

# Study of Spatial Variability into Contaminated Soil using Kriging Techniques at Basrah

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**Abstract-** Depleted Uranium (DU) ammunitions were used by the U.S.A and UK troops in an open environment for the first time in history against Iraq on civilians and military targets during Gulf wars in 1991-2003. Spatial distribution and risk assessment of soil in the estimated sites at Basrah Governorate with uranium contaminations have been screened using statistics and geographic information system (GIS) methods, and a performance model of predication distribution and potential distant values of DU and other polluted components were detected by data collection. An interpolation technique was practiced in order to accomplish certainties in the data set and to decrease the influence of outliers. After choosing a tailored model, parameters can be recycled with the data to estimate Uranium concentrations at unsampled locations using the kriging technique to define the weights of adjacent monitoring in the predicating underground surfaces similar to contaminated elements and radionuclides of uranium chains. The problem appears when were increased in the deaths and congenital malformations resulted from carcinogenic diseases among Basrah population, after 1994 of due to use of DU extensively in these regions. The primary purpose of this paper is to present the current state of the determine DU sites and to predict in adjacent points of specific locations using different techniques. A review is provided aiming to discuss the effect of pollution by DU and transferring the pollutants to groundwater.

**Index Terms-** Contaminated Soil; Kriging Technique; Spatial Variability; Depleted Uranium; Contaminants Transport; Groundwater prediction; Healthiness Risks

## I. INTRODUCTION

Uranium is a severe silvery-white, ductile and lightly paramagnetic metal, which is pyrophoric when lastly involved it is slightly softer than steel and reacts with water when present in a finely divided state. In air, it naturally oxidizes and transforms shielded with a layer of oxide. All isotopes of uranium are radioactive. although generally believed of as infrequent is more ordinary in environment than other elements such as cadmium, selenium, cesium in addition to some of the infrequent elements (Bowen,1979; Kay and laby, 1995). DU is different from natural uranium by lesser percentage concentrations of  $^{235}\text{U}$  (0.7%) and  $^{234}\text{U}$ . In typical DU, the purport of  $^{235}\text{U}$  is about one-third of its original value (0.2–0.3%). Subsequently, the activity of DU is about 60% of the activity of natural uranium. Depleted uranium may comprise traces of  $^{236}\text{U}$  and  $^{239+240}\text{Pu}$  of cross-contamination. Metallic uranium is 65% more ambiguous, than instructor, has a high dissolving point (11328C) and is exceedingly pyrophoric as table1. (Burkart, et al., 2004).

**Table 1: Shows the Outputs of enrichment uranium isotopes:**

Outputs of enrichment			
Isotopes	U234	U235	U238
Weapon grade uranium composition	1 %	93.5 %	5.5 %
Depleted uranium composition	0.001	0.25 %	99.8 %

The process of conducting the DU risk assessment which involves selecting reference values, obtaining concentrations in environmental media, and identifying exposure parameters. Additionally, it is associated with exposure models which include benchmarks, site characteristics and chemical properties. Exposure parameters have been formulated in the database, and then behavioral studies were based on remediation of these contaminants and exposure of any material radioactive (Paustenbach, 2000).

## II. DISTRIBUTION OF CONTAMINATED SOILS BY DU

Different ways have contributed to spread of pollution, such as the migration of DU to the surface and underground water, it and can be incorporated ultimately into the food chain by corrosion process of ammunitions. Inhalation of DU dust through the war period, and ingestion contaminated water or food after the war also paid to spread contamination. Thus, groundwater based on several studies on formation the suitable method to simulate the groundwater zone, integrated assessment of thematic maps using a develop model based on GIS techniques is the most suitable procedure for groundwater potential zones prediction (Eliza et al., 2010).

