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GROUNDWATER IMPACT ASSESSMENT FOR IRRIGATION PURPOSES IN THE VILLAGE OF SHOUIRA, WEST OF TAL AFAR DISTRICT, IRAQ

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ABSTRACT

Groundwater is an important source, especially in the areas lacking surface water as observed in the west of Nineveh Governorate, Iraq. Groundwater extracted from the wells has been extensively used for irrigation in the Shouira village. The study was conducted to examine the quality of groundwater from selected feeder wells, Ten wells were identified for collecting water samples starting from October 2019 to February 2020. The aim is to find out the extent to which such irrigation waters can be used for agricultural purposes by assessing through chemical, biological, and physical parameters. Field measurements such as fecal coliform, pH, EC, as well as laboratory water quality parameters such as Na, MAR, PS, PI, SAR, RSC, KI were chosen for the study. The results indicated that some standards such as EC and PS were higher than standard irrigation specifications. Nevertheless, in applying classifications based on the IWQI mathematical model, the results show that all well water can be considered suitable for irrigation, ranging from good to excellent. This is because most of the parameters considered were identical to standard irrigation specifications and thus well water did not need treatment. The improvement in water quality for most of the studied parameters is due to not exceeding the permissible limits.

KEY WORDS : IWQI, Water quality, MAR, Irrigation, Well, PS

INTRODUCTION

Water is a major focus of agriculture, and the Al-Jazeera region in Nineveh Governorate suffers from a shortage of freshwater resources due to its geographical location within the dry and semi-dry area and limited rainfall, as well as the steady increase in population growth and the pursuit of agricultural land use. consequently, it became necessary to study the groundwater of the Al-Jazeera region, which is one of the proposed solutions to develop and rationalize the use of well water as an economically feasible production resource, less than half of the previously estimated 45 billion m^3 of surface water (Tigris and Euphrates) reaches Iraq, representing 42% of the water requirement for existing agricultural projects, Iraq is therefore suffering from a significant shortage of irrigation water and on this basis, concerns have been directed towards the use of alternative freshwater resources for horizontal agricultural expansion to ensure food security (Al-Mashhadany, 2019). Estimate the amount of groundwater used in different areas in Iraq is estimated at 2.4 million cubic meters per year. Thus, according to this context, this research aims to analyze the water of some of the wells and demonstrate their irrigation viability in the light of Iraqi and global specifications (Al-Mashhadany, 2021a).

Attention to water quality for irrigation depends on several basic factors, which differ greatly in terms of the amount of salts and their chemical composition as a result of the melting of gypsum and limestone rocks. Groundwater is generally richer in mineral content than surface water its great ability to dissolve various minerals, their chemical composition depends on the type of rock they pass through (El Baba *et al.,* 2020). Groundwater contains different chemical elements, the most important of which are ions that combine with some mineral elements to form melting salts. The proportion of these mineral elements determines the quality of groundwater's different uses (Al-Saffawi and Talat, 2019; Khatri, 2020).

The term waters quality means water quality assessment and concentration of water components, then compare the results of this concentration with the purpose for which this water will be used, for example, distilled water is one of the best forms of water (Shivhare *et al.,* 2020). However, it is not suitable for all organisms and their environment, hence, it is not possible to measure the quality without specifying the purposes used. Water used in homes for drinking and food preparation is different from that used to fish culture water, or used to irrigate plants, while marine and ocean waters are of high quality for many fish species, but it's not suitable for other organisms, including humans (Nag, and Das, 2014). Using the water quality model (IWQI) to evaluate the irrigation water quality is one of the most effective means to determine water pollution, which reflects the interaction of irrigation water components of several factors. Permeability damage, ionic toxicity, salinity, and so on

MATERIALS AND METHODS

The chemical composition of well water depends on precipitation, leaking water into the underground reservoir, the nature of the soil and rocks, and the velocity with which this water flows in the underground reservoir. As the chemical structure determines the possibility of water being used for irrigation, knowledge of the chemical properties of well water and the changes in it resulting from water use or the fluctuation of water feed sources will help us determine the best way to use water (Alfji and Swaid, 2016). The research was based on the results of the analysis of 50 groundwater samples taken from 10 wells used for irrigation at the rate of a sample per well for five months. Fig. 1 shows the distribution of wells in the study area and outside the village in the agricultural area and table 1 shows the coordinates and altitude above sea level for the wells of the village of shouira (Al-Mashhadany, 2021b).

