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Determination of Physiochemical Properties of Groundwater in Al-Abbasiya Locality, South Kordofan State, Sudan

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Abstract

Groundwater is main source of drinking water in Al-Abbasiya locality. The study aimed to evaluate Physiochemical properties of ground water comparing with Sudanese Standardization Metrology Organization (SSMO) and World Health Organization (WHO). This study was conducted in 2019. 20 samples of water were randomly collected from different areas, and carefully stored. the samples were analysed using an Atomic Absorption Spectrometer (A.A.S), pH Meter, Conductivity meter (E.C), Turbidity meter. the analyses were carried out in Water Quality Lab Unesco Khartoum. the following parameters such as: pH, Electronic Conductivity (E.C), Turbidity, Total Hardness (T.H), Total Dissolved Salt (T.D.S), and total alkalinity (T.A), in addition to some cations, (Na^+, Mg^{2+}, K^+, Ca^{2+}, Mn^{2+}, Fe^{2+}) and anions such as: (F^-, CI^-, SO_4^{3-}, NO_3^{2-}, NO^{2-}). The results showed that, pH ranging between (7.7-6.7), Electronic Conductivity (E.C), (3450-575 µs/cm), Turbidity (10.5 - 1.1) NTU, Total Hardness (T.H) (436-308 mg/L) and Total Dissolved Salt (T.D.S) (1170-286 mg/L), the values of alkalinity (TA) found (450 - 316 mg/L), Na^+ (87-33 mg/L), K^+ (2.0 -1.1 mg/L), Mg^{2+} (69.5-5.35 mg/L), Ca^{2+} (81.6- 25.8 mg/L), Mn^{2+} (0.9-0.02 mg/L), Fe^{2+} (0.08-0.03 mg/L), NH_4^+ (0.35- 0.10 mg/L), F^- (2.10- 0.5 mg/L), Cl^- (23- 3.54 mg/L), NO_3^- (36.1- 0.03 mg/L), NO_2^- (11.8- 0.02 mg/L), SO_4^{2-} (440- 011 mg/L), CO_4^{2-} (364 - 170 mg/L), all samples revealed pH and total solubility values of salt within permissible limits according to drinking water quality guidelines of WHO and SSMO, except sample No. S10 (Al-gabal Al- ahamar), which contained slightly higher than the acceptable limit (1170 mg/L), and all showed higher electrical conductivity than the approved limit excluding samples No (S4 and S7) which were recorded values less than permitted standard (120 and 98) respectively. The hardness of the all samples were within allowed range and from analysed the values of dissolved bicarbonate, nitrate and salts were noted lower than their standard values, 0.3 mg/L. Concentration of Magnesium 25 mg/L and Calcium 45 mg/L in some samples are less than suggested range. As the result of these findings the water can be use without treatment with the exception of (S4 and S7) remained unfit for human usage due to increase in total dissolved salts.

Keywords: Manganese, Iron, Groundwater, Al-Abbasiya locality, Spectrometer.

INTRODUCTION

Groundwater is the most important source of drinking water in Al-Abbasiya locality, South Kordofan State, Sudan, especially it plays a vital role in the development and public health of the population. Unfortunately, due to random goldmining and the nature of geological area be expected to contamination of the groundwater. The resource of water may have degraded in quality (Parihar S.S., 2012). Water is one of the most important chemicals known to man. without it neither animals nor plants life will exist. Water is essential in processes of digestion, circulation, elimination and the regulation of body temperature. Water is used as a solvent for many substances (Georgal, Sackein and Ronald, M. Schultz, 1973), ground water is contaminated by undesirable elements that introduced by directly or indirectly into a natural water supplied by human activity (Anil Kumar, 2023). Groundwater quality is influenced by the geological background of the water behaving rocks of the source. Changes in source water or degraded quality of source supplies may, seriously, impair the quality of ground water supply. Municipal and an aquifer

