Valuation of Irrigation Water at Shagordari, Jashore, Bangladesh

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Abstract - *Application of agrochemicals materials, water of sewage, and contaminated water in drain has become a serious threaten condition to groundwater for Intensive agriculture. The main theme of the study was to evaluation the quality of groundwater and to spatial difference of their mapping in terms of appropriateness for the purpose of irrigation and drinking. Ordinary kriging technique was applied for preparation of thematic circular maps of several hydro chemical and IWQI parameters such as electrical conductivity, sodium adsorption ratio, and magnesium/calcium ratio, total dissolved solids, chloride, and hardness, KI, PI, SSP. Irrigation water quality index model was considered best fitted where determine all quality parameters together in a process. The contamination level was maximum at the north part of the investigation area. Excellent quality of groundwater may be identified at the middle and south middle part areas of the groundwater quality is good. Here high salinity indicates the higher chloride concentration of the groundwater. High dissolved solids and total hardness made eastern part of the groundwater inappropriate for irrigation. There were also found lower sodium and magnesium hazard in the investigate area. The groundwater quality index was developed to investigate the combined influence of several quality parameters on irrigation purposes.*

Key Words: Contaminated, Agriculture, GIS, Ordinary Kriging, SSP, SAR, KI, PI, IWQI.

1. INTRODUCTION

The sources of groundwater contaminate not only from anthropogenic activities but also from the inherent groundwater material substances decreases its supply which makes a threaten situation for the development and turns into a challengeable condition for managers of water resources. The resources of groundwater create around 73% of the whole potential part of irrigation potential in Bangladesh [1]. About 67% of the entire cultivated area is totally reliant on groundwater for irrigation purposes [2] and again 50% also irrigated food production is associated with the wells of groundwater [3].The total condition leads us to overexploitation as well as is apparent from the circumstances which "defiled" and "blocks of dark" in this state have augmented from 270 in 1995 to 1,498 in 2008 in Bangladesh [4]. It is apart from the deterioration of capacity which is indicated the deterioration of excellence is also a major apprehension. Bangladesh has become a rapid rising country which is facing the problems of both groundwater superiority and extent. Increasing urbanization, population of explosion and exhaustive are the problem contributing factors on agriculture sectors. The Sagardari union, the main studied area, is required to use 50% of its water prerequisite from groundwater resources. The unlined drains which is opened and the removal of pollution in different locations in the recharge extents act as pollution source of groundwater [5].

1.1. Location

Sagardari is a union in the Keshabpur Upazila of Jahore district, built on the bank of the Kopotakho River, which is famous for poet Michael Madhusudan Dutt's parent house.

The weather of this areas is moderately subtropical with normal annual precipitation and evaporation is also moderate separately. For this research 40 deep well water sample were collected from different location **(Figure 1).**

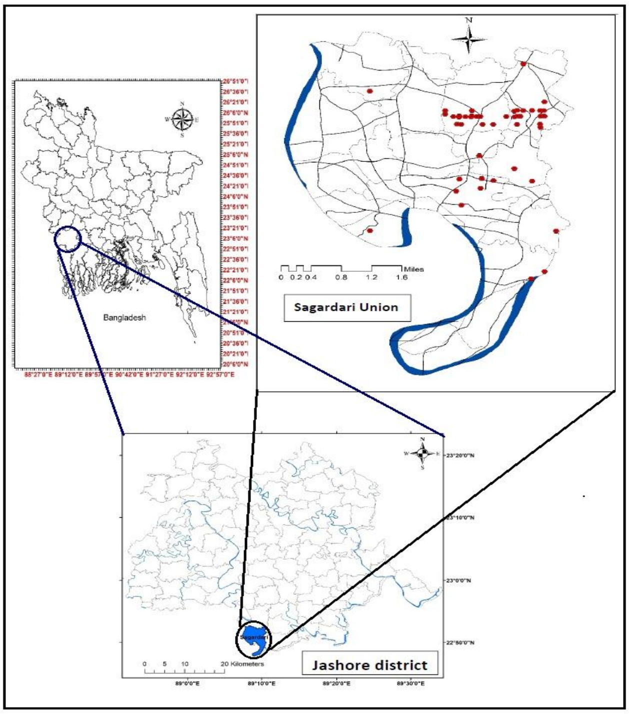

Figure 1. Location with different water sampling position of the study area in Sagardari Jashore

