chemical agents included mustard gas, sarin, tabun, and VX [4]. The site was bombed heavily during the Gulf war. From 1992 to 1994 the UNSCOM Group operated at this site to eliminate remaining precursor materials, equipment's, and destroy production plants or burn remaining chemical agents [2].
The storage area was semi-underground structures covered with a protective layer of sandy clay. They resembled a truncated pyramid.

3. Materials and Methods

In this paper, a total of 300 soil samples was analyzed by using GC mass spectrometer procedure and USEPA335.4 method. The samples were collected from the inner and outer perimeters of Muthanna storage area, during 2015 The storage area (850 m *1000 m) divided as grid into 30 sectors (196 m* 163 m) as major sectors then each sector divided into ten minor sectors the sampling method depends on Two levels of soil samples, surface soil samples and samples from 50 cm depth were averaged, the minor sub-grid also averaged. Finally, each grid represented by one sample point for final statistical analysis. The background level is defined from samples located within about 1 km north and south from storages site. The contamination level of two main chemical compounds has detected and evaluated (Copper Cu and cyanide Cn), from the soil samples of the site, surrounding areas have investigated and compared to the reference points selected. The Average results for the two depth layers have been combined to give us major perspicacity for toxic soil contamination in al Muthanna storage site. The output digital map layer includes contours for AL Muthanna Storage maps were created by additive interpolation method of the geographical information system using the integration between ArcGIS 10.4 and golden surfer. With ArcMap and Surfer spatial analysis extension and, DATA of subareas values can be imported to Geospatial through grid cells. These grid cells which have been classified in various ways and different colors are chosen for each class; the colors represent the progression of values for specified data. It is achieved after the raster themes are converted into a shape file, which includes contaminations doses and information that represents sub grade characteristics. Data are interpolated by kriging method to introduce a continuous surface as visual display by using spatial interpolation which is the process of using points with known values to estimate values at other unknown points. In geospatial statistical analysis, spatial interpolation of these points can be applied to create a raster surface with estimations made for all raster cells. [5].

Table 1: Al-Muthanna Site Location

Latitude	N 33 52 522
Longitude	E 43 50 538
Bunkers area	1 km^2

Figure 2: Al-Muthanna storage site area

4. Results and Discussion

The Analysis contamination of activity levels of Cu and Cn in the soils collected from different locations of the site shows a relatively asymmetrical distribution tailing slightly towards higher concentration. However, the activity level of Cu in the soils exhibit higher variability and ranged between 3-42 ppm with an average value of 6.08 ppm. Similarity, it is observed that the activity level of Cn in the soils of the study area also exhibits large variability and ranged between 0.1-60 ppm with average values of 4.16 ppm.
Whereas, indicating that the activity level of Cu and Cn in the soils was above the reference background level taken about 1 Km away from the study site as shown in Table 2.

Table 2**:** Statistical summary for heavy metals soil samples

	Cu ppm	**Cn ppm**
Avg.	6.08	4.16
Max.	42	60
Min.	3	0.1
Reference point	**3.15**	**0.1**

The obtained values of Cn level exceed the permitted level by 55000 times and for Cu by 1050 times. as shown in Figures 3 and 4 as contour and mountain range plots.
This approach used to recognize that the contaminant and overall distribution, particularly

higher concentrations due to hot spots are important parameters for demonstrating that the cleanup is very necessary to precisely achieve. Thus, it is necessary to have an overall understanding of the contaminant distribution to make this determination on hot spots acceptability. Many difficulties can be faced in this approach, one of them is the large numbers of samples are required to adequately characterize the upper tail of the distribution.

