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Research Article

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ABSTRACT

In this study a total of 209 well water samples analyzed after well drilling (construction routine analysis, CRA) and a total of 121 well water samples analyzed by the current study (CS) were used to investigate the distribution of TDS and its effect by long-term pumping of groundwater. Results indicated that the majority of TDS levels (<250 mg/l) are dominant in the southern part of the study area and the levels between 500 and 750 mg/l are dominant in the central part, whereas the levels (>750 mg/l) characterized the northern part of the study area. The TDS levels increase progressively from the southern towards the northern periphery of the study area along the recharge flow direction from the Blue Nile. Trend-comparison between the CRA and the CS data indicated that the TDS levels are continuously decreasing during withdrawal-time in accord with the daily pumping rate and aquifer geochemical formation type.

Key terms: recharge, assessment, groundwater, water quality, Blue Nile.

INTRODUCTION

A total dissolved solid is a term used to describe the inorganic salts and small amounts of organic matter (WHO, 1997). Yasir (2004) reported that TDS concentrations in the study area ranged between 20 and 3290 mg/l while in some villages located to the extreme northwestern boundary of the study area, the TDS levels were found to range between 1088 and 1952 mg/l (Abdel-Magid *et al.,* 1984).

Groundwater of low TDS, 10 mg/l TDS, has been found in the sediments where chemical composition is predominated by quartz with small amount of clay minerals (Zhou *et al.,* 2007). It has been reported that groundwater form a very large reservoir of hyper-saline subsurface brine in aquifers of subsurface gypsum precipitation (Harrington *et al*., 2008). It has been reported that groundwater salinity is highly affected by the local hydrogeological conditions and the intensive evaporation of effluent surface irrigation water that led to the precipitation of evaporites, e.g. calcite, dolomite, and gypsum, especially affecting the groundwater at shallow depth (Ali, 2005). However, another factor affecting groundwater quality is the chemical makeup of minerals. Some chemicals are more soluble than others, making them more likely to become dissolved in water. For example, groundwater in contact with sediments containing large concentrations of sodium, sulfate and chloride will become salinized at a faster rate than if other less soluble chemicals were present (Harrington *et al.,* 2008).

Groundwater of high salinity usually occurs, in some arid areas, in shallow phreatic aquifers, in confined systems, owing to dissolution of evaporites (evaporatic precipitates). The differences in groundwater quality are related to the well depth (Joseph and Lonna, 1999). Shallow groundwater in ephemeral rivers in some arid regions, display high seasonal TDS and major ion variation, high salinity caused by the evaporation of the recharge waters and dissolution of evaporites (Shanyengana *et al*., 2004). High salinity groundwater is found in deeper aquifers that are adjacent to seawater due to invasion of seawater into the aquifers, which have direct contact with it (Fouad and Shaaban, 2001). It has been found that there is a positive relation between depth to water table and TDS (Subba, 2008). Deep groundwater in fractured crystalline basement has been reported from deep mines and from scientific deep wells (Stober and Bucher, 2002).

The potential movement of groundwater mixes different types of waters. The intersect between the high-and-low TDS end-members are generally observed in areas of high discharge or in an area adjacent to seawater, due to replacement control activities. The salinity is a result of cross-formational flow underling evaporite units; increased salinity is attributed to natural cross-formational discharge along distinct flow paths as influenced by topography (Mehta *et al.,* 2000).

Agricultural chemicals dissolved in irrigation water vary in their potential for moving down into the groundwater. Three major characteristics influence the movement of groundwater contaminants:

1) Chemicals solubility, which varies greatly among chemicals and it plays an important role in the movement of groundwater contaminants; the greater the water solubility, the more potential for movement of the contaminant to groundwater.

2) Soil adsorption also plays a major role in groundwater contaminants movement; some chemicals are tightly attached “strongly adsorbed” to soil particles and do not move in the soil while some are not so strongly adsorbed, and are more likely to move.

3) Persistence of groundwater contaminants to breakdown plays a major role in their movement down into the groundwater; the more persistent chemical contaminants are more likely to reach groundwater over an extended period of time (AFBF, 2008).

