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Evaluation of Chemical Quality and Salinity Origin of Groundwater in a Semi Aried Area; Seyed Gholi Region Saveh, Iran

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Background & Aims of the Study: In recent years, groundwater resources of Seyed Gholi in Saveh area has been deteriorated because of some factors such as unconventional withdrawal in order to agricultural and industrial uses. This study has been conducted to evaluation of chemical quality and salinity origin of groundwater in this region.

Materials & Methods: In order to survey on salinity of water in this region, data from 6 sampling wells (2002-2011) has been used. In first step by collecting valid information about the chemical quality of related aquifer, investigation on fluctuation trends of ions concentrations of Ca, Mg, Na, HCO_3, Cl, SO_4, from 2002 to 2011 has been conducted. Then, pH and EC has been surveyed for ten years (2002-2011) to determine the general chemical quality of region groundwater. Finally, changes trends of ions and water salinity has been plotted on descriptive diagrams, piper, statistical models and other plans.

Results: Results show that the average ion concentrations of sulfate and chloride are 803.52 and 579.72 mg/l, the average amounts of EC and TDS are 3665.70µm/cm & 2152.96 mg/l respectively in the period of 2002-2011. In other words, the average concentrations of sulfate and chloride iones have increased from 750.24 and 619.12 to 890.4 and 635.095 mg/l respectively and also TDS have changed from 2076.69 to 2357 mg/l in the period of 2002-2011.

Conclusion: It has been concluded that descending trend of flow rate and increasing of ion concentration of sulfate and chloride indicated that quality of water in this region is not desirable which will lead to the deterioration of chemical quality of water for various uses. If the current conditions continue, the water will be non- potable.

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Background

Access to safe drinking water is a fundamental human need. Unfortunately, in addition to problems associated with lack of available water quantity, there exist also problems related to contamination of water resources and deterioration of quality of water. Population growth and industrialization and extensive discharge of pollutants associated with them, have deleterious impaction the quality of water resources. Therefore, clean drinking water supply requires a high cost in terms of treatment and improvement of its quality (1).

Unfortunately, most of the literature on groundwater in Iran focuses on the quantitative aspects and little attention is paid on qualitative items (2). Nowadays, investigation of chemical water quality (natural and anthropogenic ions in groundwater) and identification of water salinity by considering qualitative and quantitative aspects are of great importance in order to evaluate the sensitivity and vulnerability of water resources.

By monitoring of water quality trends, it is possible to analyze qualitatively and quantitatively water resources in order to identify adaptation strategies to reduce the vulnerability of water resources and improve the management of water resources for different purposes in such regions in the future (3).

The chemical composition of groundwater resources reflects the influence and interaction of many stressors such as chemical composition of feed water, litho logy, subsurface rocks (geology), hydro geological properties of rocks, human activities which change chemical quality of water and intrusion of seawater into fresh groundwater reserves because of water table fluctuations (4).

It is unarguable that groundwater management is impossible without sufficient knowledge about distribution of saline and fresh groundwater and factors affecting it (5).

Salinity is an environmental problem, which affects other resources in many aspects such as, reduces agricultural production, destroys soil structure, leads to climate change and causes human health problems (6). Investigation of variations in the groundwater quality due to rainfall and the pattern of water distribution in the plains provide the possibility to enforce limitations in term of water withdrawal in areas with increasing trend of salinity. Moreover, in areas with high and enough recharge and with no qualitative water changes, a much higher amount of water allowed to be withdrawn.

Appropriate control on variations of water quality provides a description of the past framework of water quality and predicts long-term trends in groundwater quality in the future.

Pulido Bosch et al. (1992) studied groundwater problems in semiarid areas of Low Anderax River, Almería, in Spain and found that seawater intrusion, dissolution of salty formations in the underlying soils and overexploitation for agricultural purposes all has resulted in the salinization of the majority of water tables (7).

Rezaeei (2011) studied factors controlling salinity of aquifer of Mend plain in Boshehr city, Iran, reported that high dissolution of sulfate containing rocks in Fars area surrounding Mend plain as the main reason for salinity (8). Etesami (1999) surveyed the trends in salt intrusion into groundwater of a plain in north of Kashan and reported that water table has decreased with a mean value of 16 m for the period of 1965–1988.

