Available online at www.elixirpublishers.com (Elixir International Journal)

Pollution

Elixir Pollution 47 (2012) 9029-9034

ISSN: 2229-712X

Temporal and Spatial change of Groundwater quality in Shahr-e-Babak plain for Agricultural the base Wilcox and FAO

Ali Azareh*, Mohsen Mohseni Saravi, Sosan Salajegheh and Masood jafari Shalamzari

M.Sc Student of Management of Desert Regions, Professor of Watershed Management, M.Sc Student of Environment Science, M.Sc Student of Dedesertification, University of Tehran.

ARTICLE INFO

Article history:
Received: 31 March 2012;
Received in revised form:
15 June 2012;
Accepted: 20 June 2012;

Keywords
Groundwater quality,
Spatial and temporal variations,
Kriging,
Wilcox,
FAO.

ABSTRACT

In recent years, increased water use and decreased precipitation have led to increased pressure to groundwater resources, this its quality decrease. Therefore, the main reasons for studying groundwater are potential hazards for groundwater contamination and protect it (ground water) from contamination: te main purpose of this research is the assessment of spatial and temporal trends in ground water quality in Shahr-e-Babak plain to besides of measurement of variation trends, by identifying contaminated regions (for agricultural purposes) issues and problems raised due to contaminates water usage could be prevented for this reason, data related to qualitative parameters of ground water such as EC, SAR, TDS during inventory period 2002-2009 were used. After fitting the best variogram model to empirical model of each of qualitative parameters of Ground water, by Arc GIS 9.3 software and by using Kriging interpolation method. Zoning maps of the region were prepared. Also the water of the region in the view point of agricultural use, was assessed using Wilcox and FAO method results obtained from this research showed that from comparison between Kriging interpolation and inverse distance weighted, Kriging method have the higher precision (based on low RMSE and MAE) than IDW. Also result from water classification based on Wilcox show the increased contamination trend especially in southern parts, and generally in this period the water of the region is classified as moderate-quality water, and also in FAO method contamination trend of waters in this region is increasing and in this method southern parts of this region are classified as the most contaminated parts (water classed with high salinity) of the region. The reasons of contamination of southern parts of the region are the type of Geological of the region and also high agricultural activities.

Introduction

Generally middle -east region is encountered with two problems: water shortage and rapid growing population. Thus, water is the most important factor required for development in this region in future (Haddad 2001). Additionally, water shortage problem for some countries such as Iran that has arid and semi-arid climate has been existed from the past, thus, availability to water resource in the view point of quality (siadati, 2000). In addition to water resources shortage that in turn is a major problem in present time, today, contamination of these critical resources due to human activities results intensifying this problem (ghasemi ziarani et al., 2006). Therefore, it is necessary to understand the distribution and diffusion of contaminants to control and reduce the groundwater contaminations and their effects. Achiving these information only feasible through contamination-measuring stations distributed in the study area and interpolation of sampled points and accomplishment of different analyses (Abdolghaderi Bokani et al, 2008). Various studies about application of Geo-statistical in assessing, ground water quality have been conducted in Iran and in the world that some of them have been discussed bellow.
Gause et al., (2003) investigation the arsenic concentration in ground waters in Bangladesh in this study information from 3534 wells were used. The obtained data showed high skewness in arsenic data to estimate concentration and to prepare the probability map. The Kriging interpolation method was used and the results showed that in the study area about 35 million people are exposed to high concentration of arsenic (50 mg/L), and about 50 million people are exposed to a concentration of 10 mg/L. kumar and Romadui (2006) analyzed the ground water levels in Rajestan region (India) using Geo-statistical techniques. The data set was included ground water tables measured in 60 points, twice a year (June and September) and for a six-year period (1985-1990) at a region with area about 2100 km^2. The results showed that Gaussian, Exponential and Spherical models had the best fitting to data and also Kriging interpolation method had higher precision than ISD.