Amounts of DU weapons were estimated at Iraq between 320 – 800 tons, which used against Iraq since the first Gulf War in 1991. The use of DU bullets and projectiles on Iraqi region hasn't stopped since 1991, also the 1998 attack on Iraq. Then, big invasion was come in these areas at 2003 and spending more than last wars of DU weaponries (William, 2002). But USA Group green peace and Holland larka institute (1999) have been proved that about (700-800) ton of DU were used in southern operational of Iraq. These amounts of DU are containing of radiation to enough of (500000) case threaten in death. Big amounts of DU were led to high chemical toxicity more than 700000 times, of the dust dispersion in the DU projectiles factory at 1980, which follower to US defense ministry, collony city, New York.

USA and its allies militaries were used DU projectiles in seriously residential areas this time, such as in Basrah. So, Japanese scientists have been measured the radioactive nuclides for <sup>238</sup>U and decay series. Many of the numbers of sampling was collected from different sites of the southern Iraq, they are

utilized Gamma spectrometry High purity Germanium analyzer and they had gotten increases in the radionuclides concentrations in the core samples after 2003 war. Those are due to exist high amounts of DU fragments, bullets, missiles, and munitions, were all used in the locations of martial actions (Komura et al., 2003). The global DU waste stockpiles all around the world have been estimated to be 1.3 million tons in 2001 by a yearly upsurge of 50,000 tones [48]. Ecological administrations, groups, and campaigners have been occupied last twenty years to forbiddance DU arm. There are three US corporations that products great caliber DU rounds are provided most of the countries which they are consider assistance USA to implementation all their planners. So there are eighteen countries are supposed to have DU weaponries in their armed. These comprise of UK, USA, France, Russia, Bahrain, Egypt, Oman, Thailand, Kingdom Saudi Arabia, China, India, Taiwan, Greece, Turkey, Israel, Kuwait, Pakistan, and Jordan (Dug Weir, 2007) as in figure 1.

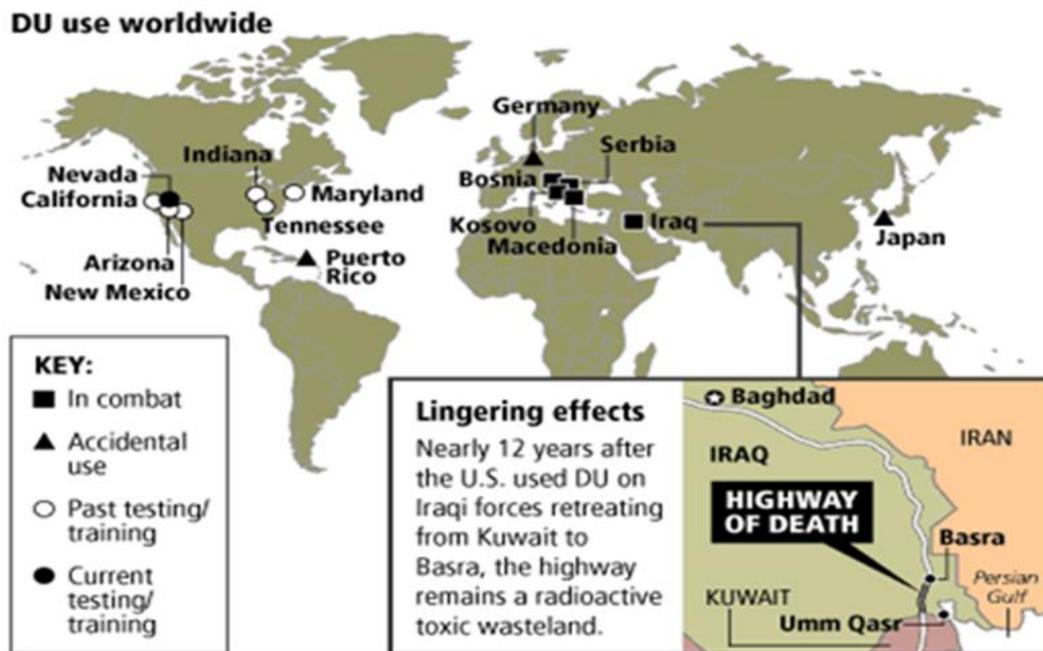


Fig. 1: Map of world explain Depleted Uranium in Iraq and around the world

### III. DATA DESCRIPTIONS

The proposed study will include taking different contaminated samples of many of parameters that are soil, air, water, doses, cancer cases, and biological samples from diverse departments such as institutes, universities, environmental, and health ministries. Data collect and developed in the database to determine the DU concentrations which will leads to various carcinogenic hazards on human body. These samples will be taken from different locally registered data for the last twenty years and create a mathematical model representing them. The meant data will be modeled statistically, a further studies will be presented to show that possible future hazards on human health, plants and animals. Also may be continuous to decades or centuries due to transfer DU contaminants to underground water.