Moreover, during the same periods, the mean value of EC was 6930µmoh/cm and attributed the problem to the extensive groundwater withdrawal in the area (9). Soleimani (2013) investigated the analysis and trends in chemical parameters of water quality of Chemanjir River, Khorramabad, and using nonparametric Mann-Kendall test and showed that the increasing trend of water salinity in the area, indicating water quality abatement due to the increase of dissolved salts in the river (10). The major ion compositions and ^{13}C values of inorganic carbon in groundwater were used to determine the hydro geochemical processes, and Pearson's correlation analysis (Davis, 2002) was used to evaluate the ion exchange behavior of the major cations. Radiocarbon dating was carried out to estimate the residence time of the brackish groundwater in the confined basal aquifer. This study concerns the impact of sea-level changes during a period of pale o-intrusion on coastal aquifer systems, with an emphasis on naturally-occurring high salinity groundwater (11). Investigation and analysis of ground water status in every area is important in order to know the changes occur in water to prevent water quality deterioration. The mentioned study used available data to study the trends in water salinity fluctuations in water table to predict the possibility of saline water intrusions into groundwater in different locations with time (12).

Aims of the study: The purpose of the present study is to identify and discriminate causes of ground-water salinity of Seyed Gholi area, Saveh, Iran and comprise recommendations for the prevention and decrement of water salinity in the area

Materials & Methods

Seyed Gholi covers a plain of 2189 hectares, situated in Markazi province near Saveh-Hamadan road. The area is located at 50°20'N and 35°6'E, lies between a height of 1140–1260 m above the sea level.

The plain has a general southern gentle slope, and experiences a semiarid climate in south and west, semi tropical in east and north east and south east (13).

Seyed Gholi area is located in Salt lake basin, which is the driest basin in Iran and has many crucial problems because of water scarcity. The basin accounts for 3% of the country resources and more than 30% of Iran population are living in it. The area has vast and good lands suitable for agricultural and industrial developments which water scarcity has limited all these opportunities (14).

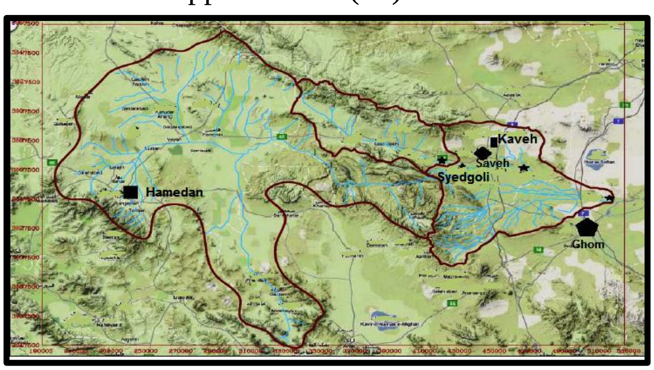

Figure.1) Description of the study area of Seyed Gholi area (13)

This work was a descriptive study. The study population was 48 deep wells located in 25 km away from Saveh-Hamadan road in Seyed Gholi area. Aquifer resources studied in the region are including wells, plains and Qanats. The present study was carried out investigate quantitative and qualitative status of groundwater in the area. The ten years data of the wells were acquired from regional water company in Tehran, water resources management organization and also from regional water company in Markazi province. Moreover, more data were taken by chemical analyses of water quality in the wells of Seyed Gholi area during ten years from 2002-2011.

According to the data derived from the Iran geographical organization, totally 48 wells there exist in the study area which most of them have been abandoned. 11 wells out of the 48 wells were situated in Nobaran area and 37 wells were in Markazi area as is shown in Fig.2 (15).

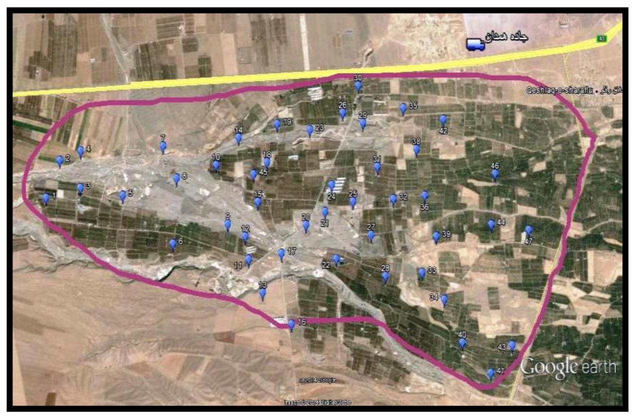

Figure.2) Location map showing wells in Seyed Gholi area

To investigate water salinity and hydro chemical processes affecting on it in Seyed Gholi region, 6 representative wells out of the 48 wells were selected in determined different distances with a percent error less than 5%.

