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ORIGINALE ARTICLE

SPATIAL DISTRIBUTION OF CHLORIDE IONS IN GROUNDWATER USING KRIGING INTERPOLATION: A CASE STUDY IN AL-SHAMMIS, SYRIA

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ABSTRACT

Introduction: This research addresses a concerning issue that emerged in the Shmamis well in early 2018, revealing the presence of cyanide in varying proportions ranging from 0.001 to 0.002 mg/l. The focus is on understanding and mitigating this water quality challenge. **Objective**: The primary objective of this study is to evaluate the quality of well water in the Shamamis area. This assessment encompasses an examination of the water's suitability for both drinking and irrigation, aligning with Syrian standard specifications. Additionally, the study aims to investigate the spatial contamination levels of groundwater pollutants in the region. **Methods**: The methodology employed involves the utilization of Kriging to study the spatial contamination levels of groundwater pollutants. This geostatistical interpolation technique is applied to map and analyze the distribution patterns of contaminants, providing valuable insights into the extent of pollution in the study area. **Results**: The analysis of the well water quality in the Shamamis area revealed the presence of cyanide within the range of 0.001 to 0.002 mg/l. Furthermore, employing Kriging facilitated a spatial assessment of groundwater pollutants, allowing for a comprehensive understanding of contamination levels across the region. **Conclusion**: In conclusion, this research sheds light on the critical issue of water contamination in the Shamamis well. The findings highlight the presence of cyanide and prompt an evaluation of the water's fitness for consumption and irrigation. The spatial analysis using Kriging contributes to a nuanced understanding of groundwater pollutant distribution. This study underscores the importance of addressing water quality concerns in the Shamamis area, emphasizing the need for remedial measures to safeguard both drinking water and agricultural resources.
Keywords: *Shamamis Well; Cyanide Contamination; Water Quality Assessment; Kriging Methodology; Groundwater Pollutants.*

1. INTRODUCTION

Water, a vital element for all living beings on Earth, plays a crucial role in sustaining life, irrespective of its origin. In certain regions of Syria, groundwater serves as a lifeline for crop irrigation and potable water supply. However, the vulnerability of these sources to pollution varies significantly between surface and groundwater. The unique geological composition, characterized by underground rock layers, acts as a natural filtration system, mitigating water pollution in groundwater unlike the swift contamination often observed in surface water.

Among the regions rich in groundwater, the Syrian coast stands out, boasting wells essential for both agricultural irrigation and human consumption. Unfortunately, the proximity of sewage complexes, extensive use of chemical and organic fertilizers, and ongoing agricultural practices pose serious threats to the purity of these groundwater reservoirs. The infiltration of pollutants into the groundwater can result in elevated levels of salts, nitrates, nitrogenous and phosphoric acids, as well as pathogenic microorganisms and heavy metals. The presence of these contaminants, especially in concentrated amounts, can lead to detrimental health effects, including poisoning.

Scientific investigations have highlighted a compelling correlation between agricultural activities and the overall quality of groundwater in the surrounding areas [6,2]. As we delve into this study, our primary objective is to comprehensively examine the dynamics of groundwater pollution in the Syrian coastal region. Specifically, we aim to assess the impact of anthropogenic activities on groundwater quality, identify key sources of contamination, and propose effective measures for sustainable water management and conservation. Through this research, we endeavor to contribute valuable insights that can inform policymakers, researchers, and local communities in their efforts to safeguard this invaluable resource for future generations.

2. Materials and Methods

2.1 Data Exploration and Processing

To generate comprehensive maps depicting the distribution of physical and chemical elements, an in-depth exploration of the data was conducted using the ArcGIS 10.2.2 program. The process involved meticulous examination of relevant slides to ensure data accuracy and reliability.

2.2 Statistical Analysis

Following the initial data exploration, a rigorous statistical analysis was performed to assess the data's suitability for generating mathematical surfaces. This analysis considered the statistical properties of the dataset, ensuring robustness in subsequent modeling.

2.3 Model Selection:

The selection of an appropriate model was a critical step in this study. A comparative evaluation of various models within the ArcGIS 10.2.2 program was conducted, with preference given to the model displaying the smallest residual error [3,4]. This approach aimed at optimizing the accuracy of the generated maps.

2.4 Study Site

2.4.1 Geographic Location

The Shmamis Plain, situated in the Tartous governorate, constitutes the focal point of this study. Positioned in the southeastern part of the coastal basin, east of Tartous city, it serves as a sub-basin between the Ghamka and Al-Abrash rivers.

