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# Comparitive Analysis of Soil Contamination in Various Land Uses of Madurai City using GIS

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**Abstract:** In Madurai, there are 18,646 industries functioning, which resulted in contamination of ground water characteristics in the nearby area to analyses the soil contamination. The disturbed soil samples were collected from 6 locations (4 industrial areas, 1 residential area and 1 agricultural area) at 0.3m depth. The chemical properties of soil such as pH, Electrical conductivity, Organic matter, Total dissolved solids, Macro nutrients and Micro nutrients were determined. The geo co-ordinates of sampling location were obtained using GPS. Based on the concentration of chemical constituents present in soil in all the locations, a continuous surface has been created by various spatial interpolation techniques such as Inverse Distance Weighted, Spline, Kriging and trend using GIS technology. By cross validation technique the interpolation techniques for various chemical parameters are identified. In order to assess the degree of soil contamination the consistency index map is generated. This map can be used to classify the study area as very high to low contaminated soil. Thus the GIS approach of analyzing soil contamination provides permanent base for monitoring contaminated sites and also to understand the level and extent of contamination. From this project the comparative analysis among land uses can be made, so that we can prefer areas for various land usage and can recommend crops based on the report. In this project we will also do a comparative study between each interpolation technique with the manually tested value and find out the best interpolation technique.
**Key words:**Inverse Distance Weighted, Spline, Kriging.

## Introduction:

### 1.1 General:

In developing countries like India, rapid industrialization results in voluminous production of the waste and thereby scarcity of land for safe disposal of hazardous waste increases. The liquid waste generated from the solid waste percolate into the ground and causing problem like ground water contamination, degradation of vegetation, modification of soil properties, etc. Contamination of soil causes failure of foundations, land subsidence, landslides, pollution of ground water quality, etc.

### 1.2 Objective for the Study:

The comparative analysis among the land uses (residential, industrial, agricultural) are to be made in Madurai region and suggest the best suitable crops for those regions based on the outcome of our result. Also to create awareness about the contamination of the soil for the people who are residing near the industrial regions.

**1.3 Need for the Present Study:**

In Madurai, there are 18646 industries are functioning. The liquid wastes coming out from these industries not only contaminate the ground water but also affect the soil behavior. To assess the level of contamination of the study area, it is essential to know the contamination characteristics of soil spatially in and around Madurai, which can be used, have safe proposed structure and prevention of failure of existing structures within the study area. Contamination characteristics of soil can be inferred from the physical, chemical, index and engineering properties. Manual interpolation and model generations are difficult and tedious process. In such cases, GIS approach can be effectively used. Due to the rapid growth and wider application of GIS in various field it is proposed to use this technology in soil contamination analysis. Further this study aims at the analysis of chemical properties soil, generation of continuous surface using various spatial interpolation techniques, identifying the best interpolation technique and characterization of study area through contamination index map.

**2. Details About Study Area:**

The study area for our project is Madurai district. The area is having more than 18,000 industries. The samples were collected from four industrial regions, three residential regions and two agricultural regions. The soil samples were collected from different industries.

The four industries are:

1. Dyeing industry in Perungudi.
2. Electroplating industry in Villapuram.
3. Plastic industry in Kappalur.
4. Workshop in Arappalayam.

The three residential areas are Villapuram, Arappalayam and Kappalur.