The present study was carried out on ground water quality of Seyed Gholi area, two wells in upland (two wells with higher level of water table), two in middle, and two in lowland were selected (16).

To assure reliable data, the validity of the data was checked and low accuracy ones were neglected. At the beginning, values of statistical parameters such as minimum, maximum and average were calculated. Afterwards, the type of water quality in the areas was described and then different parameters of water quality were investigated.

The annual fluctuations of chemical parameters investigated in the study include total dissolved solids, electrical conductivity, acidity, calcium, magnesium, sodium, carbonate, bicarbonate, sulfate and chloride.

Concentration of cat ions and anions (sulfate and chloride, sodium-potassium and calcium, magnesium and bicarbonate), TDS and pH were measured on the basis of standard method guidelines with spectrometer, flame photometer, titration, conductivity meter and pH meter respectively.

To classify the ground water ability for different purposes, various plots like, Schoeller, Piper and Durov diagrams have been drawn.

Finally, quantitative data were statistically processed by means of AqQA software and finally type of groundwater was identified. The predominant hydro chemical processes affecting water composition in the plain are the area lithology, solubility of salts in water and flow pattern.

Generally, hydro geological facials in the study area were represented by developing Scholler and Piper diagrams (17). Piper diagram was used to make a tentative interpretation as to the origin of the groundwater and to characterize different water types by considering a combination of major anion and cation such as sodium, potassium, magnesium, calcium, sulfate, chloride, carbonate and bicarbonate (18).

Moreover, Schoeller diagram was used to evaluate of water quality and to classify groundwater for drinking, agricultural, industrial and livestock purposes (19).

Results

According to the results of the present study on 48 wells in Seyed Gholi plain between 2002 and 2011, only 12.5% of the wells had EC values in the range of 500-1000 µmoh/cm. Also, 87.5% of the wells had EC values above 1000 µmoh/cm. (Fig.3).

It can be seen from the figure that the highest and lowest levels of EC in the studied wells were 5220 µmoh/cm and 3180 µmoh/cm, respectively. Also, a peculiar observation from Fig.4 reveals an increasing trend of EC levels during 2002-2011 in the six studied wells.

According to the results of the present study on 48 wells in Seyed Gholi plain between 2002 and 2011, only 12.5% of the wells had EC values in the range of 500-1000 µmoh/cm. Also, 87.5 % of the wells had EC values above 1000 µmoh/cm. This can be attributed to relatively bad quality of ground water in the area (Fig.3).

The results summarized in Table 1 show that values of EC and TDS in the wells were 3665.7 µmoh/cm and 215.96 mg/l, respectively during 2002-2011. All the units in the study are given in meq/l, exceptionally for pH, TDS (mg/l) and EC (µmoh/cm).

The trend in water quality changes during 2002-2011 were summarized in Fig.5. The data in the table and figures show that levels of sodium was highest among all cations (calcium, magnesium and potassium). Moreover, among anions (carbonate, bicarbonate and chloride), the level of sulfate was maximum.

Moreover, Table 2 explains the qualitative characteristics of the analyzed samples in the study area. However, as can be seen from the table, the frequencies of sulfate, chloride and sodium (as meq/l) were highest among all cations and anions. The qualitative parameters in Table 2 show that most of the parameters had a meaningful increasing trend. The salinity of the well water also had an increasing trend, indicating deterioration of water quality in Seyed Gholi plain during 2002-2011. The trend in water quality changes during 2002-2011 are summarized in Fig.5.