So there are many methods were used effectively to study contamination and attempt to define unsampled sites, one of these procedures are kriging techniques that uses to predict unknown points at specific locations.

Most of studied areas in Basrah governorate were appeared contaminated with radiation as a result of second Gulf war 1991. Radionuclides isotopes of the <sup>238</sup>U decay chains have been increased significantly, also main composition of DU projectiles on comparison amid investigated and background levels are effective in southern soils of Iraq. It seems clear there is an increase in the uranium isotopes in soil surface due to Exposure to these weapons during combat maneuvering by American troops causing cancer significantly between Basrah populations (Koul and chadderton, 1988).

The aim of this paper is to give an overview of the present features by employing geostatistical interpolation. Also, to utilize kriging technique in predictions of the supporting data and to develop the methodology and procedures in detail. Also, to a gain knowledge during a literature reviews about prediction of the contamination at Basrah governorate and define hot-spots in this areas, including the use of ancillary data.

#### IV. GEOSTATISTICAL INTERPOLATION TECHNIQUES

This paper presents an overview of interpolation techniques with a precise emphasis on the characteristics of significance to its implementations for determination of hazard in the mining manufacturing, but ,some sites has implementations that different from others, might be the pollutants elements are concentrated in these sites. Nevertheless, we as well briefly show the connotations of interpolation and diverse methods to interpolate unsampled pointes from other known points at specific locations. This is a review paper proposing to briefly the comprehensive field of geostatistical interpolation. As such, an extensive index is given. These indices exceeds the papers mentioned in the manuscript of this paper and is aimed to give people guidance of the main references. So, many researchers investigated the effect of pollutant elements on the properties of contaminated soil by conducted series of tests using geostatistical interpolation with many kinds of kriging techniques:

Geological methods, involving interpretation of geologic data and field exploration, represent an important first step in any groundwater investigation. The various surficial parameters prepared from remotely sensed data and ancillary data can be integrated and analyzed through GIS to predict the potential of groundwater zone, and to monitor and conserve this important pollutant resource. And also characteristics of underground water may be helpful to explore and understand the natural resources of groundwater and its potential area and the mapping of the area (Eliza et al., 2010).

Arc GIS geostatistical analyst 2001, can be used to explore data variability, look for outliers of data to examine global trends, and to investigate spatial autocorrelation and the correlation between multiple dataset. Also, It creates prediction of standard errors with the probability that particular threshold was exceeded. Quantity maps used various geostatistical interpolation techniques are based on statistics which not only produce prediction surfaces, but also error and indecision of surfaces. Thus, this analyst provides many tools and defaults which can be help to create surfaces quickly. GIS gives a very effective tool for generating maps and statistical reports from a database. However, GIS functionality far exceeds the purposes of mapping and report compilation, database management systems and automated cartography. The most significant uses of GIS are spatial analysis capabilities. As spatial information is prearranged in a GIS, spatial analysis is the vigorous part of GIS. It can be done in two ways; one is the vector-based and the other is raster-based analysis. Two essential tasks of GIS have been extensively recognized; cohort of maps and a cohort of tabular reports; Satellite Remote Sensing and GIS applications in agricultural meteorology (Raju, 2004).

The spatial distribution of soil nutrient factors laid a foundation for further assessment of soil fertility, the prediction

is made possible by the existence of spatial dependence between observations as assessed by the correlogram or Semivariogram. The variance analysis and the geostatistical methods are used to determine the relative interpolation accuracy of each soil nutrient factors. Thus, the appropriate lag size was found and it became the stationary parameters along with isotropy, transform methods and neighborhood reference in order to select the optimal interpolation model that ensures the accuracy of the kriged results acceptable (Shen and Sarris, 2009).