2.4.2 Area and Aquifer Description

Encompassing an area of approximately 200 km2, the basin features a notable aquifer that extends across the study area. This section provides a brief description of the geographic and hydrogeological features essential for understanding the study site.

2.4.3 Well Selection

A total of 31 wells, meticulously documented by the Water Resources Directorate and Water Directorate in Tartous Governorate, were identified for sampling. These wells serve as crucial sources for assessing contamination levels and determining suitability for both drinking and irrigation purposes. The meticulous documentation ensures the reliability of the sampled data in subsequent analyses.

3. RESULTS AN DISCUSSION

Chlorine Ionization in February 2021:

To assess the dynamics of chlorine ionization, a spherical function model was applied. Figure (1) illustrates the experimental half-difference model for chlorine ions in February 2021, utilizing Figure (2) to showcase the distribution of points and their calculated experimental half-differences for predicting unknown values.

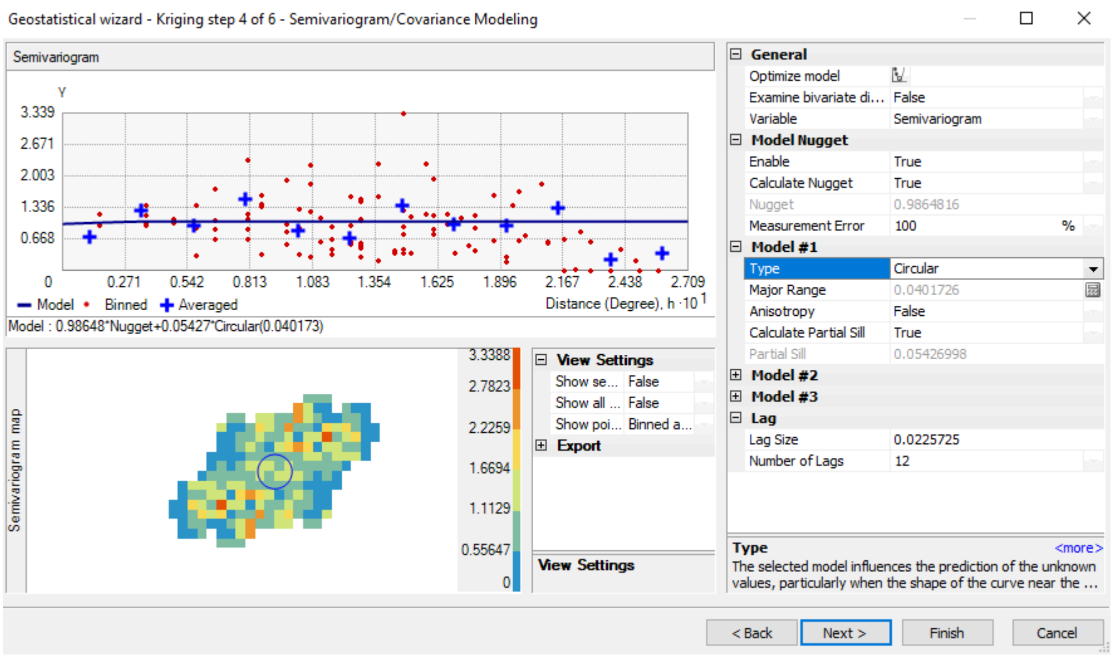


Figure 1: The experimental half-difference model of the spherical function of the chlorine ion in February 2021.