The Water samples were measured, including pH, EC_{25}, F.C (F. colif) (APHA, 1998; 2017), as well as the calculation of the percentage of sodium (Na%), sodium adsorption (SAR), magnesium adsorption (MAR), residual sodium carbonate (RSC), and Kelly's guide (Kelly) permeability index (PI) and potential salinity (PS), Which is calculated based on the equations below (Bhat *et al.,* 2018):

$$Na\% = \frac{Na}{Na + K + Ca + Mg} \times 100$$

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

$$MAR = \frac{Mg}{Ca + Mg} \times 100$$

$$RSC = (CO_3 + HCO_3) - (Ca + Mg)$$

$$KI = \frac{Na}{Ca + Mg}$$

$$PI = [Na + (\sqrt{HCO_3})/Ca+Mg+Na] \times 100$$

$$PS = Cl + 1/2SO_4$$

Water quality index

The IWQI mathematical model was used to assess the quality of water studied for irrigation in the study area, applied to 10 parameters (pH, EC_{25}, PC,

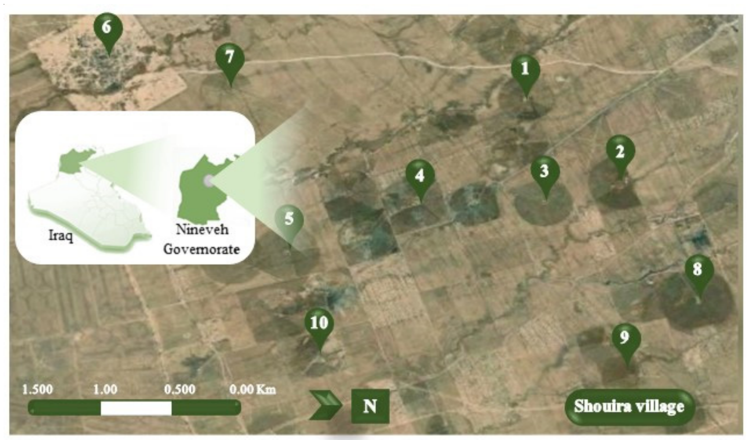

Fig. 1. Well locations in the study area

Na%, SAR, MAR, RSC, KI, PI, PS) (Moghimi, 2016), and simply calculated the following equations:

1. Finding the value of the proportionality constant A of the following equation:

$$A = 1/\sum_{i=0}^{n}\frac{1}{S.EC}+\frac{1}{PI}+\cdots..\text{etc.}$$

2. calculate Rn values for the attributes of the following equation:

$$Rn = A/Sn$$

Rn = unit weight per property
A = proportionality constant
Sn = Allowed standard concentration

3. calculation of Zn values for adjectives from the following law:

$$Zn = 100 \times [Vn - Vi]/[Si - Vi]$$

Zn = Sub-Index
Vn = measured value
Vi = ideal value

Table 2 below shows the standard specifications and (Rn) for the parameters (Jaafer and AL-Saffawi, 2020).

Table 1. Coordinates and altitude of the wells shouira village

Well No.	E	N	Altitude (m)
1	42p2328622	36p2826222	323
2	42p2520422	36p2923322	311
3	42p2522422	36p2827422	305
4	42p2322622	36p2826622	306
5	42p2529422	36p2525722	312
6	42p2720122	36p2520122	315
7	42p2428022	36p2520822	312
8	42p2425922	36p3120722	311
9	42p2625022	36p2825922	319
10	42p2623122	36p2728022	304

Table 2. Standard limits (Si) and relative weight values (Rn)for measured irrigation parameters

Parameters	Standard limit (Si)	Values of (Rn)
pH	6.5-8	0.062125
Ec	2.0	0.217436
Na%	60	0.007248
MAR	50	0.008697
KI	1	0.434873
PS	10	0.043487
SAR	18	0.02416
PI	75	0.005798
RCS	2.25	0.193277
FC	150	0.002899
	Σ	1.0

4. calculate the value of the IWQI for irrigation from the following equation:

$$IWQI = \frac{\sum Zn \times Rn}{\sum Rn}$$

Finally, the IWQI result is compared with the classification Table 3 to see the water class (Ewaid and Ali Abe, 2017).

