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Assessment of Irrigation Water Quality for Kshipra River using GIS

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ABSTRACT: The quality of irrigation water available to irrigators has a big impact on yields and crops. As a result, a better understanding of irrigation water quality is required. Water from Kshipra is used for agriculture and industrial purposes. As a result, research into water quality evaluation is required. The current research is primarily concerned with using Arc -GIS software to assess the quality of irrigation water. Thirty samples of water were gathered from various locations in Ujjain, Madhya Pradesh, India. Both river and tube well water samples are included in these water samples. pH, Electric Conductivity, Hardness, SAR, RSC, Kelly's ratio, Magnesium Hazard, alkalinity, chloride, phosphate, sulphate, and TDS are among the physical and chemical parameters measured. The IDW maps are generated using Arc -GIS to show the variation of parameters at different – different locations. The presence of earth metals, it's safe to assume that river and tube well water is slightly alkaline. The range of Electric Conductivity is very broad. Total dissolved solids, chloride concentration, RSC, SAR, phosphate, sulphate, magnesium absorption ratio, and Kelly's Ratio are all within permissible limits. The hardness of both types of water samples is varied. Hardness levels of 50 to 75 mg/l CaCO₃ are considered acceptable.

KEYWORDS: Water quality, Irrigation water quality, Arc - GIS, Kshipra River, Physical and Chemical parameters, IDW.

I. INTRODUCTION

After air, water is possibly the most valuable natural resource. Though water covers the majority of the earth's surface, just a small portion of it is usable, making these resources rare. As a result, these precious and limited resources must be used with care. The acceptability of water for use is referred to as its quality. A maximum yield can be attained if the water quality is acceptable and the soil and management conditions are ideal (Bhat, March10,2018). Irrigation water, whether pumped from tub wells or collected from streams, contains considerable levels of toxic compounds in solutions that can reduce agricultural productivity and harm soil fertility. The key criteria used to measure irrigation water quality include pH, Total Dissolved Solids, Electric Conductivity, Sodium Absorption Ratio, Residual Sodium Carbonate, Magnesium Hazard, Kelly's Ratio, Hardness, Phosphate, Chloride, Sulphate etc(Arshad & Shakoor, October 2017). A total of 30 samples were collected from various places across Ujjain City. These samples include both river and tube well water. On the other hand, GIS is a valuable tool for assessing water quality, determining water availability, and understanding the natural environment on a local or regional scale. Interpolated distance maps were created using GIS. This information is extremely valuable in gaining a better understanding of irrigation water quality.(Latha & Rao, 2010)

II. STUDY AREA

The River Kshipra, commonly called as "Avanti Nadi," flows through Ujjain, India. It is approximately 195 kilometres long, with 93 kilometres passing through Ujjain. For this study, water samples were collected in a one-liter glass bottle from a river and a tube well in the morning hours. A sample of water is collected and examined in a laboratory. There are 30 zones in the Kshipra River. The starting point for all these zones is Shani Mandir, while the ending point is KD Palace.

III. METHODOLOGY

The approach used in this study can be separated into three categories. The first is the gathering of water samples from various locations. The lab tests in the second section are used to determine the various parameters. Finally, Interpolated Distance Weighted (IDW) maps were created to show the spatial distribution of the parameters.

- **Sample Collection**

Along the Kshipra River in Ujjain, a total of 30 sample stations were selected. The starting point for these zones is Shani mandir, while the ending point is KD palace. For physical testing, water was collected in a fully cleaned standard plastic bottle. The container, a glass bottle, was thoroughly cleaned before water was collected in it for chemical analysis. To keep dirt and other debris from accumulating on the bottles, they should be closed as soon as possible after collecting the sample. Below figure shows sample collections from River and Tube well.



Figure 1: Sample collection from Kshipra River.