2. MATERIAL AND METHODS

Samples which were collected from the study areas were evaluated in the **AAS-Jashore** laboratory for the quantity of concentration of the superiority parameters using standard techniques (Table 1). The superiority of groundwater for deep tube wells were compared to standard level from higher or lower. It showed the distributional areas of geo chemical water sample by GIS. Consistently the restrictions of temperature, pH was designed in the selected area by applying Thermometric and Electrometric system. The laboratory analysis of parameters was identified with the main ion's absorption (Na^+, K^+, Ca^{+2}, Mg^{+2}, Cl^-, As^{+3}, temperature, pH, electrical conductivity, hardness, salinity, manganese determines the total samples of ground water.

Table 1. Specific approaches of estimation of several hydro chemical parameters of groundwater

Properties (Groundwater)	Progression
Temperature	Technique of thermometric.
Chlorine	Ion selective electrode process.
Ions	Selective techniques of electrode.
pH	Technique of thermometric.
Total dissolved solids	Conductivity bridge method
Na	Flame photometric method
Mg	EDTA titration method
Ca	EDTA titration method

3. RESULTS AND DISCUSSION

3.1 Hydro geochemical facies

Drop diagram (1944) is applied for the identification of the groundwater facies where the main basement of specification is on ions (Drop, 1944). In the figure of drop illustration, foremost ions are designed in two spaces triangles as major cations and major anions (Table 2). This diagram is applied to classify the groundwater facies where in this case depend on dominant or space ions. Investigation of drop diagram exposes that chloride, salinity, %Na earth and all are the main ions in the area (Figure 2). The foremost groundwater is considered by area is the $CaMgHCO_3$ and salinity in highly distribution types.

3.2 Sodium adsorption ratio (SAR)

There is a vast important connection between the sodium values in water irrigation purposes and the amount to which sodium is fascinated by the soils. While a great salt absorption in groundwater hints to saline soil formation, higher amount sodium indicates to growth of soil alkalinity. Hazard of alkali of the irrigation purposes groundwater is identified by SAR (Figure 4). If the amount of Na (Figure 3) is higher, the hazard alkali is higher[14][15].The values of SAR of groundwater taken from the investigated area varied from different places (Figure 4). According to the (Table 3), the distribution of SAR focused 25.04%and 50.06% area were under safe and moderately safe zone, respectively, but other 24% areas represented the unsafe (poor) zone. The SAR formula represented that:

$$SAR=\frac{Na}{\sqrt{\frac{Ca+Mg}{2}}}$$

3.3 Electrical Conductivity and Percentage Sodium

EC and Na contribute a vital purpose to regulate the appropriateness of groundwater for agricultural persistence. The larger quantity of Na in farming water will rise the Na subastances to the crop areas which indicatiores to transformed soil soil penetrability as a significance soil becomes firm to plow and unsuitable for the seeds propagation [16][17][18].The **(Figure 3)** showed the distribution areas of EC and identified zone according to **(Table 3).** Percent Sodium (%Na) is an appearance to catch the Na amount in cultivated areas groundwater. The percent sodium is obtained by the formula given below:

$$\%\ Na = \frac{Na+K}{Ca+Mg+Na}$$

3.4 Magnesium Hazard

In general, the chemical properties or ions of groundwater, calcium and magnesium mainly have been found in a process of equilibrium a state [19]. It is mentioned [20] that a hazard of magnesium values (Figure 4) on areas of groundwater has a relation of agriculture purposes. The hazard of Magnesium values can be achieved by following method:

Magnesium Ratio $=\frac{Mg}{Mg+Ca}\times 100$ (All values are measured in mg/l)

It is mentioned that if the magnesium ratio has remained above 50 in a groundwater (**Table 3),** it appears to be unsuitable for the purpose of irrigation and utilization of such kinds water will unfavorably affect on the cultivation o yield by growing on the basis of nature of soil procedure [22]. The magnesium hazard ratio values on the study areas are shown on the **(Figure 4)** and it also identified that excellent to poor by GIS method of Kriging on circular distribution based on magnesium ratio of agricultural purposes (**Table 3).**

Table 2: Groundwaterand their statiscal comparison with irrigation.