Table 3. Water quality index values and water quality status

Dsecription	IWQI
Excellent	0 – 25
Good	26 – 50
Poor	51 – 75
Very poor	76 – 100
Unfit for Irrigation	> 100

RESULTS AND DISCUSSION

In many countries, groundwater is essential for people's livelihood and health, because they are usually the main source of domestic water, they are also widely used in irrigated agriculture, especially in arid areas, where surface water is scarce in the study area with a scattered population spread. Climate change is expected to lead to greater reliance on groundwater as a means of drought relief and to determine the availability of surface water (Al-Youzbakey and Eclimes, 2018; Yakubu and Omar, 2019). The pH value of the wells is between (7 – 8.2) and SD± (0.0 – 0.4), this parameter criterion plays an important role in determining the acidification and base of the water reaction when presenting the result means shown in Fig. 2 to the classification adopted in the Table 4, they determined the range between (6.5 – 8) It is suitable for agricultural use, and there is no problem with irrigation (Jaafer and AL-Saffawi, 2020).

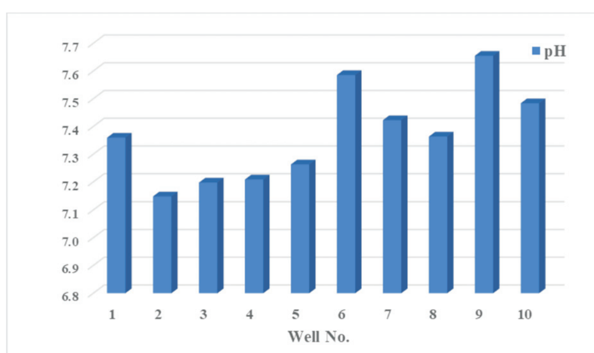

Fig. 2. Mean values of pH for the studied water sources

The EC_{25} of water gives an idea of the level of ion concentration and salinity. The higher the conductivity, we expect an increase in ion concentration and salinity, this is because electrical conductivity occurs as a result of the presence of ions capable of carrying an electric current, through the results we have obtained that most of the samples are higher than the standard specifications (Yang *et al.,* 2020), which ranged between (1.63 – 3.49) ds. m^{-1}. An important parameter is to estimate the percentage of sodium dissolved in the water Na% because it assesses the risks of sodium to the soil and the plantings. So irrigation water above 60 percent means sodium accumulation, which destroys the natural properties of the soil in a short time (Yetiº *et al.,* 2019), It ranged between (8.7% - 30.9%) and SD ± (1.2 - 6.9), and through the results we obtained, all samples of the groundwater within the standard specifications. The SAR value of high sodium adsorption in groundwater destroys the natural structure of soil particles, and the soil becomes solid when it is dry and impervious. Highly water-soluble salts do not enable plants to have the ground moisture to grow, Despite the availability of water, Water movements within the soil are poor and crop roots are unable to obtain sufficient water even if they are available in large quantities on the soil surface. Fig. 5 shows that the values have not exceeded the 5 and are thus within the standards for irrigation water. This is because the RSC of all well water samples is lower than 35.2 (Table 4). High concentrations lead to a combination of calcium and magnesium, forming coherent salt sheets that settle in the soil, leading to an increase in SAR (Zhu, 2019).

The results in Table 4 and Fig. 4 show a higher

Table 4. Chemical and bacterial results of groundwater (maq. l^{-1})