are major sources of organic and inorganic pollution. Large-scale organic pollution of groundwater is infrequent, however, since significant quantities of organic wastes usually cannot be easily introduced underground, (Izzeldeen, 2007). Only a small fraction (about 2.5%) of earth's water is fresh and suitable for human consumption. Approximately 13% of this fraction is groundwater; an important source of drinking water for many people worldwide. The groundwater has been used for drinking for a long time and its purity has made it a well-known source of potable water all over the world (Nason Alvin ,1965). Groundwater can be defined as the water located in the pore space of soil and rocks. Sometimes it is useful to distinct between sub-surface water, that is, closely associated with surface water and deep sub-surface water in aquifer (fossil water). Sub-surface groundwater can be thought of in the same terms as sub-surface water inputs, outputs and storage. Groundwater resources in arid and semi-arid regions with limited renewable potential have to be managed judiciously to ensure adequate supplies of dependable quantity and quality. It is a natural resource with economic, strategic and environmental value, which is under stress both due to changing climatic and anthropogenic factors. Therefore, the management strategic needs to be aimed at sustenance of these limited resources (Bsnraju, 1995**)**. In many countries, groundwater is the main source of water for all purposes. This is because rural communities are found close to the groundwater and/or away from surface water resources. In addition, the water bearing stratum from which ground water is drawn usually provides a natural storage at points of intake (WHO, 1993). Ground water occurs in the shallow aquifers along the major seasonal streams or in relatively deep aquifer of the Umm Ruwaba and/ or the Nubian-Sandstone formation, which cover more than 50% of the total area of the Sudan (Whiteman A. J". 1971)

In the present study, twenty ground water samples were collected from different locations of AL-Abbasiya locality, South Kordofan State, Sudan, Sudan, all samples were analysed for their physiochemical properties and compared with the Sudanese Standards and Metrology Organization (SSMO) and World Health Organization (WHO).

Study area:

The study was conducted on Al-abbasiya locality, south Kordofan state, Sudan, groundwater sample were collected from 20 wells at different sides mentioned in table 1 along with depth of the well.

Sample collection

20 groundwater samples were collected in November 2019 from different locations in AL-abbasiya locality South Kordofan State Sudan. The samples were filtered through Whatman No:1 and packed in dark plastic bottles.

Table 1: Showed samples site, altitude and depth of the wells

Sampling code	Sampling site	Altitude M	Depth M
S1	Soog Aljabl	420	44
S2	Gimbrayh	429	53
S3	Tufin	431	55
S4	Almoraibschool	430	54
S5	Banaf	426	50
S6	Allobanaha	424	48
S7	Gardood Alzipll	427	51
S8	Alnilah-Alteib	415	39
S9	Kimsuoro	425	49
S10	Aljabalalahmar	429	53
S11	Hithem	411	35
S12	Mosque	410	34
S13	ALmak	441	65
S14	MohiEldein	429	53
S15	Hospital	419	43
S16	ALhiya	438	64
S17	AdamMusa	427	51
S18	Sudatel	410	34
S19	Gabona	420	46
S20	Fouyla	445	59

Physical Parameters:

The physical parameters of samples were analysed to determine the pH values, electrical conductivity, using instruments respectively, digital pH meter, digital conductivity meter, Thermometers, were measured and recorded on site. samples were analyzed at (Water Quality Lab Unesco in Khartoum).

Chemicals:

Potassium chromate indictor, phenol read indictor, ethylene diamine tetra acetate (EDTA), Eriochrom Black T (EBT), Muroxide indicator, Methyl orange indicator, Pheno laphthalein indicator, N, N-Diethyl-P-Phenylenediamine (DPD) reagent, Potassium, distilled Water, Buffer solution, Sodium Periodate, Hydrochloric acid, Sodium chloride Silver nitrate, Sulphate acid, Crystalline Cobalt chloride, Potassium chloro palatinates (solution), Ammonium chloride (NH_4Cl), hexa ethylene tetra mine, barium chloride.

METHODS AND VENUE OF ANALYSIS

The water samples were analyzed at Water Quality Lab Unesco Khartoum. Physical and chemical analysis was done in the laboratory following the methods of APHA (APHA,1992), such as pH, Electrical conductivity (E.C), Total Dissolved Solids (T.D.S), Total Hardness (TH), Total Alkalinity (TA), Turbidity (NTU) and major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Fe^{2+}, Mn^{2+} ppm) and anions (F^{-}, Cl^{-}, SO_4^{-2}, NO_3^{-}). All samples were analysed using Atomic absorption (AAS) model AA-6800F, Shimadzu Compa Jpan NY, Spectrophotometer Hach (DR-3900).