Fattani et al., (2008) used general Kriging to study and zoning the map of ground water quality for measuring ammonium nitrate and bacteriological contamination of ground water at agriculture plains of Terifa in northeast of Morocco. Their results showed the significant changes (variation) compared to previous studies, and they noted that if there are not any prohibitive and long- term program, expanding of agricultural- lands lead to degradation of- ground water quality in the region.

Makaspa and setapanjaro (2010) studied spatial distribution of heavy metals such as cd, Zn, and Hg in ground water at Rating (Thailand) by using Kriging method, where the region ground water samples were taken from 31 wells twice a year.

Tele:
E-mail addresses: aliazareh@gmail.com

Result showed that many of heavy metals have a concentration higher than quality standards of ground waters in Thailand. Also in southeastern part of the region where is highly susceptible to heavy metals and other contaminations, high concentration of heavy metals are found.

Barcae and passarella (2008) used discontinuous Kriging method and simulation methods to prepare nitrate hazard (risk) map in Modena plain in Italy. The results showed that the discontinuous Kriging is an appropriate method to study the degradation hazard of ground waters.

Dehghani and zarekar (2010) investigated the ground water status (condition) of ground water in Islam-shahr Town (Iran) in a six-years period for use in agriculture, and the results showed that the water in the region has four- classes of Wilcox quality including C_4S_2, C_4S_1- C_3S_1 and C_2S_1, from these classes, C_3S_1 has the highest area.

The main purpose of study is the investigation of the trend of spatial and temporal variations in the water quality properties in the Shahr-e-Babak plain in the 2002- 2009, and also preparation of maps related to these variations to prepare the zoning map, Geo statistical methods were used, and ultimately. Were classified based on Wilcox and FAO methods in order to indentifying? Contaminated regions, in addition to observing the variation percentages of these factors.

Material and methods

The study area (Shahr-e-Babak plain) with area about 600 km^2 with longitude 55˚ 8΄ E and latitude 30˚ 7΄ N located at western part of Kerman province. The average of above sea level in the region is 1845 m, and mean annual precipitation (rainfall), temperature and evapotranspiration in the catchment are 140mm, 15/5 ˚C, and 2462/5 mm, respectively. Rainfall shortage (lack) has resulted in poor condition of vegetation and rangelands, and also wind erosion occurs in overall conclusion about rainfall and Temperature diagrams in Shahr-e-Babak according to ambro-Thermic curve diagram in a period from 1989 to 2009, it was found that dry season in this town prolongs from May to November (low rainfall and high temperature), and only in Five month of year (December t April) there is not condition of dry season, thus based on these results climate in Shahr-e-Babak plain is classified as cool-dry climate. The location of study area has been shown in figure 1.

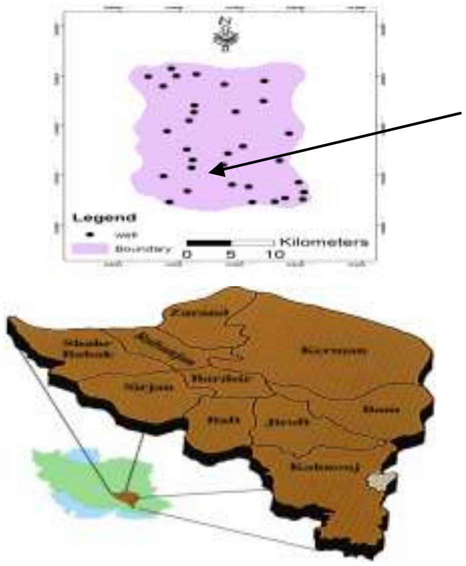


Figure1. Geograpnical location (position) of study area and sampling wells

Research methodology

In order to investigation of qualitative variation trends in ground water resources in shahr-e- Babak plain, data and information from 32 wells related to the period from 1989 to 2009 were used, these data been taken by regional water organization of and then qualitative analyses were conducted on them. After normalization of data, in order to description of spatial continuity of variables the best variogram models to spatial structure of water quality data including EC, SAR, TDS in studied inventory years was depicted. By using two measures RMSE and MAE the appropriate interpolation method was recognized and the maps of qualitative variables were delineated. Ultimately, using diagram classifications of Wilcox and Food and Agriculture organization (FAO) of United Nations for agricultural uses, water quality zoning conducted, and variation trends of parameters and identifying the critical and contaminated regions were to prevent spreading it via comprehensive management.