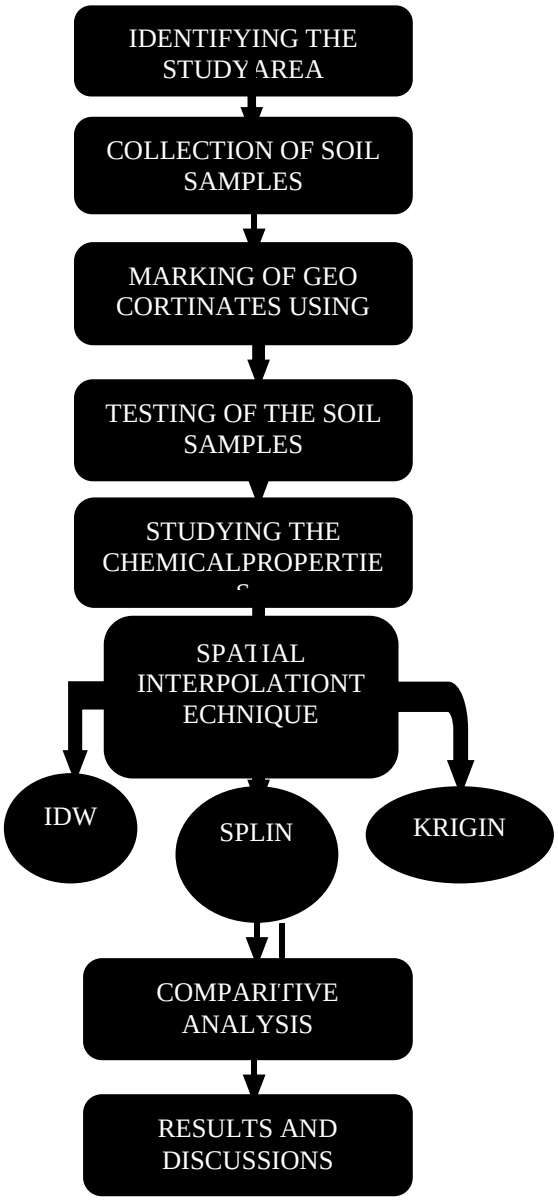
The two agricultural areas are Perungudi, NagamalaiPudukottai and Kappalur.

| Residential | Agricultural | Industrial |
|---|---|---|
| 78.104008 9.935651 DecimalDegrees - Arapalayam.<br><br>78.120231 9.892198 Decimal Degrees - Villapuram.<br><br>78.024633 9.863229 Decimal Degrees - Kappalur | 78.052443 9.926961 Decimal Degrees - Nagamalai.<br><br>78.029268 9.846427 Decimal Degrees - Kappalur.<br><br>78.101691 9.842371 Decimal Degrees - Perungudi. | 78.112119 9.931016 Decimal Degrees - Arapalayam.<br><br>78.114437 9.904944 Decimal Degrees - Villapuram.<br><br>78.099373 9.850483 Decimal Degrees - Perungudi. |

**Comparitive:**

78.075039 9.888142 Decimal Degrees – TIRUPARANKUNDRAM.

**Methodology:**




**3. Testing Procedures:**

Different characteristics of the soil can be tested in environmental laboratory, and also the tested values are compared to the standard values of the soil sample. From this comparative study we can identify the contaminated soil. Tested results are tabulated as follows (3.1.1, 3.1.2, 3.1.3). Tables are categorized based on the land uses and also it consists of location of the sample collection, different soil characteristics.

**4.Gis Based Interpolation Techniques**

**Interpolation**

Estimating the attribute values of locations that are within the range of available data using known data values.

**Extrapolation**

Estimating the attribute values of locations outside the range of available data using known data values.

### 4.1 Interpolating Surfaces in Arcgis Spatial Analyst

IDW (Inverse Distance Weighted), Kriging,Spline

### 4.1.1 IDW (Inverse Distance Weighted):

The IDW function should be used when the set of points is dense enough to capture the extent of local surface variation needed for analysis. IDW determines cell values using a linear-weighted combination set of sample points. The weight assigned is a function of the distance of an input point from the output cell location. The greater the distance, the less influence the cell has on the output value.