Parameters	Max	Min	Mean	Variance	SD	Average
TDS (mg/L)	3300	475	1432.5	705533.89	829.39	1597.95
Con. of pH	8.24	7.67	8.005	0.02114	0.143595787	7.9955
Chloride (mg/L)	1890.67	157.81	735.49	256933.79	500.5101909	859.76413
Total alkalinity (mg/L)	2830	340.09	452.49	385739.39	612.8526436	681.70246
Iron (mg/L)	1.096	0	0.1335	0.0451	0.209890177	0.1813175
Manganese (mg/L)"	0.111	0	0.0345	0.001112	0.032934936	0.0403
EC (d S m^{-1})	6310	926	2555	2503741.88	1562.417466	2883.75
Hardness (mg/L)	760	200	330	22159.702	146.9888091	370.7
Calcium (mg/L)	696	49	77	20601.87	141.7279944	120.39815
Magnesium (mg/L)	93.80	15.21	36.36	284.26	16.64806971	40.530233
Sodium in (mg/L)	904.89	23.09	326.39	58756.75	239.3487557	337.48125
Bicarbonate (mg/L)	1103.96	0.05	271.38	95068.88	304.4538765	344.59894
Salinity	0.76	0.04	0.135	0.0186	0.134845977	0.17375

Table 3: Grades of groundwater hydrochemical subastances for irrigation quality on the basis of on several indices such as EC, SAR,, KR, SSP, PI, MH, Na%, T.H. [16,17]

Parameters	Range	Water class
EC	<250	Excellent
	250–750	Good
	750–2250	Permissible
	>2250	Doubtful
SAR	0–10	Excellent
	10–18	Good
	18–26	Doubtful
	>26	Unsuitable
KR	<1	suitable
	1–2	Marginal suitable
	>2	Unsuitable
SSP	<50	Good
	>50	Unsuitable
PI	>75	Class-I
	25–75	Class-II
	<25	Class-III
MH	<50	Suitable
	>50	Harmful &Unsuitable
Na%	<20	Excellent
	20–40	Good
	40–60	Permissible
	60–80	Doubtful
	>80	Unsuitable
T.H	<75	Soft
	75–150	Moderately Hard
	150–300	Hard
	>300	Very Hard
IWQI	85-100	Excellent
	70-85	Good
	50-70	Permissible
	40-55	Doubtful
	Jan-40	Severe