The object of probabilistic risk assessment is to discover a rational and scientifically justified method of dealing with uncertainty of variability; probabilistic method can be applied to explicate the uncertainty in the parameters within a specific exposure model, and how this uncertainty might be influencing to estimate the outcome. Choice of model and its structure is a basic uncertainty factor when evaluating exposure risks in contaminated land (US EPA, 2001).

#### V. CONTAMINATED ELEMENTS PREDICTION

There are many elements were occurred different types of contamination in the environment. So, some methods used to explore and study the spatial structure and predictions with these contaminated elements particularly decay series of  $^{238}\text{U}$ , such as radon gas of the soil in south Italy, by chosen a kriging algorithm. Then, compare the prediction models among ordinary kriging, lognormal kriging, ordinary multi-Gaussian kriging, and ordinary indicator cokriging. There are many measures of accuracy; the mean absolute error, the mean squared error of prediction, the mean relative error, and a measure of effectiveness. So, showed that the multi-Gaussian kriging was the most accurate approach among those considered. The first step to understand spatial variation of radon gas, and mapping radon potential at any site. To compare the prediction performance in other areas, studies need to relate spatial variation to the lithology. (Buttafuoco et al., 2007).

Maraju, (2001) defined the weights of neighboring observation in the prediction procedure of semivariogram model where kriging has been used successfully in predicting underground water surfaces and to determine under earth levels such as our bodies, soil nutrients and mechanism of element displacement. Also ordinary Kriging was chosen and geometric means of radon gas (Rn) were evaluated for unmeasured zip codes, and this technique was used on the radon datasets to obtain a prediction maps and to present the impact of these results.

Spatial distribution of radon gas (Rn) concentrations is increasing because exposure to natural sources of radiation has become an important issue in terms of radiological protection in evaluation of radon potential at any location; it is difficult to use spatial variation alone in measured radon concentration in indoor air, so Spatio-Time distribution model is used. Its distribution depends on many factors such locally dependent factors, i.e., building material, location of the building, floor level; and time-dependent factors, i.e., exhalation from the surrounding walls and from the soil underneath the building, ventilation conditions and radioactivity contained in the outdoor air. (Baixeras et al. 1996; Nazaroff and Nero 1988; Virk 1999; Zhu et al., 1998).

Radium content usually ranges from 10 to 100 Bq kg<sup>-1</sup> at surface soil and from 15.27 to 47.27 Bq kg<sup>-1</sup> in rocks (Nazaroff 1992; Verdelocco et al., 2000). The total production rate of radon in soil is equivalent to the radium content (Nazaroff, 1992). Radon migration is known to be anomalously large on effectiveness faults (Baubron et al., 2002; King et al., 1996; Torgersen and O'Donnell, 1991) and shows temporal variation related to changing atmospheric conditions. As observed increases in spatial distribution of radon gas due to exposure to natural radiological sources. It is difficult to use spatial variation of measured radon concentration in indoor air, as its distribution is based on many parameters that are difficult to evaluate, which are divided into two groups as locally dependent factors and time-dependent factors (Baixeras et al., 1996; Virk 1999; Zhu et al., 1998).

The latter was calibrated using a radioactive source of <sup>226</sup>Ra having an equilibrium activity with <sup>226</sup>Ra of 222.96 kBq with an efficiency of 74.5%. Lucas cells were also calibrated, later to ensure radioactive equilibrium, that "noise" of other isotopes with alpha-radiation emission in the decay was avoided (Winkler et al., 2001). The prediction set was used to create a spatial model and predict the radon gas at locations in the corresponding validation set, thus providing an independent assessment of the prediction quality. It is unlikely that one method will produce the best estimate at all locations. Comparing radon anomalies with lithology and fault locations, no evidence of a strict correlation between type of outcropping terrain and radon anomalies was found, except in the western sector where there were granitic and gneissic terrain. A statistical link between them would be able to use geology as an indication of where radon levels (Badr et al., 1996).