### 5.1.2 kriging Interpolation:

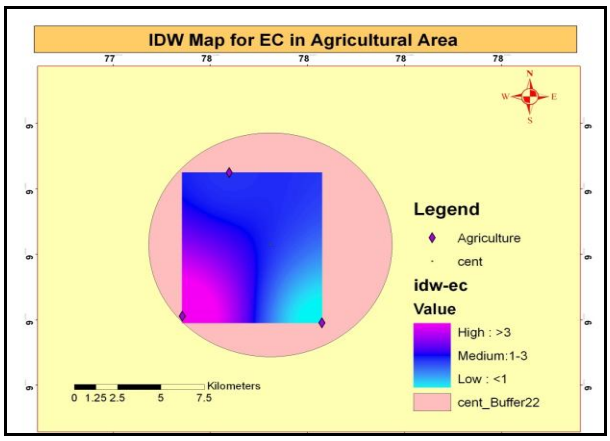
A powerful statistical interpolation method used for diverse applications such as health sciences, geochemistry, and pollution modeling, Kriging assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface. It fits a function to a specified number of points or all points within a specified radius to determine the output value for each location.

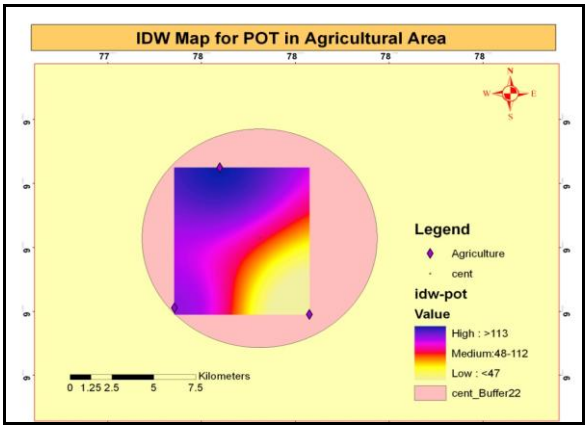
### 5.1.3 Spline Interpolation

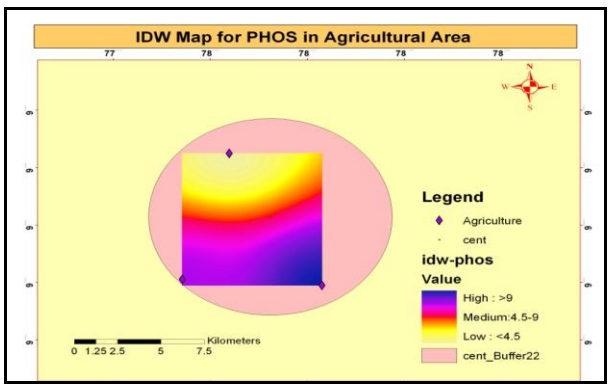
Spline estimates values using a mathematical function that minimizes overall surface curvature. This results in a smooth surface that passes exactly through the input points. Conceptualy, it is like bending a sheet of rubber so that it passes through the points while minimizing the total curvature of the surface. It can predict ridges and valleys in the data and is the best method for representing the smoothly varying surfaces of phenomena such as temperature.

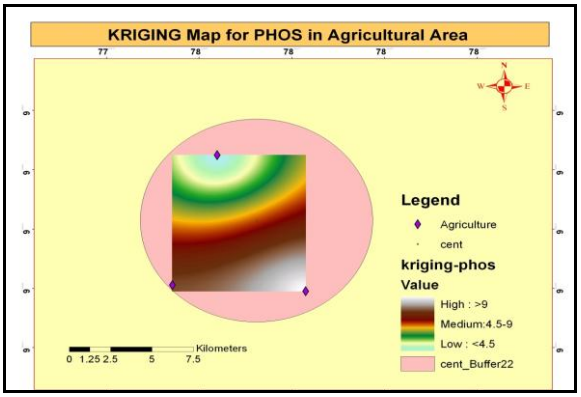
### Interpolated Maps:

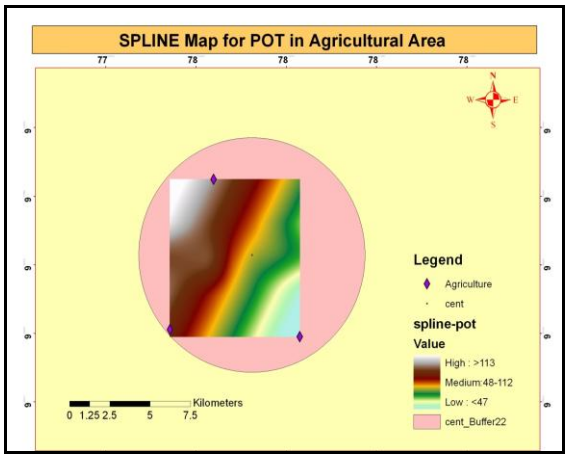
The following interpolation maps exhibits the soil contaminated areas in Madurai city. These maps are generated based on different types of Interpolation techniques using Arc GIS 9.3 software. From these maps we can classify the contaminations in various categories. (i.e. High, medium, low).



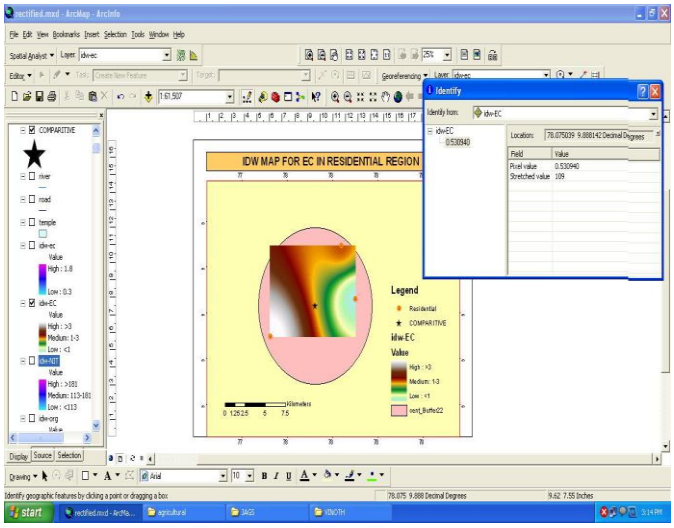



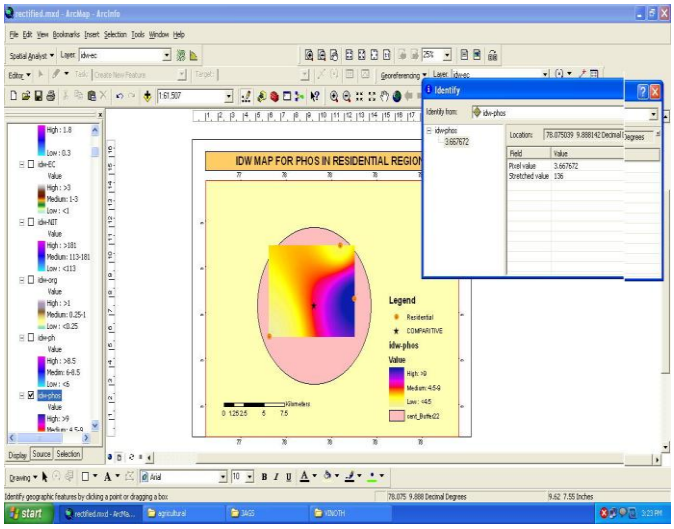



## 6. Comparitive Study:

From this comparative study we can identify the contaminated soil. Comparative results are tabulated as follows (6.1). After getting the interpolated maps for the initially tested samples, we aimed at finding the best interpolation technique. So went to a residential location in villapuram region and with the use of GPS we determined the latitude and longitude of that area. After noting down that, we took a soil sample from that area and tested it manually and using GIS. After interpolating in GIS it was found that the values obtained from IDW technique was found to coincide approximately with the manually tested values. Hence IDW technique is found to be the best interpolation technique.