Kriging is an estimation method that is based on rationale of weighted moving average and this estimator is known as the best linear unbiased estimator (Nas, 2009).

If the variable z has the normal distribution, one can use Kriging method. Otherwise, linear Kriging should be used or variable Z should be normalized somehow (Balsa, 2010). General relation of Kriging is as bellow:

$$Z^*(x_i) = \sum_{i=1}^{n} \lambda_i \, Z(x_i) \qquad (1)$$

Where Z^* (xi): estimated amount at position xi, λi: the weight related to it h sample, Z (xi): the amount of it h variable, and n: number of observations.

Another Geo-statistical method is Inverse distance weighted, that using Weightening to data around an estimated point, unknown quality would be achieved and interpolation would be accomplished. It assumed that points close to gather have more similarity compared to Remote pints. Thus the closer (near) points have a higher weight (Janson et al., 2001). General relation of inverts distance weighted Q is as bellow:

$$Z = \frac{\sum_{i=1}^{N} \frac{Z_i}{d_i^{\,m}}}{\sum_{i=1}^{N} \frac{1}{d_i^{\,m}}} \qquad (2)$$

In order to assessment of amount of error and selection of best interpolation method, there are various measures such as mean absolute error (MAE), mean bend error (MBE), Root mean square error (RMSE). In this research, RSME and MAE methods were used. Siska and Hang (2001) suggest that RMSE is an important parameter to show resolution precision in GIS and RS.

$$RMSE = \left(\sum (Z^*(xi) - Z(xi))^2 \big/ n \right)^{1/2} \qquad (3)$$

$$MAE = \frac{1}{n} \sum_{i=1}^{n} \left| Z^*(x_i) - Z(x_i) \right| \qquad (4)$$

Z^*(x): estimated amount of related variable,

Z (xi): measured amount of related variable, and n: number of data.

Results

In order to data analyses, from the viewpoint of classic statistics each of investigated qualitative parameters, data histogram and its statistics parameters were assessed. Considering histogram shapes and related parameters, it was found that all of the variables had skewness, thus to normalize data, logarithmic transfer of data in related results to each variable was uses. The related results have been shown in table 1. Also, the results from fitting variogram model to empirical variogram show that the best fitted model to qualitative parameters, SAR, EC and TDS is spherical model. Also for the parameters in 2009 is spherical model in order to determine the best variogram model to spatial structure of data, varigram sum of remaining squares, structural component to model total variance ratio were uses, and related variograms and parameters have been shown in figure 2 and table 2, respectively, and these results are not in accordance to Taghizadeh Mehrjerdi et al (2008) and Adhikori et al (2011).

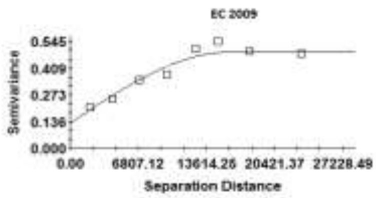
Table1. Result of statistical analysis conducted on the ground water data in study area