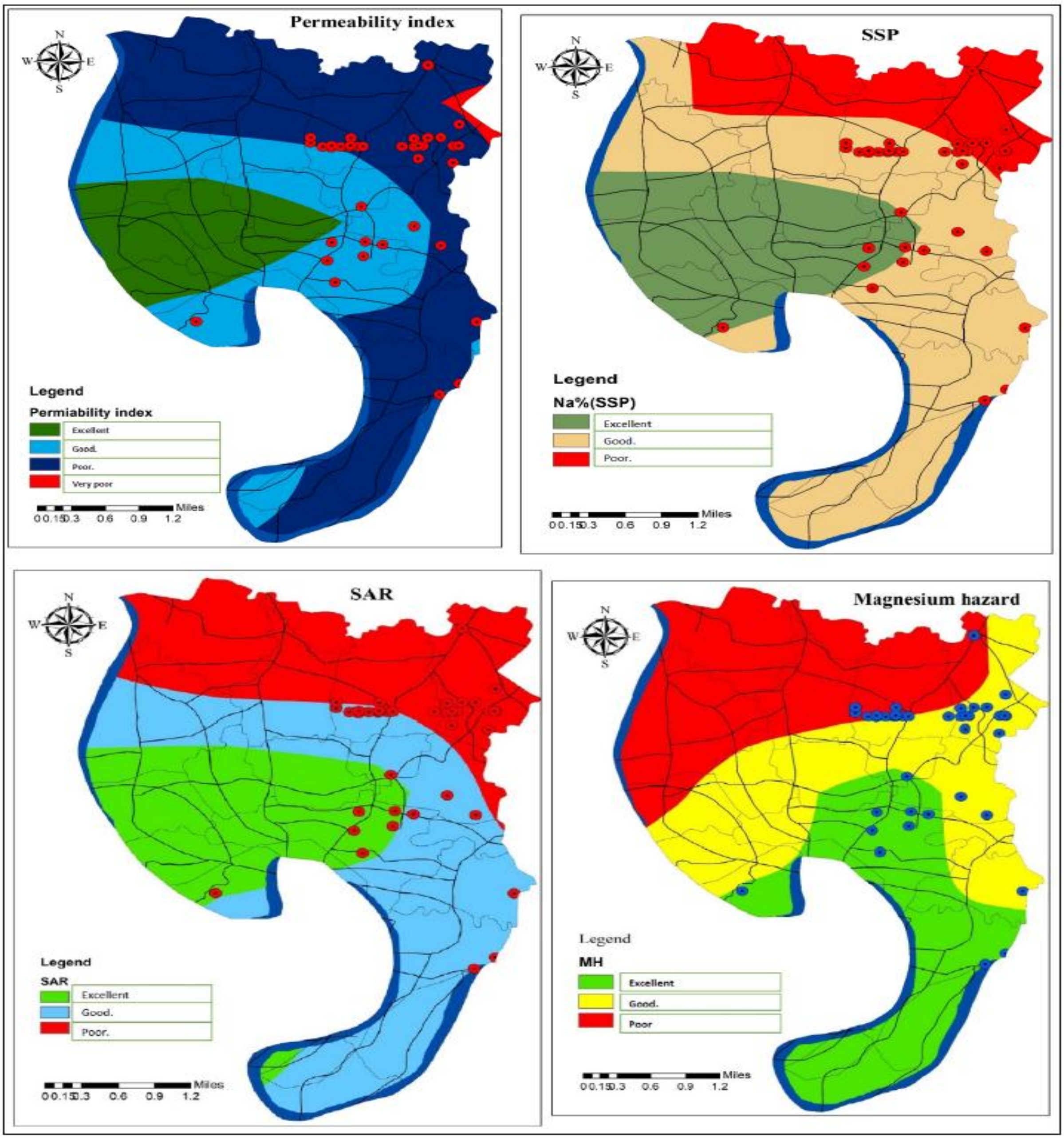

Figure 4: Groundwater identification of several parameters distribution for the purpose of irrigation quality.

3.5 Permeability index

Doreen was established the PI-basis [23] illustration to consider the groundwater chemical properties for irrigation purposes. On the larger period of irrigation water executes the impact on soil eminences **(Figure 4).** Sodium, calcium, magnesium, and bicarbonate ions mainly effect on the permeability of soil. PI can be deliberate by the following such formula:

(Permeability index) PI= $[\frac{(Na + \sqrt{HCO3})}{(Ca + Mg + Na)}] \times 100$(All values are measured in mg/l)

On the basis of classification **(Table3),** here has been shown the distribution soil permeability by GIS on Kriging [24] on circular **(Figure 4)** distribution most of the groundwater areas samples fall in class 1 (excellent), class 2(good), class 3(poor) and class 4 (very poor).