Soil characteristics are important in the movement of groundwater contaminants into the soil. Three major soil characteristics affect groundwater contaminants movement; namely:

1) Soil texture, to large degree, affects seeping down of groundwater contaminants; coarse sandy soils, generally, allow water to move rapidly downward and offer few opportunities for adsorption whereas finer textured soils, generally, allow water to move at much slower rates retarding seeping down of the groundwater contaminants. 2) Soil permeability also affects movement of groundwater contaminants; the more permeable soils allow water to move rapidly through soil pores.

3) Soil organic matter content is another factor affecting movement of groundwater contaminants; increasing soil organic matter increase the water-holding capacity of the soil and eventually obstructs moving down of the groundwater contaminants (AFBF, 2008)

Geology of soil formation controls the occurrence and movement of groundwater and, therefore, has an important effect on groundwater quality. Different types of rocks have different magnitudes of permeability, which affects seeping downward of the contaminant (AFBF, 2008).

Water in recharge areas (high areas) has a low level of mineralization and discharge areas are low areas where groundwater flows eventually and makes its way back to (or near) the ground surface. Groundwater found in such areas can be extremely high in minerals such as sodium, sulfate and chlorides (Mehta *et al.,* 2000). Abundant recharge from low TDS precipitation and longtime dissolution of the unconsolidated sediments containing small amount of soluble compositions lead to low TDS of the groundwater (Ali, 2005). High TDS value, 30000 mg/l, has been found in a confined aquifer with low recharge, in areas with spillage and improper disposal of saline produced water from oil wells (Herkelrath *et al.,* 2007). The increase of groundwater discharge increases groundwater salinity (Munday and Andrew, 2008).

Total dissolved solids of groundwater decrease at the beginning of the rainy season, and are characterized by an increase after the rainy season (Shanyengana *et al.,* 2004). It has been found that the groundwater type is affected seasonally; the concentration of Ca^{+2} and HCO_3^- vary according to season, calcium carbonate is precipitated during the summer and early autumn when evaporation is most intensive. In upper and lower water layers the concentrations of conservative ions such as Na^+, Cl^-, and K^+ decrease in winter and increase in summer, indicating dilution by winter rain and concentration via evaporation in the summer. Evaporation and evapotranspiration in arid and semi-arid areas cause accumulation of salts in the soil-weathered zone. These salts reach the water table by leaching through infiltrating recharge water (Subba, 2008).

Salinity increases from catchment divides to the valley floors and the direction of groundwater flow. Saline groundwater flows along the beds of the streams and is accumulated in paleochanels, which act as a salt depository (Ramsis *et al.,* 1999).

The drought and heavy exploitation in most coastal aquifers are the main reasons for the saline upcoming problem in the aquifer (Nassereddin and Mimi, 2005). High TDS concentration is observed in groundwater within aquifers that are adjacent to seawater due to invasion of seawater into the aquifers, which have direct contacts with it

(Fouad and Shaaban, 2001). The over exploitation of coastal aquifers for agricultural and drinking purposes, along with structural and climatic circumstances, increases the possibility of seawater intrusion (Ramkumar *et al.,* 2010). The usage of fresh water in the industrial sector has been immense, often leading to large volumes of contaminated wastewater to be disposed of. In many instances, the predominant contaminant is salt. Flowing through these soils leaches out the salt, threatening fresh water resources (Humphries and Michael, 2004).

In spite of the importance of the study area for agriculture and livestock, and due to farness from the capital of the country or may be due to shortage in financial facilities or both reasons, the study area has been overlooked and has relatively received few and scattered studies. Periodical analysis for drinking water wells is very important; therefore, this study is conducted to investigate the following objectives:

1. To compare between the current analyses conducted by this study with the routine chemical analysis that usually done after well drilling.
2. To locate areas where salinity is high in order to encourage population groups in the study area to reside in areas where groundwater is of an acceptable quality.
3. To compare the results obtained (both CA and CS) with the local, regional and international standards and guidelines.

Location and Topography of the Study Area

The study area is confined by longitudes 32 45` and 33 45` E, and latitudes 14 15`and 16 00 N, and is located to the east of the Blue Nile River and its tributary the Al-Rahad River. It is bounded from the east by upstanding Basement Complex rocks. The slope of the study area is from the northeastern side towards the southwestern one, where the Blue Nile River is situated. The study area contains many 'Khors' and 'Wadies' which drain into the Blue Nile River during the rainy season. It is divided, administratively, into three regions as follows:

1. The whole area of the Locality of East of Gezira, Gezira State.
2. The area of the Western Administrative Unit of the Locality of Umelghura, Gezira State.
3. The area of the eastern part of Sharkelneel Locality, which comprises Umdawanban, Wadabsalih and Abu-Deleig administrative units, Khartoum State.