		Well No.									
Param.		1	2	3	4	5	6	7	8	9	10
pH	Min	7.2	7.0	7.0	7.1	7.2	7.3	7.2	7.1	7.1	7.1
	Max	7.7	7.3	7.4	7.4	7.3	8.2	7.6	7.6	8.1	7.9
	SD±	0.2	0.1	0.1	0.1	0.0	0.4	0.2	0.2	0.4	0.3
EC_{25}*	Min	2.19	2.49	2.65	1.63	2.58	2.77	2.91	2.62	2.63	2.08
	Max	2.33	2.53	3.49	3.08	3.11	2.98	3.03	2.72	3.02	2.18
	SD±	0.05	0.02	0.34	0.53	0.22	0.08	0.05	0.04	0.15	0.04
Na%	Min	8.7	12.7	16.3	16.2	15.1	13.4	9.9	15.3	10.7	9.0
	Max	15.2	16.5	19.7	20.4	30.9	23.9	22.7	23.9	20.7	19.7
	SD±	2.4	1.5	1.2	1.7	6.9	4.1	5.3	3.5	4.0	4.1
MAR	Min	21.9	21.3	32.2	44.4	34.5	27.8	26.7	19.2	36.8	27.9
	Max	37.3	42.5	46.9	58.2	45.5	52.2	49.7	52.4	56.0	35.7
	SD±	5.8	8.1	5.4	5.6	4.0	8.9	8.8	12.3	8.4	2.9
KI	Min	0.10	0.15	0.20	0.20	0.18	0.16	0.11	0.18	0.12	0.10
	Max	0.18	0.20	0.25	0.26	0.45	0.31	0.29	0.32	0.26	0.25
	SD±	0.03	0.02	0.02	0.03	0.12	0.06	0.08	0.05	0.06	0.06
PS	Min	25.9	19.2	23.3	29.7	28.5	31.8	30.3	30.8	32.0	20.3
	Max	51.9	54.3	47.7	59.4	47.1	80.9	69.5	55.1	55.3	36.8
	SD±	9.9	12.6	8.8	11.1	7.3	20.7	15.7	9.6	10.1	7.0
SAR	Min	0.88	1.43	2.00	2.00	1.78	1.45	1.22	1.82	1.17	0.95
	Max	1.58	1.95	2.44	3.18	4.22	3.18	3.04	3.29	2.83	2.29
	SD±	0.26	0.22	0.18	0.50	1.05	0.69	0.79	0.56	0.63	0.52
PI	Min	12.0	17.4	20.9	19.8	17.8	18.1	12.7	19.6	14.2	13.4
	Max	19.4	20.9	24.5	23.5	34.7	27.7	26.2	26.7	23.4	23.3
	SD±	2.9	1.5	1.4	1.5	7.1	3.7	5.5	3.0	3.6	3.7
RSC	Min	-40	-42.8	-48.4	-68	-47.6	-61.2	-57.6	-50.8	-63.6	-41.2
	Max	-35.2	-37.6	-40.4	-41.2	-38.4	-38	-40	-36.8	-39.6	-36.4
	SD±	2.63	2.24	3.51	10.74	3.75	8.61	6.24	5.86	9.51	1.87
FC.**	Min	0	0	0	0	0	0	0	0	0	0
	Max	15	3	43	243	4	23	460	23	460	0
	SD±	6.7	1.3	18.7	105.6	1.8	10.3	198.0	11.2	204.0	0.0

*ds. m^{-1}. ** $x10^3$ cell. ml^{-1}

concentration of PS than Standard Specifications, ranging from (19.2 to 80.9). As a result of the high concentration of sulfate ions in all well water studied, as noted in its study to assess the groundwater quality of the village of shouira, this will salt the soil irrigated by these sources and negatively affect plants, such as burns to the leaf edges and thus affect plant productivity. The sources of sulfate in soil are sulfide oxidation from natural rock (Pyrite), decomposition of organic sulfide, and reduction of sulfate by anaerobic bacteria (Al-Mashhadany, 2021a).