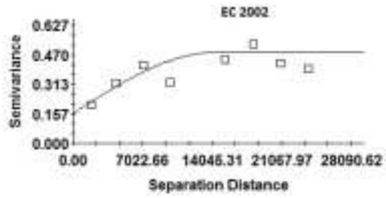
kurtosis	skewness	maximum	minimum	Std deviation	mean	year	parameter
1.8	.56	9150	716	2072.7	3343.81	2002	EC(µmhos/cm)
.25	-.25	3.96	2.85	3.31	3.52	2002	EC*
.7	1.23	16.52	1.92	2.88	7.56	2002	SAR
-.15	.09	1.21	.28	.45	.87	2002	SAR*
.06	.80	6100	477	1381.84	2229.21	2002	TDS(mg/lit)
-.22	-.09	3.78	2.67	3.14	3.34	2002	TDS*(mg/lit)
.69	.59	9150	770	2052.32	3691.66	2009	EC(µmhos/cm)
-.16	-.22	3.96	2.88	3.31	3.56	2009	EC*
.56	.74	14.67	2.58	3.34	8.29	2009	SAR
-.25	-.13	1.16	.41	.52	.91	2009	SAR*
-.35	.71	6050	472	1379.10	2312.58	2009	TDS(mg/lit)
-.45	-.14	3.78	2.67	3.13	3.36	2009	TDS*(mg/lit)

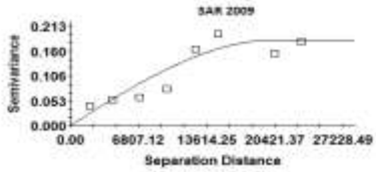
*using logarithm to normalize data.

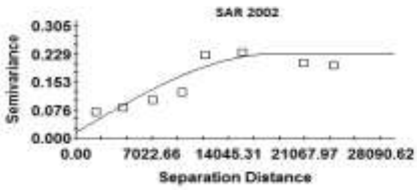
Table2. Variogram model characteristics for parameters

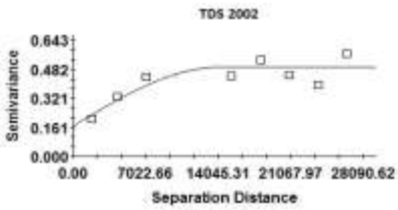
r^2	C/C_0+C	A_0	C_0+C	C_0	RSS	Model	Year	Parameter
.80	943.	18370	.229	.013	.0152	spherical	2002	SAR
.71	.674	14380	.484	.158	.0558	spherical	2002	(µmhos/cm) EC
.68	.661	14290	.496	.168	.0553	spherical	2002	TDS(mg/lit)
.94	.994	19950	.179	.001	.0326	spherical	2009	SAR
.74	.746	16050	.504	128	.0412	spherical	2009	(µmhos/cm) EC
.67	.741	15900	.492	.127	.0525	spherical	2009	TDS(mg/lit)











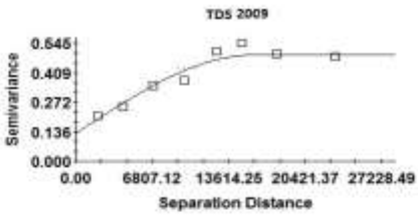


Figure2. Variograms related to ground water quality parameters.

In order to selection the best interpolation method to prepare zoning map of the region, of two interpolation method, IDW and Kriging, the general Kriging method (based on lower RMSE and MAE) was selected as the best method for zoning of all of qualitative parameters and the results are shown in tables3 and 4.

Table3. Amount of RSME measure of parameters for determination the best Geo-statistical method

IDW EXP3	IDW EXP2	IDW EXP1	Kriging	year	parameter
1618	1685	1635	1595	2002	EC(µmhos/cm)
2.55	2.53	2.52	2/43	2002	SAR
1090	1124	1165	1063	2002	TDS(mg/lit)
1515	1526	1531	1192	2009	EC(µmhos/cm)
2.38	2.48	2.54	2.37	2009	SAR
1177	1195	1218	1112	2009	TDS(mg/lit)

Table4. Amount of MAE of parameters for determination of the best Geo-statistical method

IDW EXP3	IDW EXP2	IDW EXP1	Kriging	year	parameter
36	74.75	58	22.12	2002	EC(μmhos/cm)
.19	.16	.10	.09	2002	SAR
38.66	49.86	38.24	14.77	2002	TDS(mg/lit)
143	125	88.1	7.27	2009	EC(μmhos/cm)
.1	.16	.23	.17	2009	SAR
43.24	58.46	50.44	21.37	2009	TDS(mg/lit)

Then using Kriging interpolation method, zoning maps of the region for agricultural uses were prepared based on Wilcox classification and the results has shown in figure3. Variation trends of parameters based on Wilcox diagram have shown in tables 5 and 6.