Climatic and Geology Characteristics of the Study Area

According to Oliver (1965), the study area is located within the northern part of the poor savannah belt through a region of semi-desert that is characterized by a short humid rainy season, hot summer and dry winter. Temperature is generally high and reaches its maximum during the hot season, April to June, when the dry hot north wind is dominant. The mean maximum temperature reaches its maximum in April and May. Temperature decreases in winter, November to February, and reaches its minimum in December. Rainfall is associated with the northward and southward movement of the inter-tropical convergence zone (ITCZ). In July and August the ITCZ is situated near its northern limit in the Atbara area (16 43N, 34 00E). South of the ITCZ cool moist air, probably derived from the Indian Ocean and from the South Atlantic Ocean, prevails but dry air prevails north of it. The area is characterized by a short wet season in mid-summer and a long dry season throughout the rest of the year. The mean relative humidity varies from a minimum of 16% in winter (April) to a maximum of 60% during the rainy season (August). A secondary peak also occurs in December, the coolest month of the year. The open nature of the area and free movement of the air accelerate evaporation. The mean relative humidity varies from a minimum of 25% in April to a maximum of 65%, 74% and 72% during the rainy season (June, August and September), respectively.

The geology of Al-Butana consists of the Basement Complex in the middle and to the southeast; Nubian Formation in the west and south, the central region is a Basement Complex with flat surface; with only a few rocky hills breaking the monotony of the plain. The central part is clay plain with numerous water courses. Most of these watercourses form their own deltas and do not drain into nearby rivers. At the deltas of these watercourses or 'Khors' the people normally cultivate sorghum crops (Elhassan, 1981).

Soil and Vegetation Characteristics of the Study Area

The variation in the rainfall, together with variations in relief, drainage and parent materials produce clear local differences in soil of the study area. The top soil is mid-brown gray friable clay with round quartz pebbles and stone fragments. The cracks are not wide but medium in size and are more abundant in the soil under grass. The soil is a medium to fine textured tight clay, sandy clay or silty clay which contains more than 40% expanding clay. Recent alluvium provides bases for productive agriculture in the narrow Nile Valley and elsewhere soils are sandy with little agricultural potential (Khalil, 1986; FAO, 1995; FNC, 1995). In general, the description of the dense vegetation life in the past, and partially scattered in recent decades, can be summarized as follows: *(Acacia mellifera)* 'Kittir', (*Acacia Seyal*) 'Taleh', (*Acacia nubica)* 'Lota', (*Faidherbia albida)* 'Haraz', (*Acacia tortilis*) 'Seyal', (*Acacia nilotica*) 'Sunt', (*Balanites aegyptiaca)* 'Hegleig' and (*Cymbopogon proximus*) 'Maharaib' (Harrison, 1955).

Economic Activities and Population in the Study Area

In past centuries, agricultural activities were limited and confined to small areas nearby the Blue Nile River. In rainy season, far from the river, some of the inhabitants used to rare animals and grow durra for their own supply and subsequently, communities have been established. In recent decades, agricultural schemes were introduced and the communities being enlarged.

According to the 1993 census, the population is about 69827 people in all parts of the study area. In the last census (2008), the population has increased to 414437 (33% per year). As a result, there has been a great increase in demand for drinking groundwater. The expansion of population in the study area depends very much on the availability of adequate palatable and safe supplies of drinking groundwater.

Water Supply in the Study Area

In the past, the communities in the study area were having their own water supplies from hand-dug wells. The depth to groundwater varies from one well to another according to the distance from the Blue Nile. The depth to groundwater increases with distance from the Blue Nile River, until it entirely disappears in the extreme north of the study area, where pools 'Hafirs' are constructed to solve the problem of lack of groundwater. Deep boreholes are introduced in the study area during the 1960^{th} of the past century and spread throughout the study area for few years later. Groundwater availability is greatly dependent on both of the distance of the Blue Nile and the hydrogeological characteristics of the aquifers (Abdellah*,* 2011).