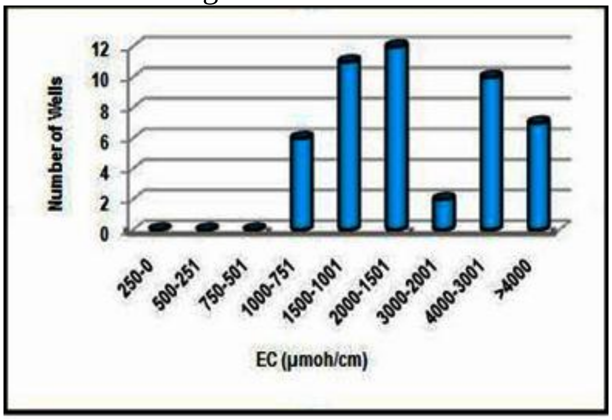

Figure.3) Values of EC in all wells of Seyed Gholi plain between2002-2011

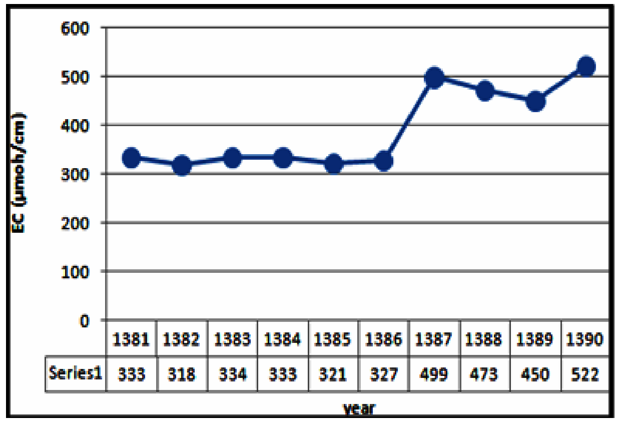

Figure.4) Values of EC in the selected wells of Seyed Gholi area between2002-2011