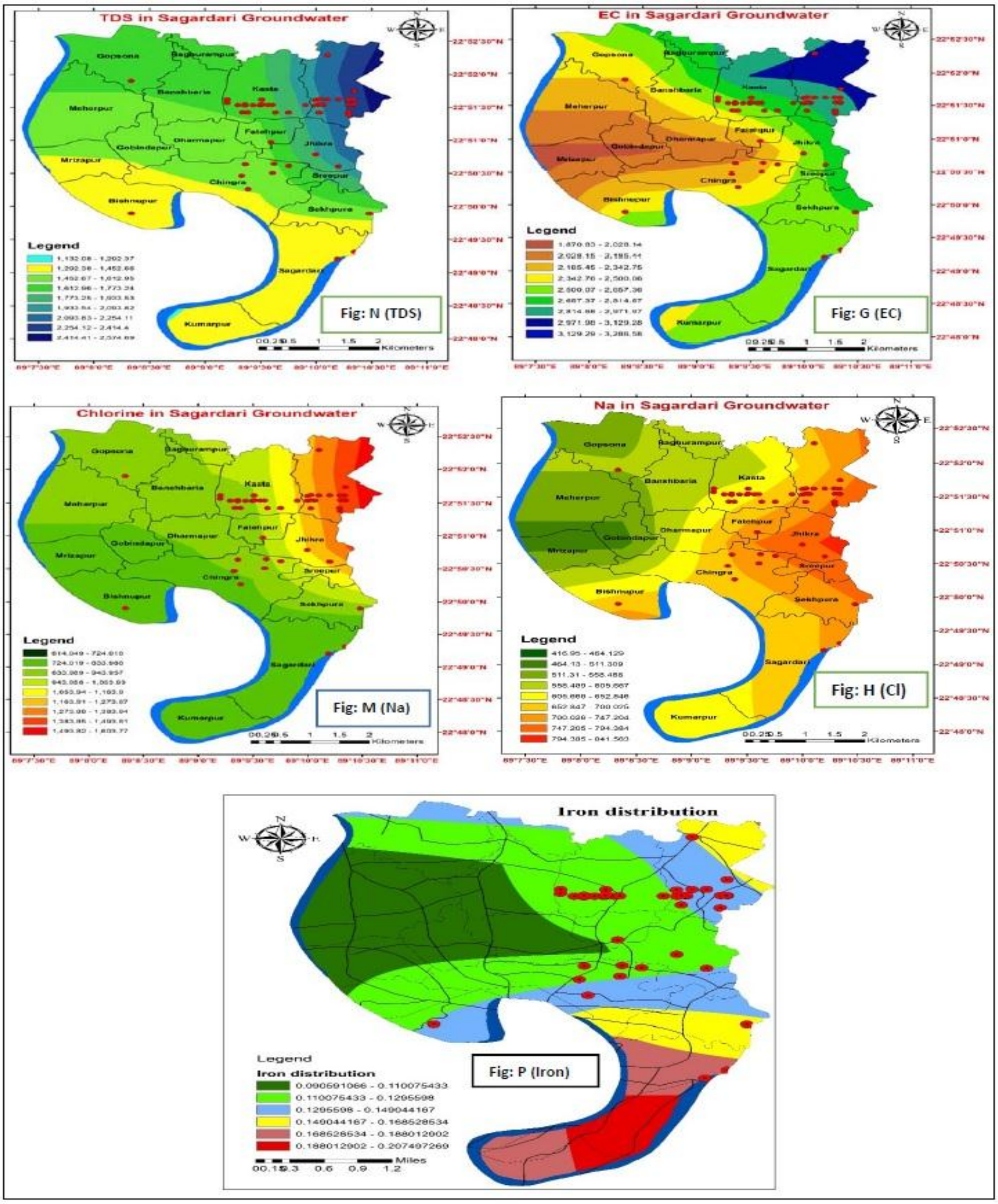

Figure 3: Hydrochemical (Iron ,TDS,Na,Cl, EC) parameters distibution with different zone at Sagardai union.