A scatter plot of measured versus predicted values provided additional evidence on how well an estimation method has performed. The best possible estimates would match the measured values and therefore the slope of the scatter plot should be close to 1. Lastly the map of Rn concentration was computed on a 50 m×50 m grid using ordinary multi-Gaussian kriging. The nugget effect is a discontinuity at the origin of the variogram and relates to measurement errors and to spatial sources of variations at distances smaller than the shortest sampling interval (Journel and Huijbregts, 1978). Type of anisotropy is evident from the differences in sill in different directions; it reflects the effect of fractures and errors on the spatial distribution of radon gas, because they act as a preferred way of gas migration (Tansi et al., 2005).

Kriging interpolated map has shown areas with high values of lead Pb concentrations. The good variogram structure of Pb is observed, revealing that there are clear spatial patterns of Pb on the distribution map and also that the current sampling density is ample to reveal such spatial patterns. The probability map was produced depending on the kriging interpolation and kriging standard deviation that provides useful information for hazard assessment and decision support. So, explicit monitoring points were used to observe, assess the main sources and pollution levels in the polluted regions. Then mathematical models are applied to distinguish Unknown values and, and also to compare and combine all data to use in predications (Batmunkh et al., 2007).

A majority of the spatial variability and soil dependence in the landscape may have been caused by interactive effects of micro-topography and hydrologic conditions. As verified by the kriging analysis, plants that were grown in flooded plots with gypsum treatment had higher dry matter yields. The Variability of individual physicochemical properties of soil as indicated by CVs differed widely and significantly ( $p \leq 0.01$ ) among sampling sites and transects directions. The resulting landscape signatures and functional integrity may likely affect several abiotic and biotic components of a wetland ecosystem. The deleterious effects of Na on soil structure and plant growth have led to removal of Na from soils, usually by replacement with Ca. The emphasis in the reclamation of alkali soils is usually on reducing the Na to less than 15% of the exchange capacity (Sigua and Hudnall, 1991).

Lefohn et al., (1987) used the method of Lagrange multipliers to solve the constrained optimization problem. The variograms used in kriging were derived from a linear rather than a spherical model. In 1982 monitoring sites were used in the kriging analyses and each cell was estimated using the nearest five monitoring sites. It could not be found within 500 m, the cell was estimated by using a site's 7-h average if the site was located within 30 m; the cell was not estimated if either of the two criteria was not met. There was a 1-ppb per degree latitude southerly increasing from Minnesota to Missouri. While trend-surface, triangulation, and moving average models are alternative approaches to the kriging method, assumptions built into each of the models may not provide completely satisfactory results.

Zeng and Huang, (2007); Manthena et al., (2009) were showed that Kriging is a geostatistical interpolation performance which used to design model of variography, and to interpolate the value of a random fields at unobserved from observation values at neighboring locations. So, the spatial structure of the data was implemented predicting and quantifying by kriging. Based on the autocorrelation of the element concentrations between two points. Statistical and Spatial analyses were performed for the sampling data of these variables in detail, and the corresponding to interpolation model was determined after many tests.

Kriging is not a good estimator in those cases and precision differences by means of semivariograms for each soil type or a pooled Semivariogram are negligible. Predictions by using kriging interpolation show less bias. The predictions of these properties using soil maps are also less accurate than those obtained by kriging. Nevertheless, no improvement is obtained when using a soil-separated by Semivariogram in kriging predictions in Xhantic Ferralsols. Combined kriging soil-map procedure was reduced effectually the bias that found in soil map predictions. It seems to be related to the greater variability of these soils, as well as the small datasets were provided for Semivariogram calculations (Utset et al., 2000).

Snepvangers et al., (2003) used two techniques of the spatio-temporal (ST) kriging of soil water content. First (ST-OK) has used only information about soil water content and second (ST-KED) has used kriging with external drift, to detect relationship between soil water content and net-precipitation. To show that the behavior of soil water content that predictions is physically more realistic, when using spatial-temporal kriging with external drift. The uncertainties of prediction are slightly smaller. Also how a dynamic physical relationship between soil

water content and net-precipitation can be used to improve interpolations. Coleman and Li, (1996) were used standard Matlab subspace trust region algorithm that depend on the interior-reflective Newton method to prevent the iteration, due to the initial choice of parameters which were fitted with 500 randomly chosen of initial parameter sets.