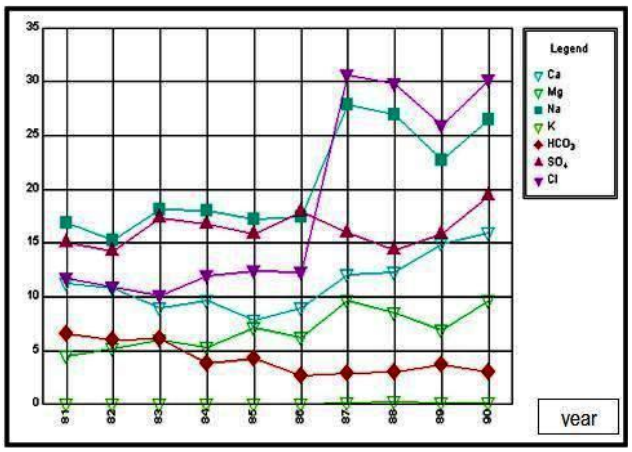

Figure.5) The trend of water quality changes between 2002-2011

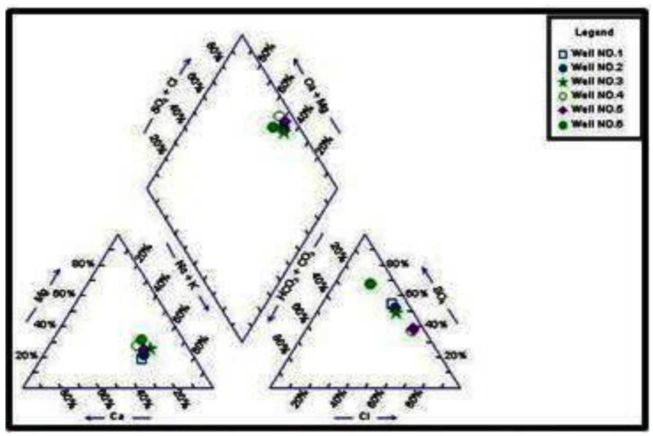

Figure.6) Piper's diagram of wells No. 1-6 adjacent to the study area in 2011

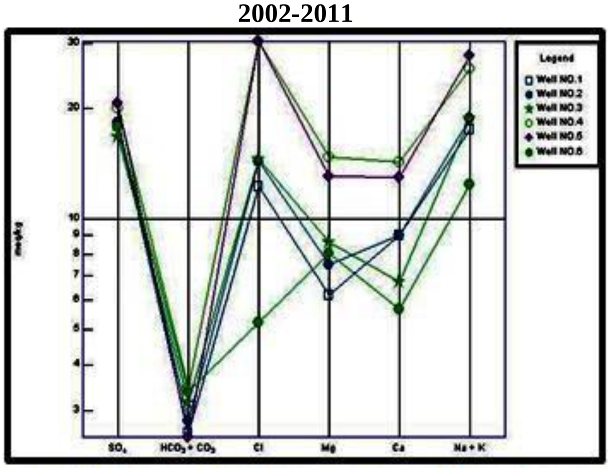

Figure. 7) A Schoeller plot for wells No. 1-6 adjacent to the study area in 2011

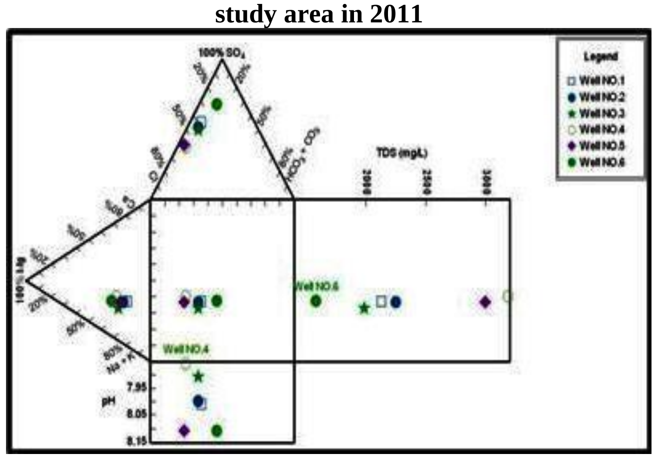

Figure.8) A Durov diagram for wells No. 1-6 adjacent to the study area in 2011

Table 1) The average values of statistical parameters analyzed for water samples during 2002-2011

parameters	TDS(mg/l)	pH	EC	anions and cations (meq/L) Cl	SO_4	HCO_3	Na	Mg	Ca
maximum	3550	8.53	5500	32.32	20.64	6.70	27.90	15.95	15.95
minimum	1090	7.38	2224	4.33	12.18	2.00	9.40	3.46	3.70
average	2152.96	7.93	3665.70	16.33	16.74	3.54	18.62	8.15	9.50

Table.2) The average values of all water quality parameters in selected wells of Seyed Gholi plain during 2002-2011

type of water	TDS (mg/l)	pH	$EC*10^6$	anions Average (meq/l)			Cat ions Average (meq/l)			Y	X	Location
				Cl	SO_4	HCO_3	Na	Mg	Ca			
Na-SO4 Ca-SO4	2014.70	7.88	3264.50	11.27	15.96	5.09	16.67	5.73	9.54	3871778	430294	Well No.1
Na-Cl Na-SO4	2719.77	7.93	4374.00	23.53	17.22	3.13	23.35	8.54	11.70	3870656	430162	Well No.2
Na-SO4 Ca-SO4	1427.91	8.01	2649.70	7.37	15.32	3.53	12.30	5.03	8.57	3871843	428734	Well No.3
Na-Cl Na-SO4	2374.54	7.92	4073.00	19.04	18.34	3.37	22.26	9.56	8.24	3870992	428812	Well No.4
Na-Cl	2929.86	7.75	5186.00	30.15	18.88	2.81	24.86	13.08	13.48	3872008	427639	Well No.5
Na-SO4	1451.00	8.10	2447.00	6.65	14.74	3.28	12.28	6.97	5.45	3871569	427735	Well No.6

The data in the table and figures show that levels of sodium was highest among all cations (calcium, magnesium and potassium). Moreover, among anions (carbonate, bicarbonate and chloride), the level of sulfate was maximum.
The Schoeller diagram is used to study quality parameters for different samples of water. As is evident from Fig.7, values of sulfate and chloride were more than maximum permissible limit in 2011.
Durov diagram provides more information to identify the water types. It can display some possible geochemical processes that could help in understanding quality of groundwater and its evaluation.As seen from Fig.8, TDS value is above the maximum permissible limit (20).