Samples and Data Collection

A total of 121 groundwater samples were collected from different boreholes of various communities using 250 ml plastic bottles, each bottle was rinsed with the targeted water 3-4 times before filling. Samples were collected directly from the outlet points of the well, where and when possible. In boreholes without outlet point, samples were collected from reservoirs or from the nearest water-tap to the groundwater source.

Mapping and Statistical Analyses of Data

The spatial data of TDS levels have been analyzed using geographic information system (GIS) software (Arc View). Basic statistics program (Microsoft Excel Spreadsheet) was used to prepare graphs and to calculate mean, range and standard deviation of the obtained data. The CRA data were obtained from the Information Center archives of Groundwater Directorate.

Chemical Analyses of TDS Concentration

The electric conductivity (EC) (dS/m at 25°C) in groundwater samples was measured by Beckman Solu Bridge type equipment. To convert the EC readings to TDS, the results for the EC dS/m were multiplied by 640 according to Rhoades (1982).

RESULTS AND DISCUSSION

The original data gathered for the TDS levels in the study area were entered into a database and handled in a GIS program (Figure 1).

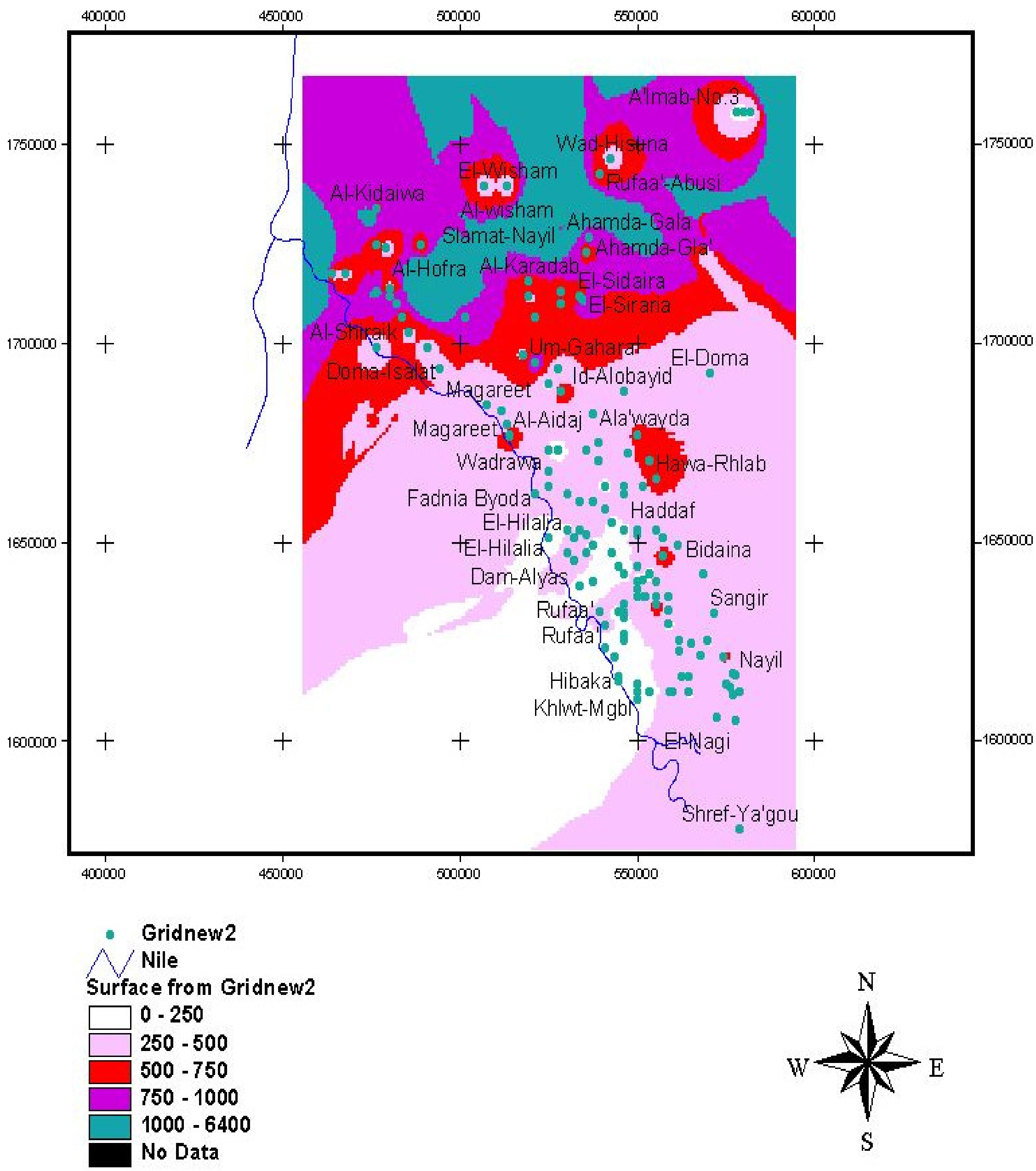

Figure (2): Distribution of TDS in the study area, East of Blue Nile Communities of Sudan.

The GIS map revealed that the levels below 250 mg TDS/l in the groundwater of the study area are, generally, found in limited aquifers in the southern part of the study area extending from Abu-Haraz (where River Rahad joined the Blue Nile) to El-Hilalia at the bank of the Blue Nile. TDS levels ranging between 250 and 500 mg/l dominate the southern part of the study area. In spite of being far from the Blue Nile, a spot area located in the extreme northeastern part of the study area has low TDS levels (0 – 250 mg/l). There are some small pockets with relatively high groundwater salinity (ranging between 500 and 750 mg/l) in the central part of the study area. Generally, high TDS levels increase progressively from the southern towards the northern periphery of the study area along the recharge flow direction from the Blue Nile, thus indicating that the flow of groundwater-recharge, which seeps from the Blue Nile towards the north direction, dissolves and bears minerals during movement of groundwater; as a result, the concentration of soluble salts increases towards the direction of groundwater flow. According to Plan-Sudan