Figure 2: Sample collection from Tube well

- **Lab Test**

Following that, the researchers examined at both physical and chemical properties. pH is measured using a pH meter. A conductivity meter measures electric conductivity. Evaporation method was used to determine the total dissolved solids in water. The EDTA Titrimetric Method was used to determine total and calcium hardness. Titrimetric Method for Alkalinity Chloride is measured using the Argentometric technique. Phosphate is produced using the Stannous Chloride technique. Sulphate is measured using the turbidimetric method. Flame photometer used for Sodium and Potassium.

- **Interpolated Distance Weighted (IDW) Analysis**

GIS is a valuable tool for assessing water quality, determining water availability, and understanding the natural environment on a local or regional scale. Interpolated distance maps were created using GIS. This information is extremely valuable in gaining a better understanding of irrigation water quality. (Latha & Rao, 2010). The distribution of color shows the variation of parameters.

IV. RESULT AND DISCUSSION

pH:

The pH of the Kshipra River varies from 7.95 to 8.4. And the pH range for Tube well water is 7.6 to 8.4. pH levels for irrigation are typically in the range of 6.4 to 8.5. It signifies that the pH range is within the acceptable range.

Electric Conductivity

The range of Electric Conductivity of Khipra River varies from 782.5mho/cm to 1687.8. And the range of Electric conductivity for tube well water varies from 860.8 to 1105.1mho/cm.

The range of electric conductivity can be classified in following categories:-



Table 1 Electric Conductivity

Class	Range of EC (mho/cm)	Classification of water
Class 1	< 250	Low
Class 2	250 < EC ≤ 750	Medium
Class 3	750 < EC ≤ 2250	High
Class 4	>2250	Very High

The best suited irrigation water is class one and worst suited irrigation water is class four. Electric conductivity levels of river water and tube well water are in class three here. It denotes that the water has a high electric conductivity.

Total Dissolved Solids

The range of TDS for Kshipra river water is 469.5 to 1012.6 mg/l. And the range of TDS for Tube well water is 520.8 to 1680 mg/l. The standard value of Total Dissolved Solid for irrigation purpose is > 2000 mg/l. So it signifies that the value of TDS for Kshipra river water and Tube well water is within the acceptable range.

Hardness

The range of Total hardness of Kshipra river water is 228 to 488 mg/l. calcium hardness of Kshipra river water is 140 to 224 mg/l. And magnesium hardness of Kshipra River water is 76 to 208 mg/l. whereas the range of tube well water is 264 to 636 mg/l. Calcium hardness of Tube well water is 140 to 360 mg/l. And the range of magnesium hardness for Tube well is 72 to 316 mg/l. The range of Hardness can be classified as follows:

Table 2 Hardness

Range of hardness	Classification of water
Less than 50	Soft
50 -75	Moderate
75 -150	Slightly hard
150 - 300	Hard
>300	Very hard

Here the values shows tube well water is harder as compare to river water.

Sodium Absorption Ratio

Sodium Absorption Ratio is calculated by the Equations (LA, 1954).

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} \dots\dots\dots(1)$$

All ionic concentrations are measured in meq/l. Tube Well water has a SAR range of 0.267 to 0.963. And the SAR range for river water samples is between 0.56 and 1.02. This indicates that the water from both the tube well and the river is low in sodium. Which is best suited for irrigation purpose.

Chloride

Chloride is the most typical damaging ion found in irrigation water. Damage symptoms such as leaf burn or leaf tissue drying appear when the chloride content in the leaves exceeds the crop's tolerance. (RS & DW, 1985). In groundwater, chloride ion concentrations up to 70 mg/l are considered safe, but concentrations greater than 350 mg/l cause major difficulties in crops. (Bhat, March10,2018). Chloride levels in tube well water range from 100.2 to 184.4 mg/l. The concentration of chloride in River water ranges from 92.2 to 180.4 mg/l. It signifies that the amount of chloride in the water is within the permissible level.