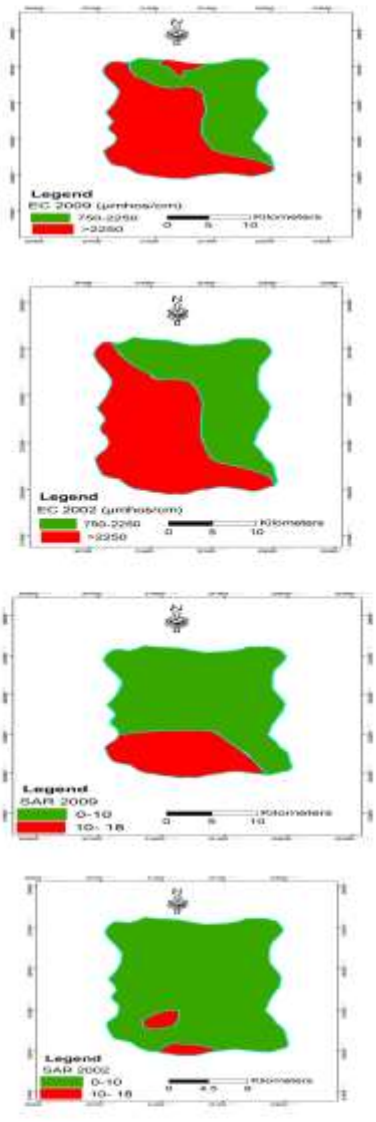


Figure3. Zoning maps related to Wilcox qualitative parameters

Table5. The area of EC classes based on Wilcox

Year	750-2250 (μmhos/cm)	>2250 (μmhos/cm)	classification
2002	39	61	Area(٪)
2002	234	366	Area(km^2)
2009	31	69	Area(٪)
2009	186	414	Area(km^2)

Table6. The area of SAR classes based on Wilcox

Year	0-10	10-18	Classification
2002	95.5	4.5	Area(٪)
2002	330	270	Area(km^2)
2009	79.5	20.5	Area(٪)
2009	477	123	Area(km^2)

Ultimately, using overlaying SAR and EC layers by using Arc GIS 9.3 software, qualitative state (condition) of water of region for agricultural uses was prepared in 2002 and 2009 years based on Wilcox classification (figure 4) and area of each group was calculated (table 7) and variation trends of water quality in whole region were compared based on two measure EC and SAR.

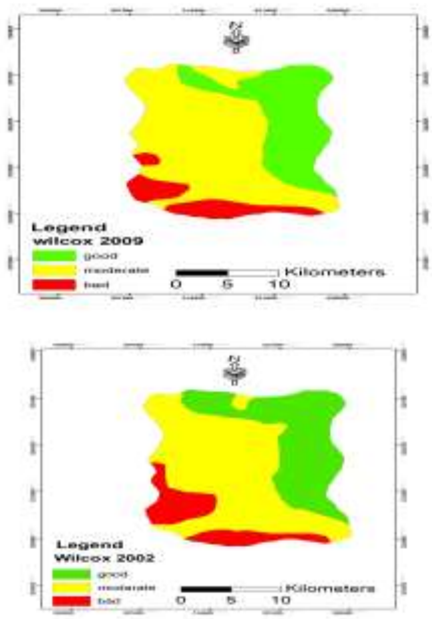
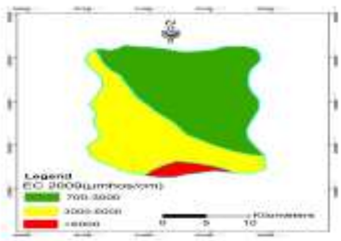