(1991), the basin system of the study area is bounded from the east and the south by impermeable (non-flow) boundaries, from the west by a recharge boundary of the Blue Nile, and from the north by an outflow (discharge) boundary. Therefore, in view of the drastic decline of the Blue Nile flow from Ethiopian Highlands, the recharge flow direction is thought to be from the south to the north, parallel to the river with slight deviation from the river flow. This deviation increased northwards due to the relative decrease of the river decline. It is noteworthy that the role of geological conditions of the aquifer on groundwater TDS in the study area is not unexpected. Wide TDS range in the study area has been reported by Yasir (2004), who reported that TDS concentrations in the study area ranged between 20 and 3290 mg/l while in some of the villages located to the extreme northwestern boundary of the study area, the TDS levels were found to range between 1088 and 1952 mg/l (Abdel-Magid *etal.,* 1984). Farah *et al.* (1997) reported a TDS level of 3505 mg/l in the upper aquifer of west and southwest of Omdurman City metropolitan area whereas in the lower aquifer the TDS did exceed the level of 640 mg/l. Shommo (2007) reported a TDS level range of 97 - 2600 mg/l for southern Omdurman metropolitan area. El-Tingari (2010) reported a TDS level range of 128-1024 mg/l for groundwater of Grand Khartoum City. Al-Redhaiman and Abdel-Magid (2002) reported TDS level ranges of 493 - 6995 mg/l and 109 - 909 mg/l for irrigation and drinking water, respectively, in Al-Gassim region of Central Saudi Arabia.
To make the picture clearer, the TDS data obtained for both CRA and CS were categorized in table (1).

Table (1): The distribution of 209 boreholes (CA) and 121 boreholes (SA) Blue Nile Communities of Sudan according to their TDS level

Categories of TDS level (mg/l)	CA		SA	
	Number of boreholes within class	(%) of total within class	Number of boreholes within class	(%) of total within class
<250	65	31.1	48	39.67
250-500	86	41.2	58	47.93
500-750	36	17.2	13	10.74
750-1000	10	4.7	0.0	0.0
1000-1250	6	2.9	2	1.65
1250-1500	1	0.5	0.0	0.0
>1500	5	2.4	0.0	0.0
Total	209	100	121	100
Data used	CA		SA	
Mean	498		322	
Range	110-6400		115-1070	
SD	665		165	

SD = Standard deviation.