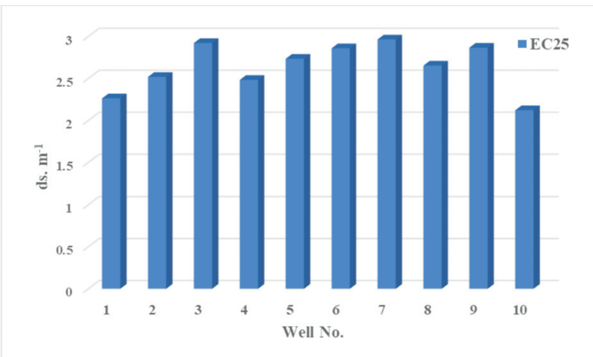

Fig. 3. Mean values of EC_{25} for the studied water sources

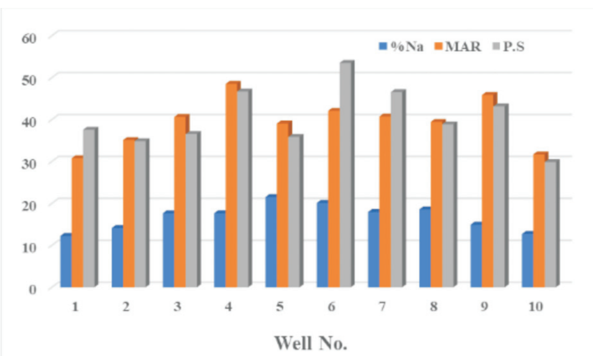

Fig. 4. Mean values of %Na, MAR, and P.Sfor the studied water sources

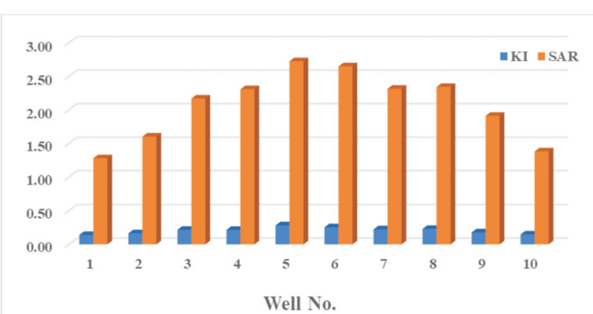

Fig. 5. Mean values of KI, and SAR for the studied water sources

The use of groundwater for irrigation, which has high accumulations of dissolved total salts and which vary in the quantity and quality of the ions involved in their composition, although all ions in irrigation water affect soil properties, the concentration of sodium is the most important. The use of irrigation water with a relatively high sodium content increases the percentage of sodium exchanged in soil and this is an indicator of the sodium problem caused by the use of poor quality irrigation water. Sodium makes clay particles and humus particles less than 0.002 mm in diameter float on the soil surface to plug the pores and this causes poor water movement within the soil,the plant cannot absorb enough water (Zhou, 2020; Al-Mashhadany, 2021c). KI and PI varied between (0.1-0.45), (12.0-34.7) and SD ± (0.02-0.12) and (1.4-7.1), respectively, It was within the standard specifications for irrigation due to low sodium concentration compared to the concentration of calcium and magnesium,as for MAR, 10% of the values were higher than the standard allowed for irrigation, But all their means were within the standards. Magnesium is one of the necessary parameters for irrigation water because magnesium ions play a prominent role in cell division and photosynthesis and contribute to the growth of vegetative parts and roots and increase the size of fruits in plants, but its rise has damaged the soil and plant (Bayan *et al.,* 2021; Gabr *et al.,* 2020).

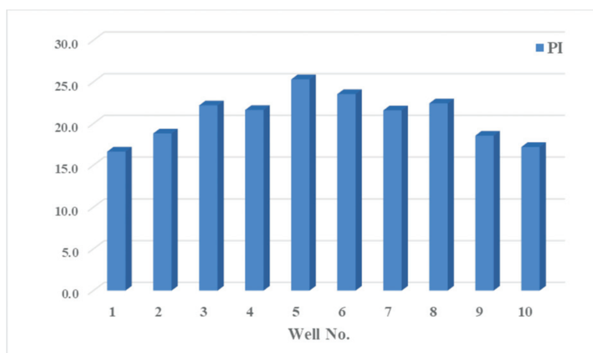

Fig. 6. Mean values of PI for the studied water sources

The main objective of the FC measurement is to see if water sources contain fecal microbes in well water, their presence is an indication of the likelihood of a pathological bacterium in the water, it also gives the impression of wastewater or animal FC (as FC is naturally present in the intestines of humans and animals) and contaminated as a result of grazing on that land, all cases the water must be disinfected before irrigation, otherwise, it may be transmitted to humans in some way, the results showed that there was microbial contamination, including fecal coliform. The cause of the difference in the numbers of bacteria in well water is after or near sources of pollutionparameters (Jaafer and AL-Saffawi, 2020). As shown in Table 1, which ranged from (0 - 460) cell. $ml^{-1}x10^3$. Fig. 7 shows that all means we're less than 150 cell. $ml^{-1}x10^3$ that is, it is within the irrigation standards.

