ACTA SCIENTIFIC AGRICULTURE (ISSN: 2581-365X)

Volume 3 Issue 12 December 2019

Research Article

Geographic Information System - Based for Spatial Suitability Mapping of Groundwater for Agricultural Uses (Iraq)

Hussein Sabah Jaber*

Department of Surveying Engineering, University of Baghdad, Aljadriyah, Baghdad, Iraq

***Corresponding Author:** Hussein Sabah Jaber, Department of Surveying Engineering, University of Baghdad, Aljadriyah, Baghdad, Iraq.

Received: October 14, 2019; **Published:** November 15, 2019

DOI: 10.31080/ASAG.2019.03.0724

Abstract

Geographic Information System (GIS) provides tools to serve a purpose for solving spatial problems. Spatial analyst can interpolate the data of constrain factors for agriculture (EC, SAR, Na%, Cl and SO4) into raster. The five raster are reclassified by grouping ranges of values into single value. Each raster can be weighted, or assigned a percentage influence. The multiple data will be treated statistically; analytical hierarchy process was used for computation of the factors weights. Each input raster is weighted. The cell values of each input raster are multiplied by the raster's weights. The resulting cell values are added together to produce the output raster. Five classes were distinguished in (Sinjar hydrogeological basin), ranged between excellent to unsuitable indexed as 1 to 5.The classification gives an output raster shows potential areas to suitability of irrigated groundwater based on the constrain factors influencing the agricultural species.

Keywords: Classification; Groundwater; Spatial Analyst; Reclassify; Weighted Overlay

Introduction

Nearly all waters contain dissolved salts and trace elements, many of which result from the natural weathering of the earth's surface. Most salinity problems in agriculture result directly from the salts carried in the irrigation water. Salts as well as other dissolved substances begin to accumulate as water evaporates from the surface and as crops withdraw water. Soil scientists use some factors to describe irrigation water effects on crop production and soil quality; Salinity hazard - total soluble salt content, Sodium hazard - relative proportion of sodium (Na+) to calcium (Ca++) and magnesium (Mg++) ions, pH, Alkalinity - carbonate and bicarbonate, Specific ions: chloride (Cl), sulfate (SO_4--), boron (B), and nitrate-nitrogen (NO_3-N),other potential irrigation water contaminants that may affect suitability for agricultural use include heavy metals and microbial contaminants [1-5]. Different classification were presented through the last century to define the irrigated water quality depending upon the constrain factors which were divided mostly into different ranges. Early irrigation water quality criteria have received strong criticism from the users [9]. It was argued that it was not possible, nor was it correct to define clear cut boundaries between different classes of irrigation water.

Scofield (1935) is among the first putting forward criteria to assess irrigation water quality. He had recognized toxic effects of Cl- and So4 in irrigation waters [7]. Wilcox and Magistad (1943) suggested somewhat simpler classification and neglected potential toxicity of excess chloride ions [11]; Doneen (1954) modified the classification suggested by Wilcox and Magistad (1943) to include chloride toxicity. Later, Doneen (1958) introduced a new concept called "effective salinity" (ES) to consider relative solubility of different salts likely to occur in irrigation water. ES can simply be calculated by subtracting concentrations of Ca and Mg carbonates from the total salt concentration since it is very likely that they can precipitate out in soil during irrigation. Christiansen., *et al.* (1977) have proposed to use a somewhat newer approach to assess irrigation water quality [7]. They defined 6 different classes of irrigation water considering total salt concentration, sodium ratio, SAR value, sodium carbonate, chloride, effective salinity and boron concentration of the irrigation water. Many other classifications were put after 1977 the famous one was that of Ayers (1985) which was adopted by FAO. It is well noticed that all the classifications were contributed in many factors that have influence on agricultural species. These factors are EC, SAR, Na %, Cl and SO_4.

The main objective of this study is to create a new classification for suitability of irrigated groundwater based on the most constrains factors influencing the agricultural species; In this classification an output raster shows potential areas to suitability of groundwater for agriculture, multiple data treated statistically, to tell us the overall quality of groundwater bodies and its suitability for agricultural uses.

Study area

Sinjar hydrogeologic basin lies in the NW part of Iraq; it occupies an area equal's to1640 Km^2 within Nineveh Governorate as shown in figure 1. Groundwater is the main resource for water in the basin which is used mostly for irrigation, and sometimes as drinkable water.

Methodology

A hydrogeological data bank which is available in Groundwater studies center and further data for the wells which were drilled in the area were taken in consideration in the study. B. GIS (V. 9.2) was used to produce maps using 3D spatial analysis, surface inter-

Figure 1: Study area Map.

polation functions create a continuous surface from sampled point values. The continuous surface of a raster dataset represents concentration of EC, SAR, Na%, SO_4 and Cl. C. Reclassifying data means replacing input cell values with new output cell values based on groundwater quality for irrigation in a suitability analysis or for creating new raster's. D. Analytical Hierarchy Process (AHP) method was used for computation the factors weights. The cell values of each input raster are multiplied by the raster's weights to produce the final suitability map.

Results and Discussion

There are several results Irrigation Water Quality Criteria as following:

Salinity hazard

The most influential water quality guideline on crop productivity is the salinity hazard as measured by electrical conductivity (EC),it affects crop growth by creating an osmotic stress that restricts water uptake and evapotranspiration." inability of the plant to compete with ions in the soil solution for water (physiological drought)" [1]. The higher the EC, the less water is available to plants, even though the soil may appear wet. Because plants can only transpire "pure" water, usable plant water in the soil solution decreases dramatically as EC increases.