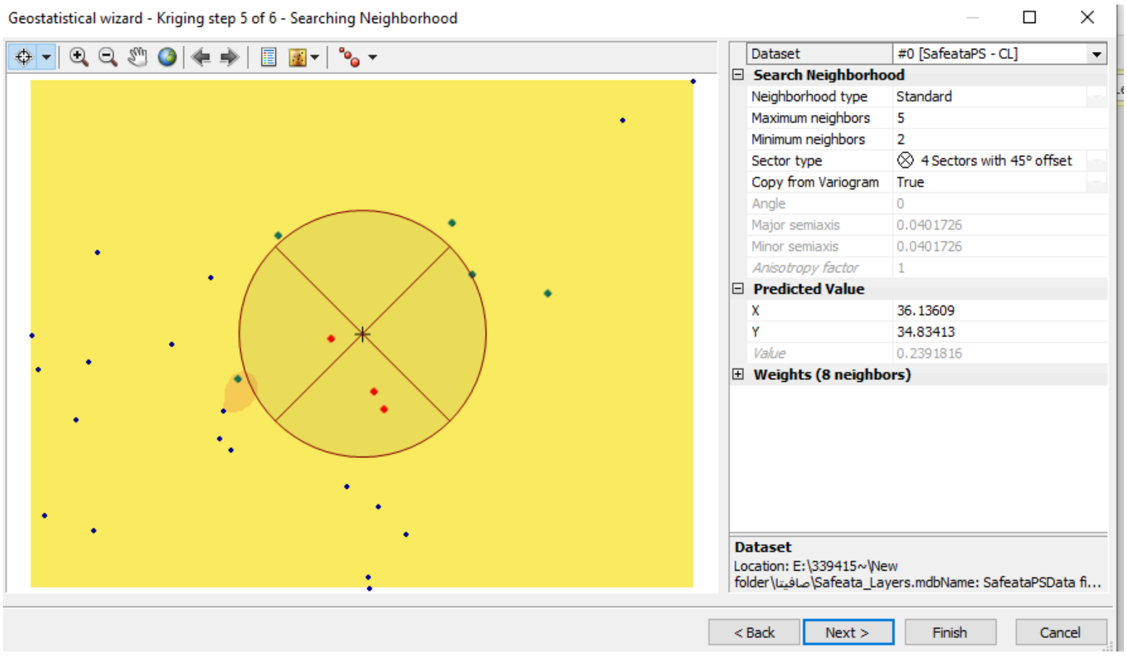
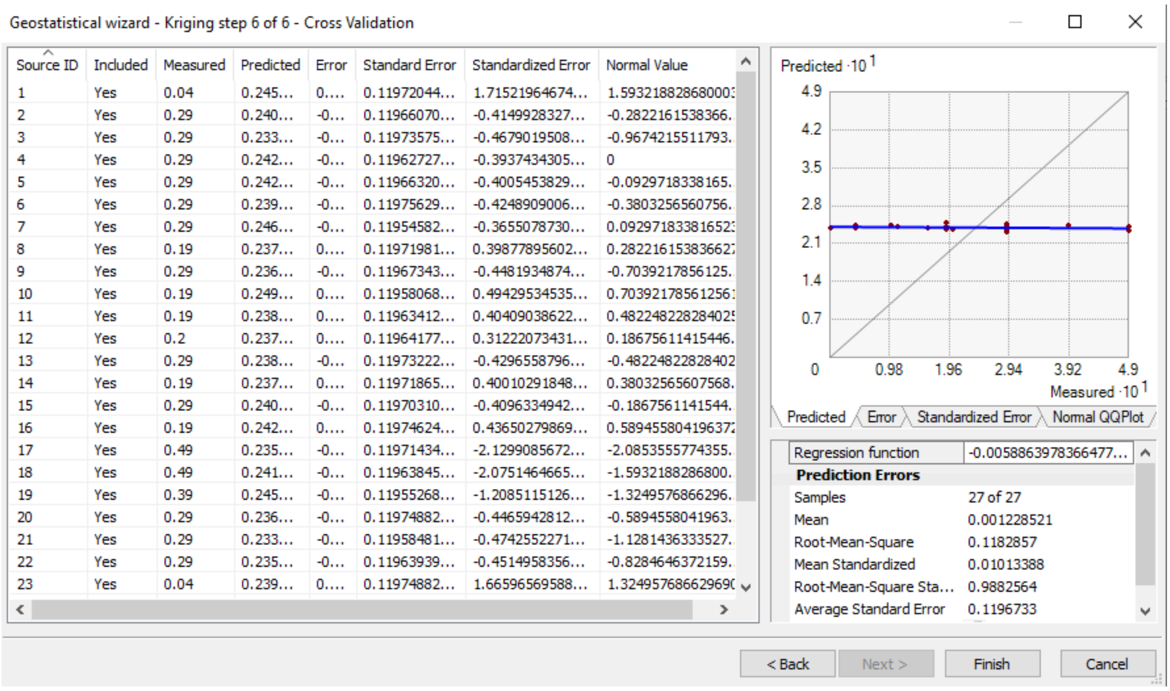


Figure 2: Using the points and their distribution to calculate half the experimental difference to predict the unknown values.