### IDW Map Obtained for the Comapritive Study:



**7. Results and Discussions:**

The tested results were obtained and the results were compared to determine the highly contaminated region. In accordance to the results, the industrial region in villapuram was found to be the highly contaminated region. Also with respect to the chemical properties of the soil we suggested the best suitable crops for the agriculture for those regions. Industrial region in villapuram is the most affected region and it has pH in acidic range. Hence CaCO3 is added according to the level of pH. After this again the soil is tested and based on those values only the crops can be selected.

For the industrial region in perungudi the pH is alkaline. But all other chemical properties remained normal. So the suggested crops are groundnut, cotton, corn, millet and other grains. For the kappalurindustrial region the soil is saline. So the suggested crops are groundnut, cotton and corn.

For all other regions the soil is good and only the above three regions are the more polluted region. The chemical properties for the regions are normal. The crops for it are cotton, paddy and seasonal grains. By the use of comparative study between manual laboratory method and GIS interpolation method we found that IDW interpolation technique is the most accurate interpolation technique. We have submitted the report to the panchayat of the respected regions.

**3.1. Tested Results**

**Table 3.1.1 Industrial Regions:**

| Location | pH | EC | ORG MAT | Nitrogen | Phosphorous | Potassium |
|---|---|---|---|---|---|---|
| Perungudi | 8.7 | 0.2 | 0.25 | 56 | 3.4 | 45 |
| Villapuram | 4.4 | 0.1 | 0.25 | 63.5 | 4.2 | 500 |
| Arapalayam | 7.6 | 0.55 | 0.25 | 56 | 2.5 | 98 |
| Kappalur | 7.2 | 0.9 | 0.25 | 56 | 3 | 250 |

**Table 3.1.2 Residential Regions:**

| Location | pH | EC | ORG MAT | Nitrogen | Phosphorous | Potassium |
|---|---|---|---|---|---|---|
| Kappalur | 5.8 | 1 | 0.25 | 55 | 3 | 213 |
| Villapuram | 5.4 | 0.2 | 0.3 | 63 | 4.4 | 440 |
| Arapalayam | 7.2 | 0.58 | 0.32 | 63.5 | 3.2 | 431 |

**Tab 3.1.3 Agricultural Regions:**

| Location | pH | EC | ORG MAT | Nitrogen | Phosphorous | Potassium |
|---|---|---|---|---|---|---|
| Nagamalai | 6.1 | 1.94 | 0.25 | 56 | 3 | 213 |
| Perungudi | 8 | 0.3 | 0.3 | 51 | 3.2 | 75 |
| Kappalur | 6.5 | 1.8 | 0.20 | 53 | 3.15 | 220 |

**Table: 6 .1COMPARITIVE RESULTS:**

| Tests | Manual | IDW | Spline | Kriging |
|---|---|---|---|---|
| pH | 6.1 | 6.03 | 6.8 | 5.5 |
| Electrical Conductivity | 0.5 | 0.53 | 0.45 | 0.43 |
| Organic Matter | 0.3 | 0.29 | 0.33 | 0.25 |
| Nitrogen | 61.3 | 60.92 | 55.87 | 67.34 |
| Phosphorous | 3.7 | 3.67 | 3.6 | 3.87 |
| Potassium | 373.13 | 374.39 | 376.12 | 370.84 |

**8. Conclusion :**

The following conclusions were made from this work.

The chemical properties of the soil were monitored and analyzeby GIS Techniques. The chemical properties of the nearby area in which the sample was taken is determined by the interpolation technique of the ARCGIS-9.3. Based upon the contamination of the soil, the crops that are best suitable for agriculture on that area is suggested. The tested results were obtained and the results were compared to determine the highly contaminated region. In accordance to the results, the industrial region in villapuram was found to be the highly contaminated region. Also with respect to the chemical properties of the soil we suggested the best suitable crops for the agriculture for those regions. Industrial region in villapuram is the most affected region and it has pH in acidic range. Hence CaCO3 is added according to the level of pH. After this again the soil is tested and based on those values only the crops can be selected.

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