Figure 4.maps of ground water quality for agricultural uses based on Wilcox classification

Table 7. Area of different groups of water for agricultural uses based on Wilcox classification

Area(km^2)	٪	Water quality	year	group
160.92	26.82	good	2002	1
357.06	59.51	moderate	2002	2
82.02	13.67	bad	2002	3
119.52	19.92	good	2009	1
379.26	63.21	moderate	2009	2
101.22	16.87	bad	2009	3

In the next step, to assure the obtained results, FAO method (proposed by Food and Agricultural organization of United Nation to classify water quality for quality for agricultural uses) was used. Using Kriging interpolation method zoning maps of the region were prepared based on FAO classification, and related results have shown in figure5. Then variation trends of parameters were assessed based on FAO method (tables 8 and 9).



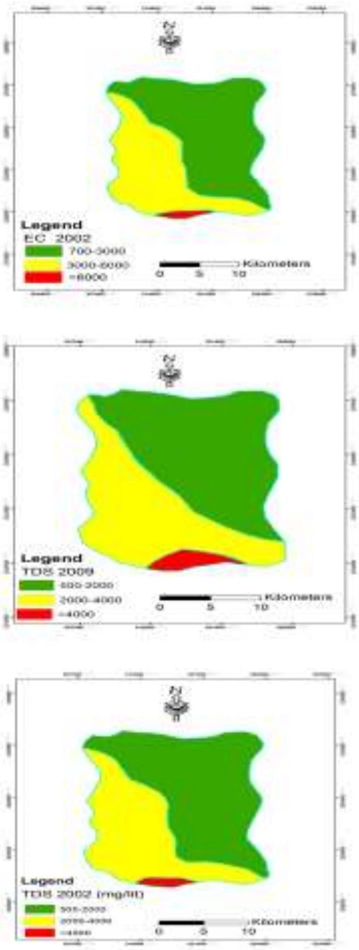


Figure 5. Zoning maps related to qualitative parameters based on FAO method

Table8.area of TDS classes based on FAO

>4000 (mg/lit)	2000-4000 (mg/lit)	500-2000 (mg/lit)	year	classification
2.6	34.71	62.69	2002	Area(%)
15.6	208.26	337.92	2002	Area(km2)
4	41.65	54.35	2009	Area(%)
24	249.90	326.10	2009	Area(km2)

Table9.area of EC classes based on FAO

>6000 (μmhos/cm)	3000-6000 (μmhos/cm)	700-3000 (μmhos/cm)	year	Classification
1.68	40.98	57.34	2002	Area(%)
10.07	245.88	344.04	2002	Area(km2)
3.8	43.94	52.26		Area(%)
22.8	263.64	313.56	2009	Area(km2)

By overlaying layers TDS and EC using Arc GIS 9.3 software, the qualitative conditions of water of the region for agricultural uses in years 2002 and 2009 were prepared based on FAO classification (figure 6) and the area of each group was calculated (table 10) and variation trends of water quality of water of the region were compared based on two measures EC and TDS.

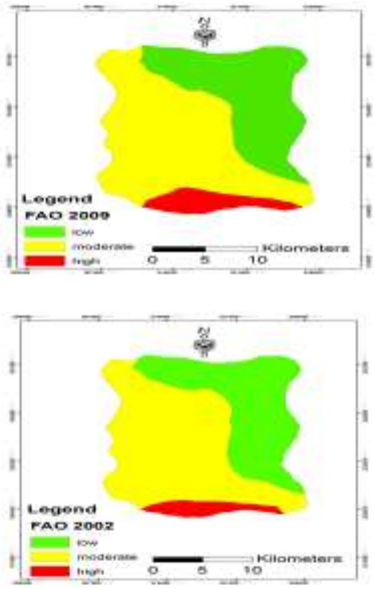


Figure5.map of groundwater quality for agricultural uses based on FAO classification