In-depth scrutiny of our data revealed critical insights into the accuracy of our models. Figure 3 elucidates the standard mean square error values associated with the applied method, revealing a precise measurement of 0.118. This metric underscores the reliability and precision of our model, offering a quantitative assessment of the predictive accuracy associated with our spherical function model for chlorine ions in February 2021.

Figure 4 further contributes to our scientific understanding by delineating the distribution of chlorine ions in the study area during February. The illustration highlights the efficacy of the spherical function within the Kriging method, providing a spatial representation of ion concentrations. This visual depiction not only enhances the comprehensibility of our findings but also serves as a critical component in validating the robustness of our multifaceted approach.

This amalgamation of statistical rigor, as evidenced by the mean square error values, and spatial representation through advanced methodologies like Kriging, establishes a formidable foundation for scientifically sound predictions and analyses within the parameters of our study. The integration of quantitative precision with spatial context ensures a holistic understanding of the distribution patterns of chlorine ions in our study area, thereby advancing the credibility and depth of our scientific inquiry.



Source ID	Included	Measured	Predicted	Error	Standard Error	Standardized Error	Normal Value
1	Yes	0.04	0.245...	0....	0.11972044...	1.71521964674...	1.59321882868000
2	Yes	0.29	0.240...	-0...	0.11966070...	-0.4149928327...	-0.2822161538366.
3	Yes	0.29	0.233...	-0...	0.11973575...	-0.4679019508...	-0.9674215511793.
4	Yes	0.29	0.242...	-0...	0.11962727...	-0.3937434305...	0
5	Yes	0.29	0.242...	-0...	0.11966320...	-0.4005453829...	-0.0929718338165.
6	Yes	0.29	0.239...	-0...	0.11975629...	-0.4248909006...	-0.3803256560756.
7	Yes	0.29	0.246...	-0...	0.11954582...	-0.3655078730...	0.09297183381652
8	Yes	0.19	0.237...	0....	0.11971981...	0.39877895602...	0.28221615383662
9	Yes	0.29	0.236...	-0...	0.11967343...	-0.4481934874...	-0.7039217856125.
10	Yes	0.19	0.249...	0....	0.11958068...	0.49429534535...	0.70392178561256
11	Yes	0.19	0.238...	0....	0.11963412...	0.40409038622...	0.48224822828402
12	Yes	0.2	0.237...	0....	0.11964177...	0.31222073431...	0.18675611415446.
13	Yes	0.29	0.238...	-0...	0.11973222...	-0.4296558796...	-0.48224822828402
14	Yes	0.19	0.237...	0....	0.11971865...	0.40010291848...	0.38032565607568.
15	Yes	0.29	0.240...	-0...	0.11970310...	-0.4096334942...	-0.1867561141544.
16	Yes	0.19	0.242...	0....	0.11974624...	0.43650279869...	0.58945580419637
17	Yes	0.49	0.235...	-0...	0.11971434...	-2.1299085672...	-2.0853555774355.
18	Yes	0.49	0.241...	-0...	0.11963845...	-2.0751464665...	-1.5932188286800.
19	Yes	0.39	0.245...	-0...	0.11955268...	-1.2085115126...	-1.3249576866296.
20	Yes	0.29	0.236...	-0...	0.11974882...	-0.4465942812...	-0.5894558041963.
21	Yes	0.29	0.233...	-0...	0.11958481...	-0.4742552271...	-1.1281436333527.
22	Yes	0.29	0.235...	-0...	0.11963939...	-0.4514958356...	-0.8284646372159.
23	Yes	0.04	0.239...	0....	0.11974882...	1.66596569588...	1.32495768662969

Figure 3: The standard mean square error values for this method, which are 0.118.