Kriging means spatial prediction used to soil properties. It is a form of weighted local averaging that provides estimates of values at unrecorded places without bias and with minimum and known variance. It has also been used to make regional estimates with substantial gains in precision over traditional practice, and to describe the structure of spatial dependence, both for isotropically varying soil properties and for anisotropic properties that vary in different locations (Vieira et al., 1983; Webster and Burgess, 1980). Ordinary Kriging is the most common geostatistical estimator. It assumes that the mean is unknown and computes the unsampled value as a linear combination of the neighboring observations (Goovaerts, 1997). Tomas Oberg & Boberback, (2010) indicated that radiation activities should be recognized and they should quantify the uncertainty to prediction of risks, also can be achieved by applying probabilistic methods. Therefore Kriging analyses of soil properties were suggested that both gypsum addition and water management should become a major part of marsh revegetation and restoration programs. Limiting the range of soil variables permits more accurate predictions for expected response to alternative soil management inputs and land contaminated use as in marsh, and to develop a stochastic model that may describe the potential capabilities of land use. The hazard foundation is the soil contaminant and the endangered object could be a human, an animal or plant species.

The function used to model the experimental variogram must be a conditionally negative definite to ensure that the kriging variances are positive, to build a model that describes the major spatial variations features under study. The best fitting function can be chosen by cross-validation, that verified by compatibility between the data and the model. It takes each data point in turn, removing it temporarily from the data set and using its adjacent information to predict the value of the variable at its location. The estimate is compared with the measured value by calculating the experimental error. The accuracy of spatial maps depends on many factors, such as sample density, sample configuration, and prediction methods (Gotway et al., 1996).

Asymmetry is the most common form of departure from normality; positively skewed data are encountered in many fields. The variogram is sensitive to outliers in the data and its behavior is affected by a few very large or small values. Kriging chosen should depend on the characteristics of the data. Lognormal kriging (Dowd, 1982), multi-Gaussian kriging (Verly, 1983), and indicator kriging (Journel, 1983), could deal with skewed data, to explore the spatial structure of soil gas radon concentration in south Italy and to compare the prediction performances of the four different kriging algorithms (Webster and Oliver, 2001).

Kriging basics include stationary covariance process and compare kriging with regression, and summarize standard designs for kriging Meta models, by presenting unique designs that are consecutive and modified using cross-validation. Regression models such as polynomials are useful in the local

search for optimization and in screening for identification of the most important factors. In distribution-free bootstrapping, and investigating the effects of non-constant variances which occur in queuing simulations, common random numbers and non-normality, kriging uses maximum likelihood estimators of the weights, which assume normality. Comparisons of different Meta model types as polynomial regression, Kriging, splines, rational functions remain a challenging problem (Beers and Kleijnen, 2004).

## VI. CONCLUSIONS

Many of techniques were used in the interpolation prediction such as geostatistical, geological, and kriging to predict unknown points of adjacent samples at specific locations. Kriging technique was considered the best estimator in the prediction and comprise of more kinds to interpolate soil properties, which are ordinary kriging, universal kriging, simple kriging, multi-Gaussian, ordinary indicator cokriging and linear regression models in combination with kriging. A spatial interpolation technique called kriging is widely applied in soil studies. It is uses to reduce the cost of sampling and analysis for mapping pollutant, and uses the semi-variogram to quantify the spatial variation of a regionalized variable.

In this paper we utilized kriging due to has ability to interpolate contaminated elements in different sites and for long terms. There are many measures of accuracy and cross-validation; like the mean absolute error, the mean squared error of prediction, the mean relative error, and a measure of effectiveness were used to compare prediction performance in different sites, define precision levels among them, and mapping contaminant elements potential at any site. So, showed that the multi-Gaussian kriging was the most accurate approach among those considered.

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