Electrical conductivity is a measure of the dissolved ions in solution, which come from the soil or bedrock through which the water travels, as well as from CO_2 which dissolves in precipitation as it falls to ground. Data of 68 groundwater samples were taken in consideration to represent the distribution of EC which was ranged between (353-8000) µmohs/cm in Sinjar hydrogeological basin as shown in figure 2.

Sodium Hazard SAR = [Na] ÷ [(Ca + Mg)/2]½

While EC is an assessment of all soluble salts in a sample, sodium hazard is defined.

Separately because of sodium's specific detrimental effects on soil physical properties (Decreasing permeability). SAR distribution of the groundwater samples in Sinjar.

Hydrogeological basin is shown in figure 3 which was ranged between 0.2-36.

Figure 2: Distribution of EC map.

Figure 3: Distribution of SAR map.

Soluble sodium percent (SSP) Na % = {(Na)/ (Na+Ca+Mg+k)} x100

SSP is defined as the ratio of sodium in epm (equivalents per million) to the total cation epm multiplied by 100.Water with a SSP greater than 60-80 percent may result in sodium accumulations that will cause a breakdown in the soil's physical properties. (Excessive Na in irrigation water promotes soil dispersion and structural breakdown.) Figure 4 shows the distribution of SSP in Sinjar hydrogeological basin which was ranges between (1 -99)%.

Figure 4: Distribution of Na % map.

Chloride

Chloride is a common ion irrigation waters. Although chloride is essential to plants in very low amounts, it can cause toxicity to sensitive crops at high concentrations. High chloride concentrations cause more problems when applied with sprinkler irrigation. Figure 5 shows the distribution of Cl in Sinjar groundwater which was ranged between (5-6549) ppm.

Sulfate

The sulfate ion is a major contributor to salinity in irrigation waters. However, toxicity usually is not an issue, except at very

Figure 5: Distribution of Cl map.

high concentrations where high sulfate can interfere with uptake of other nutrients. As with boron, sulfate in irrigation water has fertility benefits, the figure 6 shows the distribution of SO4 in Sinjar hydrogeological basin which ranged between (1-79) epm. as shown in figure 6.

Figure 6: Distribution of SO_4 map.

Values reclassification results

The above five raster were reclassified by grouping ranges of values into single value.3D spatial analyst reclassifies a range of values to an alternative value. All values on the original raster that fall within the specified range of values will receive the alternative value assigned to that range, so new distribution for the constrain factors based on the suitability of the mentioned elements for agriculture. The weighted overlay table allows the calculation of a multiple criteria analysis between Several raster. The cell values for each input raster in the analysis are assigned values from the evaluation scale and reclassified to these values. This makes it possible to perform arithmetic operations on the raster that originally held dissimilar types of values. Each input raster is weighted, or assigned a percent influence, based on its importance to the model. The total influence for all raster equals 100 percent. The cell values of each input raster are multiplied by the raster's weights. The resulting cell values are added together to produce the output raster as shown in figure 7.

Output Raster = REC x InfEC + RNa% x InfNa% + RCl x InfCl + RSAR x InfSAR + RSO_4 x $InfSO_4$

Where: R = Raster

Inf = Influence (Weight)

Figure 7: Final raster of the New Classification.

Conclusions

New classification for groundwater suitability for agriculture was produced to define the irrigated water quality and the extension of each class in the hydrogeological basin, the classification erases the dispute in the variation which may appear during the comparison among different earlier classifications. Five classes could be distinguished in the classification range "between" 1 – 5 (Excellent – Unsuitable) depending upon the hydro chemical data.

Bibliography

1. Ayers RS and West cot DW. “Water Quality for Agriculture, FAO”. *Irrigation and Drainage* (1985): 174.
2. Ayers RS. “Quality of water for irrigation”. *Journal of Irrigation and Drainage* 103 (1977): 135-154.
3. C Kirda. Assessment of Irrigation Water Quality Cukurova University Faculty of Agriculture, CIHEAM - Options Méditerranéennes, Sér. A/n031, 1997 Séminaires Méditerranéens Adana, Turkey (1997).
4. Hydrogeological data bank, Ground water Studies Center, National Center of Water Resources management.
5. Curtis G Cude. “Oregon Water Quality Index Methodology Laboratory and Environmental Assessment Water Quality Monitoring”. *Journal of American Water Resources Association (JAWRA)* 37 (2001): 125-137.
6. Saaty RW. Validation Examples for the Analytic Hierarchy Process and the Analytic Network Process, MCDM 2004, Whistler, B. C. Canada (2004).
7. Scofield CS. Salinity of Irrigation Water. Smithsonian Institute, Annual Report, Washington D.C (1935): 275-287.
8. Todd DK. Ground Water Hydrology. John Wiley and Sons Inc. Toppan Prinying Co. Ltd., New York (1980): 336.
9. USSL. Diagnosis and Improvement of Saline Aalnkda li Soils. USDA Agr. Handbook N6o0., Washington, D.C (1954).
10. Wilcox LV. “Classification and use of irrigation water”. U.S. Dept. Agri. Circ. 969, Washington; DC (1955): 19.

11. Wilcox LW and Magistad OC. Interpretation of Irrigation Water Quality and relative Salt Tolerance of Crops. U.S. Bureau of Plant Industry, Washington D.C., USA (1943).

Volume 3 Issue 12 December 2019