Residual Sodium Carbonate

Residual sodium carbonate can be determined by the following equation;

$$RSC = (HCO_3^- + CO_3^{2-}) - (Ca^{2+} + Mg^{2+}) \dots\dots\dots(2)$$

All ionic concentrations are measured in meq/l. The RSC can be classified as follows:



Table 3 Residual Sodium Carbonate

Range of RSC	Classification of water
RSC < 1.25	Low
1.25 -2.5	Medium
>2.5	High

The range of RSC for river water sample is -0.95 to 2.38. And the range of RSC for Tube well water sample is -4.47 to 2.35. The negative value of RSC shows water is good for agriculture purpose. And the values of RSC are within the acceptable limits.

Alkalinity

The unit adopted for alkalinity is mg/l as CaCO₃. The acceptable limit of alkalinity is 200 mg/l as CaCO₃. The range of alkalinity for river water is 172 to 340 mg/l as CaCO₃. The range of alkalinity for Tube well water is 172 to 380 mg/l as CaCO₃. This shows water is slightly alkaline.

Kelly's Ratio

Kelly's Ratio is calculated by dividing the sodium ion concentration versus the calcium and magnesium ion concentrations.(WP, 1940)

$$KR = \frac{Na^+}{Ca^{2+}+Mg^{2+}} \dots\dots (3)$$

Where, all ion concentrations were measured in meq/l. According to Ramesh and Elango water with a Kelly's ratio of less than one is good for irrigation, whereas water with a ratio of more than three is not good for irrigation. The range of Kelly's ratio for river water is 0.12 to 0.25. And the range of KR for Tube well water is 0.09 to 0.198.

Magnesium hazard / Magnesium Absorption Ratio

Magnesium is an essential part of plant growth, and a deficiency causes yellowing as well as a reduction in crop growth and yield. Because the amount of magnesium in water determines the quality of water for irrigation, agricultural use is important. (G & F, 2014). The magnesium hazard is determined by the following equation:

$$Magnesium Hazard = \frac{Mg^{2+}}{Ca^{2+}+Mg^{2+}} \times 100 \dots\dots (4)$$

Magnesium hazards of less than 50 are considered suitable for irrigation; however, magnesium hazards of greater than 50 are deceptive and unsuitable for irrigation, reducing crop yield as soils become more alkaline. The range of magnesium hazard for river water is 38 to 50. And the range of magnesium hazard for Tube well water is 25.71 to 50. Hence the range of magnesium hazard is within acceptable limit.

Phosphate

The acceptable range of Phosphate is 0 to 2 mg/l. The range phosphate in river water is 0.13 to 0.478 mg/l. And the range of phosphate in Tube well water sample is 0.16 to 0.475 mg/l. Here the values shows phosphate in both type of water is within the range.

Sulphate

The acceptable range of sulphate is 0 to 40 mg/l. The range of sulphate of river water is 2.566 to 8.845 mg/l. The range of sulphate of Tube well water is 2.566 to 8.845 mg/l. The values shows sulphate in both type of water is within the acceptable limit.