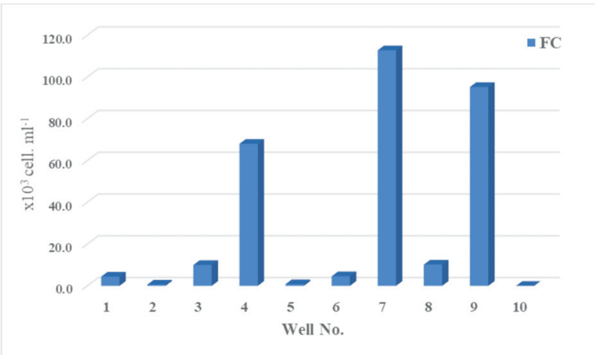

Fig. 7. Mean values of FC for the studied water sources

Irrigation water was evaluated by applying the IWQI model to the parameters shown in Table 3, and the water quality for each well was classified according to the table (Khalid, 2019; Al-Ridah *et al.*, 2020). For irrigation, which ranged from from. (18 to 50). This is because most of the irrigation standards do not exceed the permissible standard limits, which leads to a low Zn for these standards which will favorably reflect the IWQI values as shown in Table 5.

CONCLUSION

The water studied was characterized by its relatively high level by some studied parameters, including PS and EC_{25}, this is due to the high content of calcium, magnesium, and sulfate ions, the water was within the limits allowed for irrigation because all IWQI model values were between good and excellent quality irrigation. Therefore, we recommend that mathematical models such as the IWQImodel be used for periodic testing to help water officials and decision-makers take appropriate groundwater quality actions.

Table 5. Weight value (Rn and Zn) per parameter and water quality index (IWQI)

		Well No.									
		1	2	3	4	5	6	7	8	9	10
pH	Zn	48.42	65.52	36.40	42.30	58.60	26.36	20.92	19.82	14.82	36.00
	Zn×Rn	3.01	4.07	2.26	2.63	3.64	1.64	1.30	1.23	0.92	2.24
Ec	Zn	11.82	86.24	65.00	96.06	85.60	73.14	47.98	91.84	51.50	25.98
	Zn×Rn	2.57	18.75	14.13	20.89	18.61	15.90	10.43	19.97	11.20	5.65
Na%	Zn	5.45	9.91	17.17	15.95	20.27	23.09	15.38	15.37	8.28	4.54
	Zn×Rn	0.04	0.07	0.12	0.12	0.15	0.17	0.11	0.11	0.06	0.03
MAR	Zn	5.73	52.94	31.57	35.85	40.38	30.27	61.77	35.48	17.11	2.71
	Zn×Rn	0.05	0.46	0.27	0.31	0.35	0.26	0.54	0.31	0.15	0.02
KI	Zn	1.90	5.03	10.43	9.75	12.96	15.90	8.96	9.03	3.72	1.15
	Zn×Rn	0.83	2.19	4.54	4.24	5.64	6.91	3.90	3.93	1.62	0.50
PS	Zn	273	395	356	426	490	328	428	335	319	344
	Zn×Rn	11.88	17.18	15.48	18.54	21.32	14.27	18.60	14.55	13.87	14.97
SAR	Zn	2.25	5.37	7.90	7.74	9.71	10.16	7.71	6.89	3.55	1.65
	Zn×Rn	0.05	0.13	0.19	0.19	0.23	0.25	0.19	0.17	0.09	0.04
PI	Zn	3.67	5.94	12.40	11.00	14.25	17.21	11.08	11.99	6.38	2.75
	Zn×Rn	0.02	0.03	0.07	0.06	0.08	0.10	0.06	0.07	0.04	0.02
RCS	Zn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Zn×Rn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FC	Zn	3.95	1.14	0.20	81.27	13.58	1.14	5.15	72.04	0.60	3.28
	Zn×Rn	0.01	0.00	0.00	0.24	0.04	0.00	0.01	0.21	0.00	0.01
	Zn × Rn	18.46	42.89	37.07	47.21	50.07	39.51	35.15	40.54	27.94	23.47
	IWQI	18	43	37	47	50	40	35	41	28	23
	Excel. Wat. quality	good	good	good	good	good	good	good	good	Excel.	

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Conflict of interest

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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