Discussion

The main purpose of the present work was to investigate water quality and trends in water quality changes in the wells using various graphic representations like, Wilcox, Schoeller and Piper diagrams. Evaluation of chemical parameters of the groundwater in Seyed Gholi plain show that most of the qualitative parameters associated with salinity are not in the acceptable range. Graphical presentation of hydro chemical character of water samples show that groundwater quality of water resources in Seyed Gholi plain is really bad due to very high salinity hazard.
This can be attributed to high dissolution rates of evaporate deposits, extensive withdrawal of water from wells for agricultural and industrial purposes (use in Kaveh industrial area), type of formations where recharge occurs, and the presence of Alghadir dam. This can be attributed to relatively bad quality of ground water in the area.
This is consistent with the results reported by several other studies. Mozaffarizadeh, studied the reasons of high salinity and intrusion of salt

water of Dalki and Helleh rivers into Borazjan aquifer. He collected 22 samples from wells in the area and one sample from Helleh River and attributed the high levels of sodium and chloride to the intrusion of salt water of these rivers because of high rates of water withdrawal from the wells, recharge of the plain by these rivers, and also dissolution of salts from geological formations in Gachsaran and Bakhtiari (21).

The results of the present study showed that overexploitation and dissolution of dolomite and gypsum deposits are one of the main causes of high salinity (TDS above 1000 mg/l) of groundwater for the study area, which is consistent with the results reported by Jaberzadeh.

The present study evaluated the ten-year period variations in chemical compositions of water, but in Jaberzadeh study (2012), one year was considered (21).

The data on TDS of groundwater in Seyed Gholi plain showed that the studied wells had TDS values (3665 mg/l) much greater than the standards. Therefore, it hinted out that these samples belong to brackish category (TDS=1000-10000 mg/l). Since most of the wells in the area are used for agriculture purpose, therefore, the disproportionate quality of salts in irrigation water changes the physical and chemical properties of soil for plants and agricultural works consequently restrict plant growth and tumbling the production efficiency.

Greiner also found that high salinity of groundwater could cause problems in agriculture, crop efficiency, and plant growth (22). Yang et al. studied origin of groundwater salinity and hydro geochemical processes in the confined quaternary aquifer of the pearl river delta, China and reported that the aquifer had high levels of TDS (1-26.8 mg/l) which was due to the intrusion of seawater into freshwater because of hydro geochemical processes (23).

The present work demonstrated that the results of water quality variations in Seyed Gholi area with 48 wells, are similar to a study carried out in China (from December 2007 to March 2009) with 40 wells, which both areas showed an increase in TDS values and also in sodium and calcium exchange rates, except for the mean values of pH which were 2 and 7.39, for China and Seyed Gholi area, respectively.

Also in China research, seawater was the major salinity source for groundwater, but in Seyed Gholi area, the close proximity to Alghadir dam was the main reason for high salinity of water. Moreover, EC values showed an increasing trend during these ten years (2002-2011) due to overexploitation, which caused a decrease in the levels of groundwater tables by 18.4m.This causes deterioration of water and soil qualities which consequently endanger sustainable development.

Danaeean also reported that decrease in the levels of groundwater table by 42 m during 50 years in Ardakan plain in Yazd was mainly due to the overexploitation and increase of numbers of drilled wells. In addition, extensive use of groundwater in upland areas have led to the deterioration of water quality in lowland and have caused massive disappearance of pistachio garden, nearby 3000 hectares, in the area (24).

According to Schoeller diagram, all the samples of groundwater were classified in unacceptable category and thus; the water in the area was unsuitable for drinking because of high levels of sulfate (16.74 meq/l) and chloride (16.33 meq/l). But in Seyed Gholi plain, levels of sulfate, sodium and chloride were higher compared to the other salts probably due to the dissolution of gypsum in the area.

A study by Antonellini in Long well plain indicated that hydro-chemical processes due to the dissolution of evaporates including halite and gypsum have caused salinization of groundwater in that area (24). As illustrated in the results, the predominant type of groundwater in the area was sodium-sulfate (Na-SO4) and sodium-chlorine (Na-Cl).

However, from the results, it can be concluded that this continued overexploitation of groundwater in the area results in declining water table and deterioration in water quality, which becomes unsuitable for various purposes.Therefore, its strongly recommended that responsible authorities rapidly enforce management procedures and standards in order to minimize the continuing trend and improve groundwater quality.

Footnotes

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Conflict of Interest:

The authors declare no conflict of interest.

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