V. INTERPOLATED DISTANCE WEIGHTED (IDW) ANALYSIS

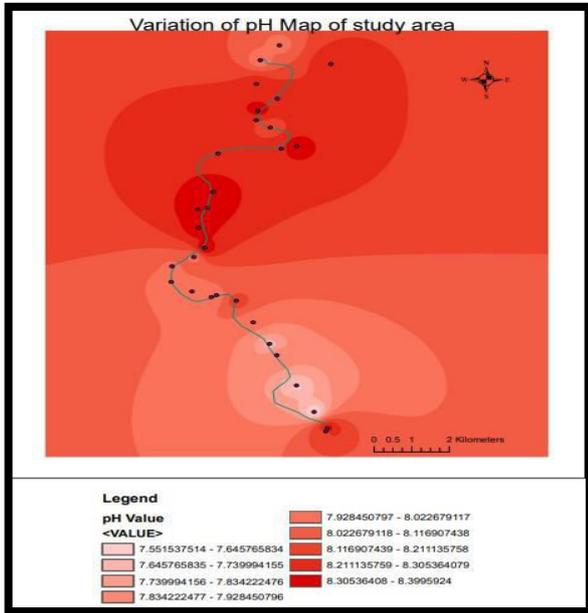


Figure 3: IDW of pH

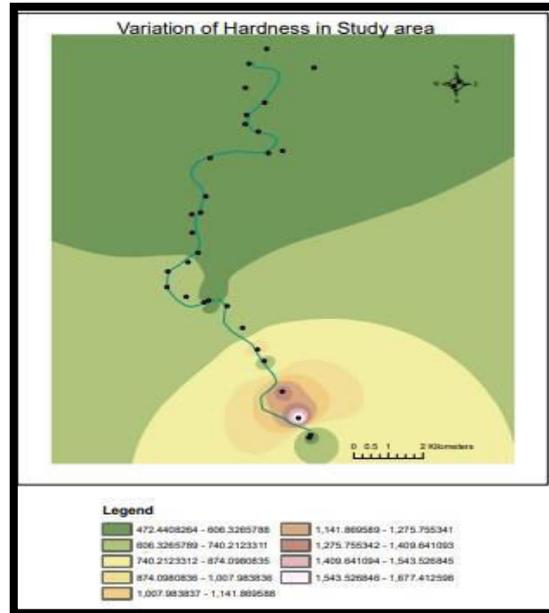


Figure 4: IDW of Hardness

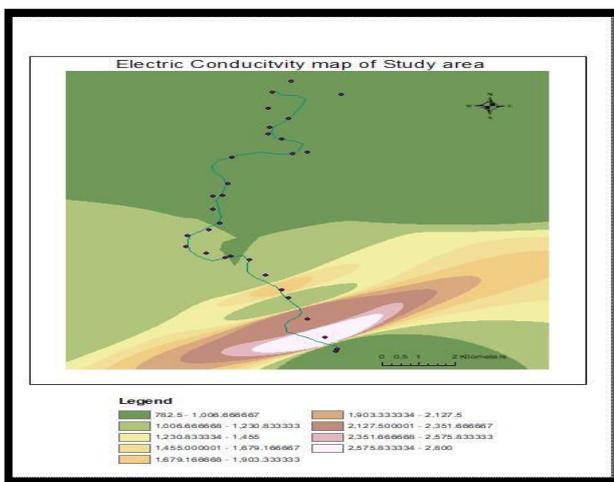


Figure 6: IDW of TDS

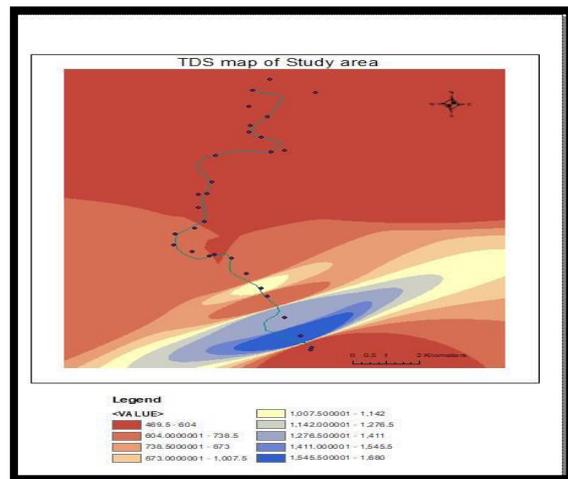


Figure 5: IDW of Electric Conductivity

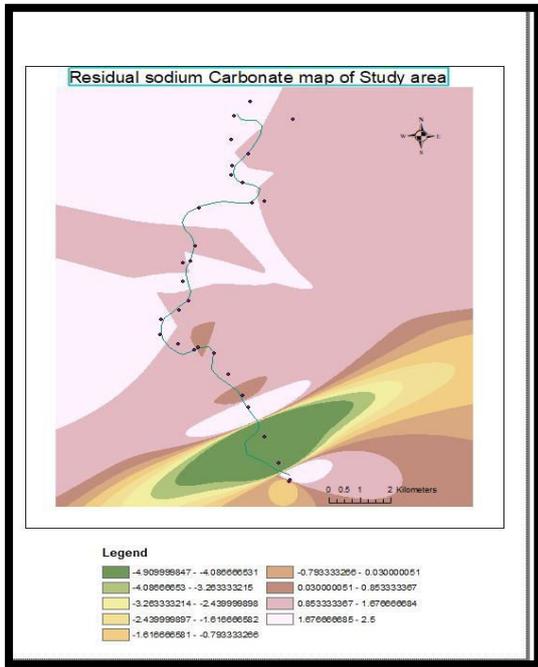


Figure 7: IDW of RSC