Analysis of the data of 209 boreholes in CRA and 121 boreholes in CS revealed obvious variations in the TDS level among boreholes. The magnitude of the standard deviation (SD) in the CA data (SD = 665 mg/l) is higher than that for the CS data (SD = 165 mg/l). The categories shown in table (17) indicate that 31.1% (65 boreholes) and 39.67% (48 boreholes) of the investigated samples were found well below the level of 250 mg/l for the CRA and the CS, respectively. Eighty-six boreholes in the CA (41.2%) and fifty-eight boreholes in the CS (47.93%) have TDS levels ranging between 250 and 500 mg/l. A total of 17.2% (36 boreholes) of the CRA and 10.74% (13 boreholes) of the CS borehole samples were found within the category of 500-750 mg/l while 4.7% (10 boreholes) of the CRA and none of the CS borehole samples were found within the range of 750-1000 mg/l. Not more than 2.9% (6 boreholes) of the CRA and only 1.65% (2 boreholes) of the CS were found within the category of 1000-1250 mg/l. Only one borehole sample (0.9%) of the CRA and none of the CS samples were found within the range of 1250-1500 mg/l whereas 5 boreholes (2.4%) of the CRA and none of the CS samples were found in excess of the level of 1500 mg/l. In general, the TDS level in the study area revealed considerable variations. The TDS concentration levels in the CRA range between 110 and 6400 mg/l, the mean value is 498 mg/l, thus resulting in a high SD of 665 mg/l. In the CS, the TDS levels ranged between 115 and 1070 mg/l, the mean value is 322 mg/l, thus resulting in SD of 165 mg/l. The

magnitude of the SD (665) in the CRA data is higher than that for the CS (SD 165). This indicates that there is, comparatively, a little variation in the TDS magnitude in well water samples analyzed recently during this study.
The levels for the TDS in the CRA and the CS samples were compared with the local, regional and international standards and guidelines for TDS in drinking water (Table 2).

Table (2): Applicability of the local, the regional and the international standards and guidelines to well drinking water TDS level in the study area.

Drinking water standards and guidelines	Maximum standard permissible limit (mg/l)	TDS category (mg/l)	CA (n = 209)		SA (n = 121)	
			No. of boreholes within category	% of total within category	No. of boreholes within category	% of total within category
USEPA (1976)	500	<500 >500	149 60	71.3 28.7	106 15	87.6 12.4
GCCS (1993) WHO (1993) SSMO (2002)	1000	<1000 >1000	196 13	93.8 6.2	119 2	98.4 1.6
EEC (1993) SASO (1984)	1500	<1500 >1500	204 5	97.6 2.4	121 0.0	100 0.0

The data indicates that 71.3% (CRA) and 87.6% (CS) of the groundwater samples have TDS levels lying well below the maximum level of 500 mg/l recommended by USEPA (1976). Only 28.71% (CRA) and 12.4% (CS) of the investigated samples have TDS levels well above 500 mg/l, 93.8% (CRA) and 98.4% (CS) of samples have TDS levels well below the maximum level of 1000 mg/l set by each of GCCS (1993), WHO (1993) and SSMO (2002), while only 6.2% (CRA) and 1.56% (CS) of the investigated samples have TDS levels in excess of the maximum recommended level of 1000 mg/l. Moreover, 97.6% (CRA) and 100% (CS) of the samples lie well below the maximum level of 1500 mg/l set by each of EEC (1993) and SASO (1984) whereas only 2.4% (CRA) and none of the investigated samples (CS) exceeded the above-mentioned level. Therefore, according to the respective standards and guidelines limits for drinking water listed in table (2), high salinity drinking water with TDS levels violating the maximum recommended levels is considered unsuitable for drinking but could be used for irrigation of crops with good salt tolerance (Al-Redhaiman and Abdel-Magid, 2002).

It can be inferred from table (3) that groundwater TDS level in the study area is continuously decreasing with the advancement of pumping time.

Table (3): The tendency for decrease of TDS levels with the advancement of pumping time in selected boreholes in the study area (n=24).