Table10.area of different groups for agricultural uses based on FAO classification

Area(km2)	%	Water quality	year	group
198	33	Low salinity	2002	1
366.6	61.1	Moderate salinity	2002	2
35.4	5.9	High salinity	2002	3
204	34	Low salinity	2009	1
352.8	58.8	Moderate salinity	2009	2
43.2	7.2	High salinity	2009	3

Discussion and conclusion

Results obtained from this research showed that because of lower RMSE and MAE, Kriging method have higher precision than increase distance weighted that this result is in accordance to Nazari et al., (2006), Gause et al (2003), Ahmad (2002), Taghizadeh Mehrjerdi et al, (2008), and Barcae and Passarella (2008). Thus, the maps were prepared using this method in next step, the maps prepared based on Wilcox measure (table and 9) were classified for agricultural water. Variation trends were classified for Twice parameters EC, and SAR. Result showed that during period of 2002-2009 amount of EC has been increased, and in period of 2002-2009 the water of the region has been remained at classes C3 and C4, but with increasing time C4 has been increased and this increase (growth) is spreading toward east and northeast of the region, and water of the region especially in western part has a high potential of a hazard for soil of region, based on Wilcox diagram, thus spreading of this problem o should be prevented using comprehensive management. Also SAR parameter has been increased in western part during period of 2002- 2009, and alkalization hazard of is speeding (i.e. class Z is increasing), but the water of the region based on Wilcox diagram in the studied period in the view point of SAR parameter occurs in very good class for agriculture. Also using overlaying layer in Arc GIS 9.3, it was related that in 2002 year, high-quality waters had the highest percent (proportion) among different classes and water contamination increased from northeast and east toward south and south west. Also in 2009, high- quality waters had the highest percent, and in this year southern and western had parts of the region were the most contaminated regions, and compared to 2002, the amount of high-quality waters has been decreased and percentage of inappropriate waters for agriculture has been increased. Water of the region occurs in classes C3S1, C4S2, C3S2 and C4S1 that from these, class C3S1 has the highest surface which this class indicates moderate-quality waters for agriculture, thus these results are in accordance to Homayon Naejad et al (2009), Heidary (2009) and Farhadi- Nejad et al (2010).

Water classification based on FAO method confirms results obtained from Wilcox method and indicates that in period of 2002-2009 waters having moderate-salinity has the highest area of region and with passing time is increasing. Water in the southern part has the high salinity and is known as contaminated region.

Ultimately, by assessment of water quality based on Wilcox and FAO classifications in the study area it was found that contamination trend is increasing and contamination intensity in southern part of the region is higher than other parts and increasing contamination should be prevented by comprehensive management to restrain damage to base resources.

References

1.Abdolghaderi Bokani N, Hojjat S.A, Ale sheikh A.A. 2008. Modeling of ground water contaminations using Geostatistical analysis (case study: Shiraz Town). Eleventh symposium of Iran geology council. Iran Topography Organization. Tehran.

2.Adhikary pp, Dash Ch,. Chandrasekharan H, Rajput TBS & Dubey SK.2010. Evaluation of Groundwater quality for irrigation and drinking using GIS and Geo-statistics in a peri-urban area of Delhi, India. Saudi Society for Geosciences

3.Ahmed S. 2002. Groundwater monitoring network design: Application of case studies from a granitic aquifer in a semi-arid region. Groundwater Hydrology, Balkema, Tokyo, Japan. pp: 37-57.

4.Baalousha H: Assessment of a groundwater quality monitoring network using vulnerability mapping and Geo-statistics: A case study from Heretaunga Plains, New Zealand. Agricultural Water Management.97 (2010) 240–246.

5.Barcae E, Passarella G. 2008. Spatial evaluation of the risk of groundwater quality degradation: A comparison between disjunctive kriging and Geo-statistical simulation, Journal of Environmental Monitoring and Assessment.133: 261-273.