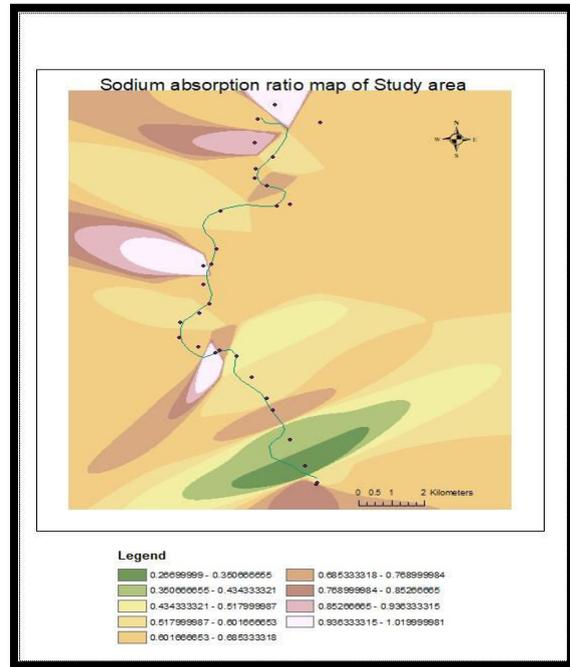


Figure 8: IDW of SAR

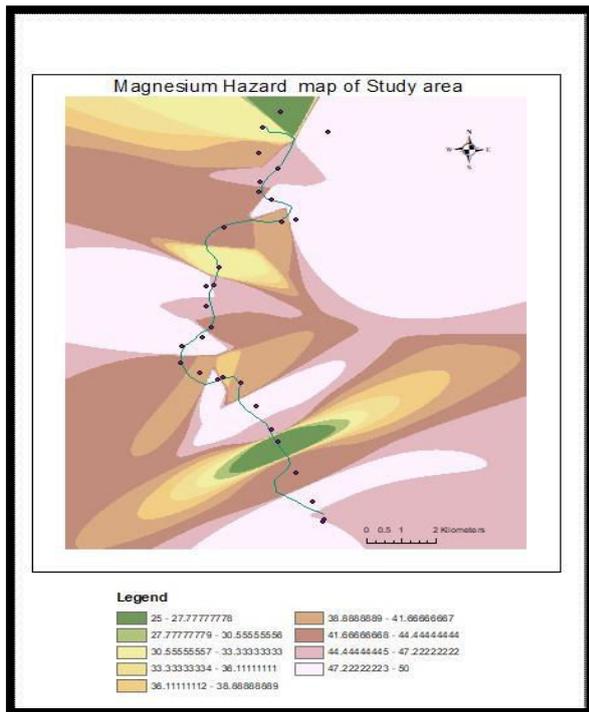


Figure 8: IDW of Magnesium Hazard

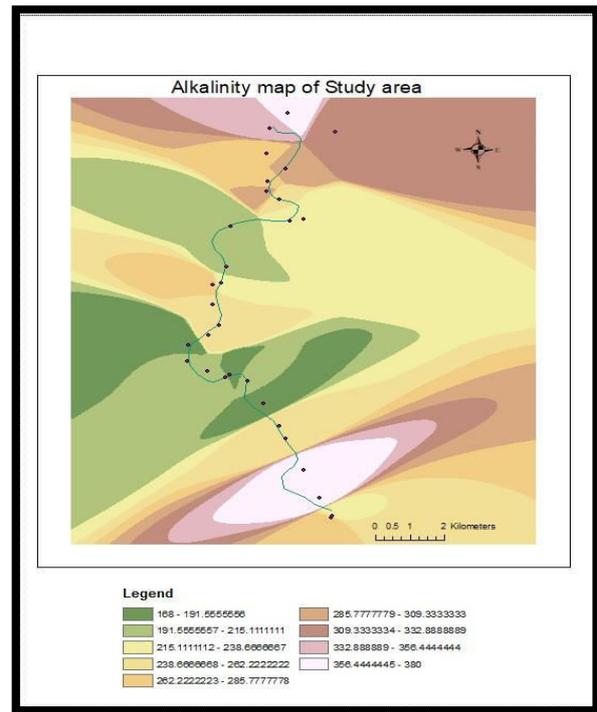


Figure 9: IDW of Alkalinity

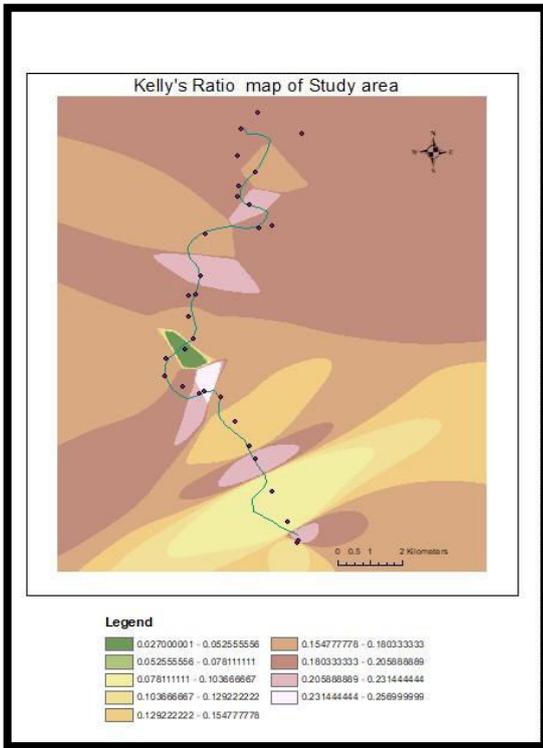


Figure 10: IDW of KR

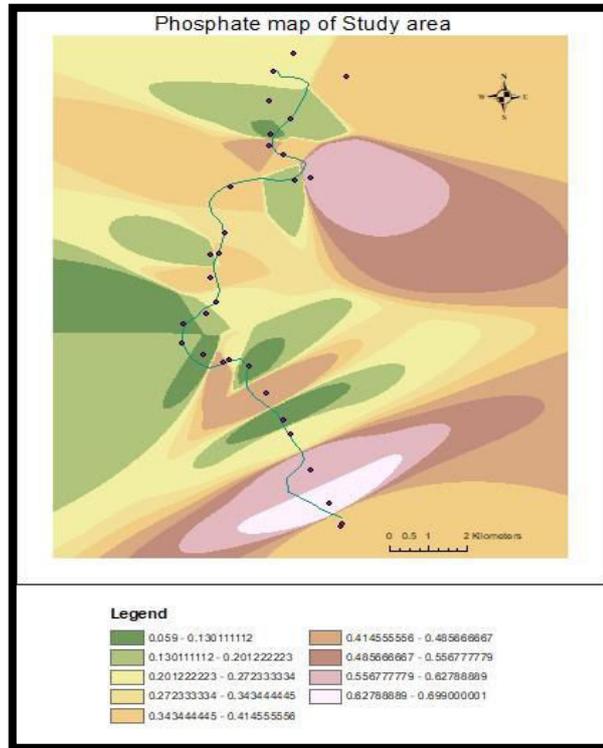


Figure 11: IDW of Phosphate

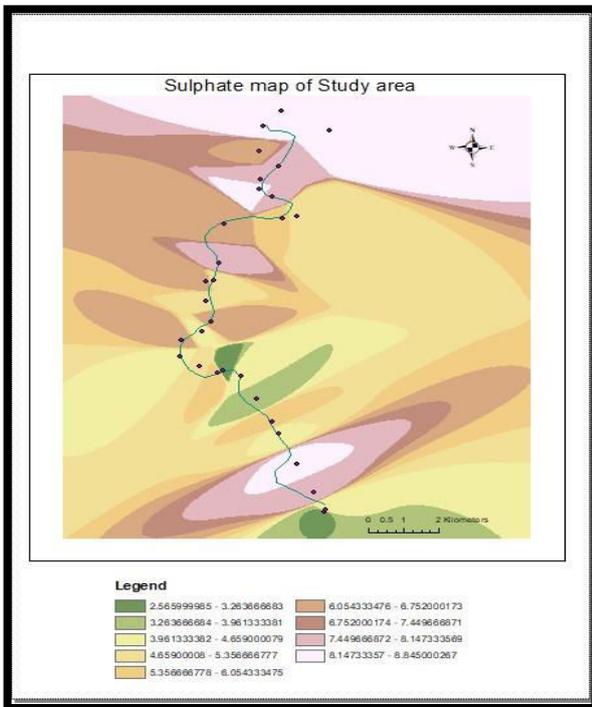


Figure 12: IDW of Sulphate