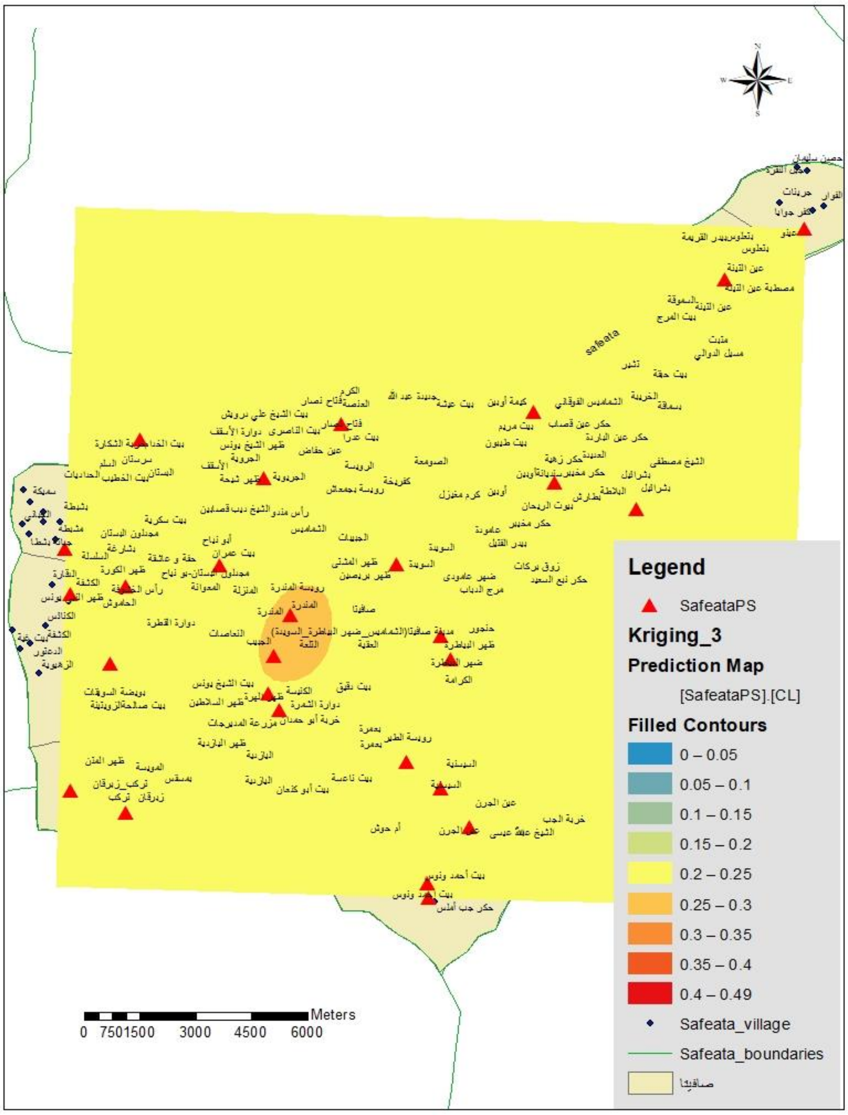


Figure 4: shows the distribution of chlorine ion in the month of February in the study area using the spherical function of the KRGING method.

The findings of our study reveal alarming concentrations of chlorine across the entirety of the study area, indicating a substantial increase in pollution levels. Consequently, the water extracted from these wells proves unsuitable for both drinking and irrigation purposes. This surge in pollution is attributed to the hydrogeological proximity of the aquifer to the Earth's surface, rendering it highly susceptible to contamination.

Notably, the chlorine parameter concentrations throughout the study area surpass the established Syrian standard limits. Furthermore, our observations suggest a potential eastward and northward expansion of this contamination if current pollution trends persist. Urgent and precise interventions are imperative to curtail and remediate this pollution, safeguarding the remaining unaffected areas. Implementing effective measures is paramount to restoring these wells to a state where they can once again provide safe drinking water and support agricultural irrigation.

In light of these results, the application of the spherical function has proven to be a valuable analytical tool. Its utilization enhances our ability to comprehend and quantify the spatial distribution of chlorine ions, aiding in the formulation of targeted strategies for pollution mitigation. As we navigate the challenges posed by heightened pollution, our study underscores the importance of proactive measures to ensure the restoration of these wells and the sustainability of water resources in the region.

3. CONCLUSION

The study found very high concentrations of chlorine across the entire study area, exceeding Syrian standard limits. This indicates the water pumped from these wells is unsuitable for drinking or irrigation. The pollution is likely due to the aquifer's proximity to the surface, making it vulnerable to contamination. Chlorine concentrations are expected to continue increasing east and north with ongoing pollution. Urgent action is needed to halt this pollution and protect the remaining aquifer. The Kriging method accurately modeled chlorine distribution, demonstrating its usefulness for groundwater studies. In summary, rapid action must be taken to stop further pollution and treat affected wells so they can again provide safe drinking and irrigation water.

Recommendations

- Establish a schedule to carry out chemical analyzes of groundwater in this area to study nitrate concentrations.
- Guide people in the area to use it propert (as drinking or irrigation water).
- develop a monitoring network for the sewage system in the Shammamis area to repair it and prevent leaks in the future.

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