3.5 Kelly Index

The groundwater chemical properties are also classified for irrigation purpose on the bases of Kelly index **(Figure 5)**. If the value of Kelly index is over than 1, it specifies a superfluous of sodium. On the other way, Kelly index [25] below than 1 which indicates shortage of Na in ground water (Kelly, 1951). According to Kelly index [26], ground water is characterized into three sectors. When the rate of Kelly index is lower than 1, the groundwater is appropriate for irrigation **(Figure 5).** When the value of Kelly index distribution of ground water are shows here by the formula

Kelly index (KI) = $\frac{Na}{(Ca+Mg)}$ (All values are measured in mg/l)

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3.6 Total Hardness (TH)

Total hardness of ground water depends on the absorption of materials such as Ca and Mg.TH in groundwater is produced by dissolved of Ca and, to a smaller amount, Mg **(Figure 5).** It is generally articulated as the correspondent amount of CaCO3 [27]. The hardness of GW is reflected the environment of the biological formations with that it has been in exchange [28]. Public suitability of HI may vary from significantly from one municipal to another dependent on local circumstances **(Figure 5).**The hardness values of this areas on the groundwater samples extended from a minimum 200 of mg l^{-1} to a maximum of 760 mg l^{-1} with the value of mean 330 mg l^{-1} **(Table 3).**The total areas 31.04% represents excellent, 63.09% represent good and 5% areas is poor identification **(Figure 5).** Total hardness calculated by following formula

$$TH=(2.497 \times Ca) + (4.11 \times Mg)$$

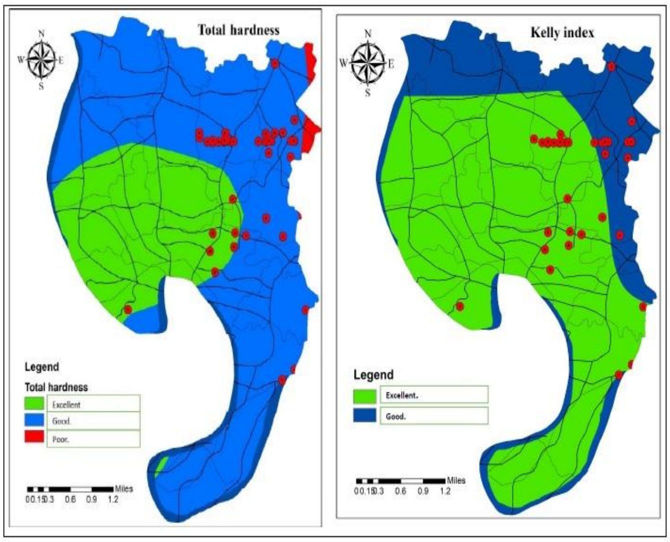

Figure 5: Irrigation quality in groundwater purposes the distributional parameters. (KI and TH)

3.7 Irrigation Water Quality Index (IWQI) Model

The Irrigation groundwater quality index (IWQI) technique delivered a good approach for determining the total combined effect of the numerous parameters of groundwater quality for the purposes of irrigation for the single variable.It is considered one of the most effective process for analyzing the appropriateness of groundwater superiority and it helpes to recognize the actual information for the total superiority of groundwater for irrigation persistence in the catchment.This process is also helped for identifying the classification of the appropriate areas of groundwater quality for irrigation purposes depend on several single parameter by considering numerous variables of groundwater quality. In this sinvestigation, IWQI model was established by conjoining the integration of eight water quality parameters: they were SAR, Salinity,SSP,KI,PI,MH,%Na, EC, As, TDS, Na and Cl. These groundwater quality parameters was designed and classified on the basis of some recommendation principles[29][30].

$$Qrv = \frac{(Cv) \times 100}{(RSv)}$$

$$Wcv = \frac{1}{RSv}$$

$$IWQI=\frac{\sum_{1=0}^{n} Wcv \times Qrv}{\sum_{1=0}^{n} Wcv}$$

Here, Q_{rv} indicates the rating of water quality values, Cv representes for the detected values of concentration from laboratory (mg/l), RSv represents the recommended values of standard levels of groundwater quality,Wcv represents the parameters coefficient of values of the relative weight, IWQI signifies for irrigation water quality index and n represents the number of groundwater superiority variables. IQWI mainly oscillating from 0 to 100 **(Table 3**).