Name of village	Date of drilling (CA)	TDS, mg/l in (CA)	TDS, mg/l in (SA) (2008)	Total decrease (mg/l)	Duration of total decrease (year)	Mean decrease per year	% of mean decrease per year
Almagareet	29,5,1972	240	164	76	36	2.0	0.9
Tikailat	25,6,1985	450	288	162	23	7.0	4.3
Sial-Thwra	1,8,1990	524	364	160	18	9.0	1.7
Damgadkrem	25,4,1972	320	270	50	36	1.4	0.4
Olwan	7,5,1972	480	422	58	36	1.6	0.3
Hilat-idres	3,1,2001	248	221	27	7	4.0	1.6
Wadelfadul	14,7,1986	510	289	221	22	10	2.0
Wadrawa	20,10,1984	580	293	287	24	12	2.1
Kairan	25,6,1971	600	208	392	37	11	1.8
Hamdallab	13,5,1992	400	202	198	16	12	3.1
Amara-Ali	18,6,1978	420	164	256	30	9.0	2.0
Umm-akash	29,8,1987	200	182	18	21	1.0	0.4
Gurra-1-2	5,4,1993	850	710	140	15	9.0	1.1
Alkidawa	5,6,1971	400	350	50	37	1.0	0.3
Rufaa-1	3,10,1986	230	205	25	22	1.0	0.5
Ahamda	14,11,1999	765	640	125	9	14	1.8
Fadnia	1,5,1972	1160	640	520	36	14	1.3
Abugroon	17,10,1967	1040	640	400	41	10	0.9
Mstafa-Fadni	26,12,1973	480	390	90	35	3.0	0.5
Umdpan-Ag	27,10,1976	600	360	240	32	8.0	1.3
Umdpan-Hs	20,6,1976	800	534	266	32	8.0	1.0
Awayda-Mh	10,12,1981	160	153	7.0	27	0.3	0.2
Alsharafa-Br	4,4,1987	235	170	65	21	3.0	1.3
Wadibsham	20,2,2005	1100	1070	30	3	10	0.9
Mean	1976	558	372	161	26	7.0	1.2
Range	1967-2005	160-1160	153-1070	7-520	3-41	1.14-14	0.2-3,1
SD	12	866	706	136	10	4.5	0.7

SD = Standard deviation

In general, the TDS mean value has decreased from 558 mg/l (CRA) to 372 mg/l in the CS. Factors other than aquifer geological formation (e.g., duration of discharge time and the daily pumping rate) may have played a significant role in washing out some of the elements that have elevated the TDS concentration level. This may be explained as due to the continuous washing out of the connate dissolved salts and their replacement by fresh water from the neighboring Blue Nile seepage, which is considered as the main source of aquifers recharge in the study area. Abdel-Salam (1966) reported that, in the Gezira formation, fresh supplies from the Blue Nile dilute the mineral content of groundwater. Conversely, Al-Redhaiman and Abd-Magid (2002) and Munday and Andrew (2008) incriminated over exploitation and excessive water pumping among factors that elevate salinity in groundwater. Increasing levels of TDS in some groundwater areas are usually caused by the intrusion of high salinity water due to over-exploitation in aquifers adjacent to seawater or by the replacement of good salinity water with high salinity water in evaporated temperate climates (Drisckol, 1986).

CONCLUSIONS

Based on the results of the present investigation, the following conclusions may be drawn:

1. High TDS concentration levels were found in boreholes drilled in the northern part of the study area. The TDS concentration levels increase gradually towards the north, northwest and northeast with concomitancy to recharge direction from the Blue Nile and groundwater static water level with some scattered high TDS pockets.

2. Only 6.2% (CRA) and 1.6% (CS) of the investigated boreholes were found to be in excess of the TDS level of 1000 mg/l set by SSMO (2002) and WHO (1993).

3. Due to the excessive pumping and extraction, TDS concentrations of groundwater in the study area are continuously decreasing during withdrawal-time in accord with the daily pumping rate and aquifer geological formation.

RECOMMENDATIONS

1. Considering the prevailing regional climatic conditions, the study suggests that the level of 750 mg TDS/l is to be the maximum advisable level in drinking groundwater due to the high consumption of drinking water in the study area.

2. Based on taste, it is suggested the following classification for groundwater on the basis of TDS level: 1) < 200 mg TDS/l as palatable water and pronounced in Arabic as “Sa’igh”. 2) 200 - 500 mg TDS/l as potable water and pronounced in Arabic as “ Mustesa’gh”. 3) 500 - 750 mg TDS/l as none palatable water and pronounced in Arabic as “Ghair mustesa’gh”. 4) 750 - 1000 mg TDS/l as salty taste water and pronounced in Arabic as “Milhy”. 5) 1000 - 1500 mg TDS/l as saline water and pronounced in Arabic as “Malih”. 6) > 1500 mg/l TDS as brine water and pronounced in Arabic as “Ojaj”.

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