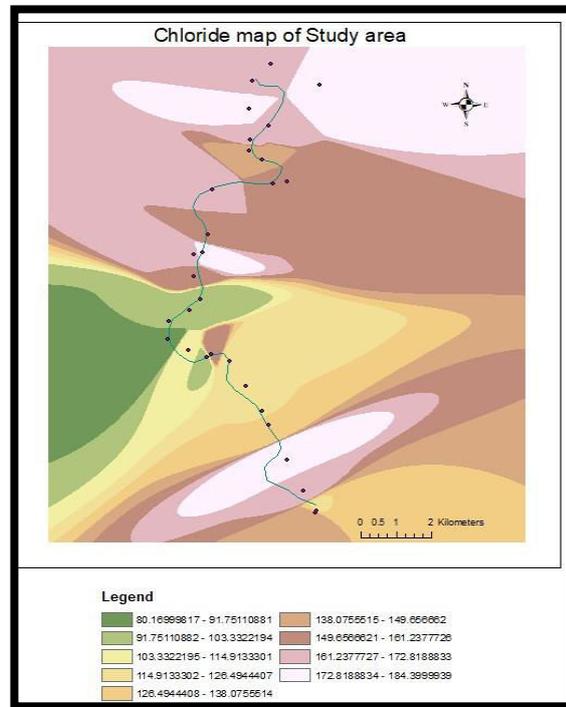


Figure 13: IDW of Chloride



VI. CONCLUSION

It's safe to presume that river and tube well water are kind of alkaline due to the presence of earth metals. The range of Electric conductivity is quite large. The total dissolved solids (TDS) are within safe levels. The hardness of both types of water samples is high. The SAR readings are within acceptable limits. Chloride levels in the water are within safe standards. Both types of water samples had RSC ranges that are within permissible limits. Phosphate, sulphate, magnesium hazard, and Kelly's Ratio are all within acceptable limits. In Arc-GIS software, IDW maps displaying the spatial distribution of various physicochemical characteristics are created for better understanding.

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