The irrigation groundwater quality index cataloguing was made on the on the basis of different parameters value, on the way of irrigation water quality parameters planned by the University Of California Committee Of Consultants UCCC, and by the criteria established by Ayres and Westcot.According to[31][32] **(Table 3)**the water range table with the corelation of expressions the identification of groundwater quality with the relative weight and the assessment of quality range rating values for irrigation groundwater quality index for each sample number 40 (GWSN40). The total calculation result of irrigation water quality index (IWQI)[33] of sample number 40 was showed according the spatial distribution on circular approach **(Figure 6).**

According to the IWQI classification level and othe rarting system, the groundwater sample of well number 40.The resultant values of irrigation groundwater quality index (IWQI) is specified: 13.26% areas is excellent or no restriction, 50.08% areas is low restriction, 30.51% areas is moderate restriction, 15.38% areas is high restriction **(Table 3).**The distribution shows IWQI by GIS on circular spatal distribution**(Figure 6)**.

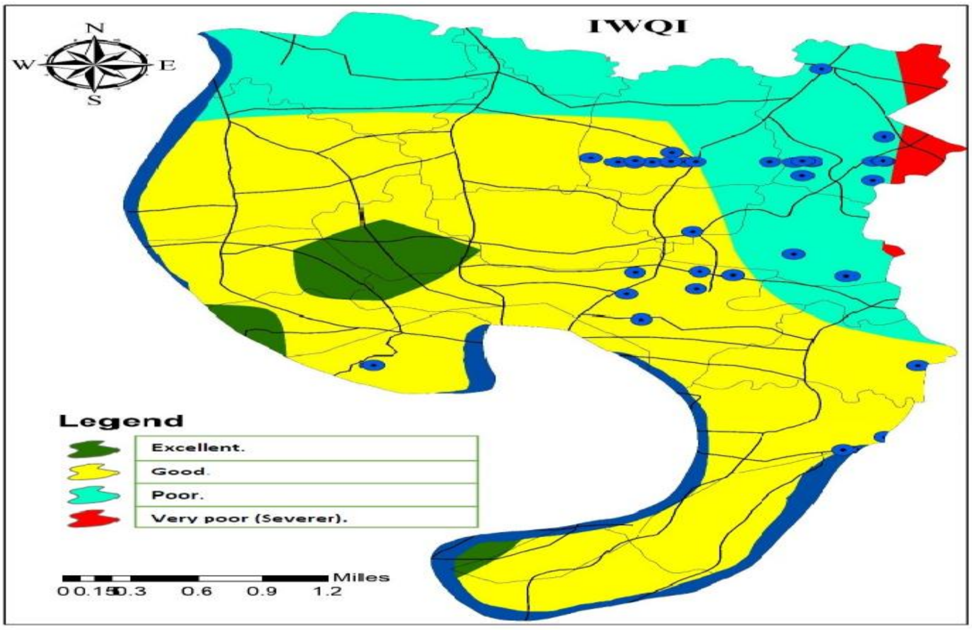

Figure 6: IWQI of spatial distribution by GIS on the circular approach of ordinary kriging (OK).

3. CONCLUSION

Environmental resources are groundwater and its superiority deprivation are an apprehension of important societal and environmental issue. The main aim of this investigate area was to map and estimate the groundwater quality. Spatial circulation of groundwater superiority strictures was carried out by GIS and geo statistical methods. The quality of groundwater hydro chemical substances was transformed different restricted areas from a normal circulation. Highly contaminated groundwater sectors were mainly found at the eastern corner of the investigated areas. Comparatively south and west part more good quality of groundwater then the other part. The hydro chemical investigation exposed that problem of sodality was very low to nil but additional absorptions of chloride and TDS, and the rate of water hardness, make the groundwater at some locations undesirable irrigation in eastern corner. The stimulating and most significant outcome of this investigation was IWQI which areas is more excellent for irrigation and lower or higher pollution by different groundwater chemical parameters. The groundwater quality index was considered very helpful to investigate the joint impact of several quality parameters on irrigation with their distributional plotting maps.

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