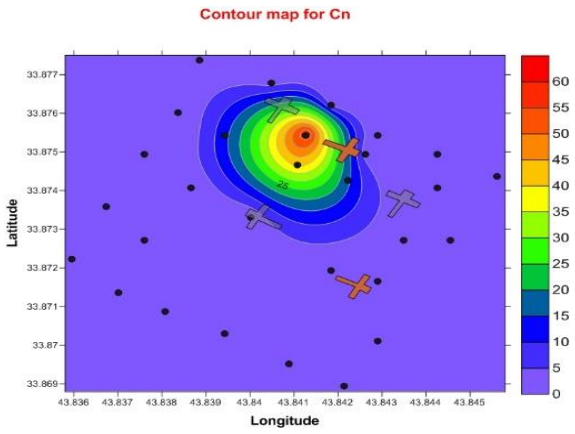
5. Conclusion

In this paper, the contamination of Al Muthanna storage site has been investigated. The results show that the concentration of Cu and Cn in the soil exceed the normal limits. It's clear that this site has suffered from the contamination due to the past chemical weapons program activities and the destruction of the chemicals and precursors related to this program. Severe contaminated hot spots were observed as follows:

- Cu hotspot near the storage bunkers exceed the reference values by 1050%
- very high contamination activity of cyanide near bunker 13 in this study area
- Cn level exceeds the reference values by 55000%

Due to these circumstances, it's essential to take the following action:

- Urgent action plan for decontamination
- Long term monitoring for the nearby water recourses.
- The agriculture activates should be moved out of the site by at least 1 km as recommended by the UN handover protocol.
- Medical examination for the nearby villages.
- More investigation and analysis for the other expected dangerous chemicals.



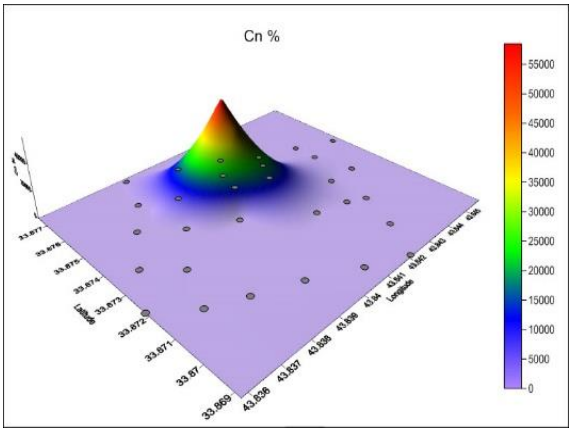
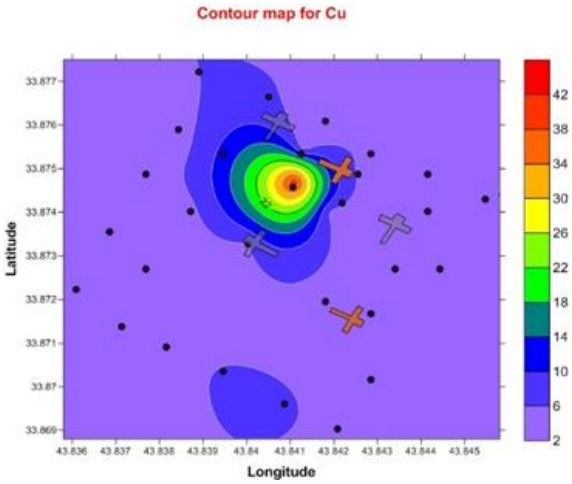


Figure 3: cyanide contamination contour and 'mountain range' plot



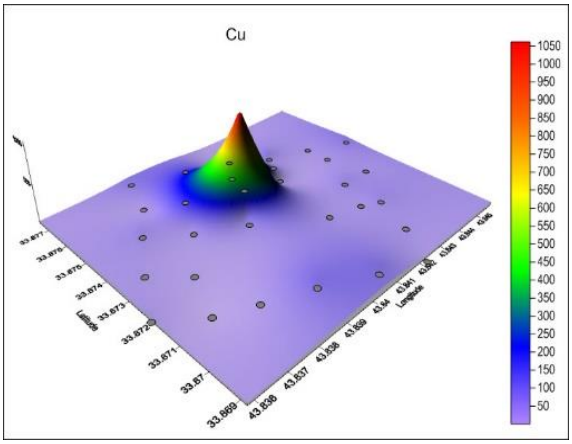


Figure 4: copper contamination contour and 'mountain range' plot

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