6.Damavandi. A, Karimi A, Takasi. M, Taheri. M. 2005. Assessment of qualitative variations in surface and ground waters in Zanjan province. Third national symposium of erosion and sediment. Tehran. September 2005.

7.Dehghani V, Zarkar A. 2010. Zoning of Ground water desirability for agricultural use in Islam-shar Town. National symposium of clean water.

8.Fetouani S, Sbaa M, Vanclooster M, Bendra, B. 2008. Assessing Groundwater quality in the irrigated plain of Triffa (Nnorth-east Morocco). Journal of Agricultural Water Management 95: 133-142.

9.Gaus I, Kinniburgh D.G, Talbot J.C, Webster, R. 2003. Geo-statistical analysis of arsenic concentration in groundwater in Bangladesh using disjunctive kriging. Environmental Geology 44: 939-948.

10.Ghasemi Ziarani A, Faryadi Sh. Sheikh Kazemi sh. 2006. Zoning the contamination in sad karaj catchment using GIS software. First professional symposium of Environment Engineering. Tehran University. Cokkege of techniques.

11.Haddad, M, lindner, K.(2001) sustainable water demand management versus developing new and additional water in the middle east:a critical review.water policy.3,143-163

12.Heidary, M. (2009). Ground water quality in the view point of Drinking, agricultural and industrial uses in Kashan plain. National symposium of sustainable development pasterns in water management.

13.Homayon Nejad E, Amirian P, peiri A, 2009. Evaluation of water quality in well reservoirs in the view point of agriculture and drinking (based on Wilcox and shuler diagrams) in Nime Zabol. Third professional symposium of environmental engineering.

14.Johnston K., Ver Hoef J M., Krivoruchko K. and Lucas N: Using ArcGIS Geostatistical Analyst. ESRI, Redlands, CA.2001.

15.Karimian A, Jafarzade Haghighi N, Afkhami M. 2006. Application of satellite images in monitoring surface water quality. Ninth national symposium of environmental hygiene medical science University of Isfahan pages 2-28.

16.Kathy Pond, 2005, Water Recreation and Disease plausibility of Associated Infections: Acute Effects, Sequelae and Mortality, World Health Organization,

17.Makkasap T, Satapanajaru T. 2010. Spatial Distribution of Cd, Zn and Hg in Groundwat at Rayong Province, Thailand. World Academy of Science, Engineering and Technology 72.

18.Mizyed, N.1996. Water resources in the Middle East:Conflict and solutions. Water peace and the Middle East: Negotiating resources of Jordan River basin. In Tony Allan, Library of Modern Middle East, New York, USA: Tauris Academic Studies.

19.Nas B: Geostatistical Approach to Assessment of Spatial Distribution of Ground water Quality. Polish J. of Environ. Stud. Vol. 18, No. 6 (2009), 1073-1082

20.Nazari zade F, Ershadian B. Zande Vakili k. 2006. Assessment of spatial variation of ground water quality in Balarod plain of Khuzestan province.

21.Siska pp and Kuai Hung I: Assessment of Kriging Accuracy in the GIS Environment. The 21st Annual ESRI International User Conference, San Diego, CA.2001.

22.Taghizadeh Mehrjerdi R, Zareian M, Mahmodi Sh, Heidary A. 2008. Spatial distribution of groundwater quality with geostatistics (Case study: Yazd-Ardakan plain).World Applied Science Journal. 4(1): 9-17.

23.Vijay Kumar and Remadevi. Kriging of Groundwater Levels – A case study. Journal of Spatial Hydrology. 2006.Vol.6,No.1

24.Zamzam A. Rahmani M. 2009. Assessment of chemical quality of Ground waters using Wilcox and shooler diagrams. 2009 first international conference of water resources management.

25.Zehtabian Gh,Asgari M. 2007. Research project of assessment and spatial analysis of qualitative properties of ground waters in Garmsar catchment. Tehran University.