RESULTS AND DISCUSSION

Analysis was carried out for various water quality parameters such as temperature, pH, total dissolved solids (TDS), total alkalinity (TA), total hardness (TH), Total Dissolved Solids meter was used to measure the temperature of water and the total dissolved solids Concentration of chemicals was measured using standard method. The analysis shows general suitability of the studied ground water sources for drinking. The results show that water quality of different areas shows no remarkable variation from the WHO and SSMO recommended values.

Table 2: The Results of physical parameters in water samples of the wells:

Sampling code	Well name	pH	TDS mg /L	EC µs/cm	TH mg /L	TA mg /L	NTU
S1	Soog Aljabl	6.7	816	1634	188.2	280	05.0
S2	Gimbrayh	6.7	708	1418	212.4	300	04.0
S3	Tufin	7.7	774	1556	226	400	3.2
S4	Almoraib school	7.2	344	687	120	720	15.0
S5	Banaf	7.1	569	1140	184	600	04.0
S6	Allobanaha	7.4	683	1366	134	240	3.80
S7	Gardood Alzipll	7.5	286	575	98	560	035
S8	Alnilah-Alteib	7.6	562	1125	200	448	028
S9	Kimsuoro	7.4	751	1505	182	336	040
S10	Aljabalalahmar	7,0	1170	3450	350	364	4.80
S11	Hithem	7.2	504	841	264	324	04.2
S12	Mosque	7.7	431	718	270	337	6.20
S13	ALmak	7.3	455	701	294	344	2.10
S14	MohiEldein	7.4	504	776	292	336	3.50
S15	Hospital	7.5	449	748	270	436	0.05
S16	ALhiya	7.2	647	1078	320	308	1.10
S17	AdamMusa	7.5	404	674	248	332	7.10
S18	Sudatel	7.3	484	745	264	344	0.88
S19	Gabona	7.2	446	743	280	308	1.70
S 20	Fouyla	7.3	430	662	270	364	10.5

From table 1. the active hydrogen ion concentration (pH), varies between (7.7 - 6.7), that mean all samples fall in the alkaline side, pH values obtained for all samples shows value within the permissible level as reported by World Health Organization standards. total dissolved solids (TDS) has a direct relation with EC, and total dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium and manganese, organic matter, salt and other particles (Ranjan Rakesh, 2012). The TDS was found ranging from (1170 -286 mg/L). except (S10) 1170 mg/L was higher than permissible level stated by WHO (1000ppm) (WHO; 2007) Results are similar to previous by (Bhattacharya T., *et al.,* 2012). May be due to characteristics presents in indoor environment in these areas or geological structure. Electrical conductivity indicates the total dissolved solids in water. Electrical conductivity in waterways is affected by different factors like geology and soils, land use, flow, runoff, groundwater inflows, temperature, evaporation and dilution. In our study EC varied between (3450 - 575 µs/cm). Sampling sites S4 and S7 demonstrated relatively higher EC values in comparing with WHO, measuring 687 and 575 µs/cm respectively. But all others samples were found out of the range of allowed by WHO the use of such sources may be unsafe for human drinking according to WHO and Sudanese Standards of Meter Organization, (SSMO) drinking water standards (WHO; 2005, 2009, and 1999). Which considered the

highest TDS permissible level 500 mg/L and the maximum permissible level as 1500 mg/L. the highest values recorded in the area may be due to the nature of mountain environment. TDS and EC values as basic drinking water quality parameters. The study of groundwater chemistry can give important indication of the geological history of the enclosing rocks and direction of groundwater movement. Hardness was found in range (350-98 mg/L). The obtained results were in agreement with the recommended values of WHO (500 ppm) of $CaCO_3$, so samples (S1, S2, S3, S5, S6, S8 and S9) were classified as moderately soft. While, (S10) sample is classified hard. Due to increase of calcium and magnesium ions concentration in the sample.

Table 2: Results of chemical parameters in water samples of the wells:

Sampling code	Sampling site	Ca^{2+} ppm	Mg^{2+} ppm	Na^{+} ppm	K^{+} ppm	Fe^{2+} ppm	Mn^{2+} ppm
S1	Soog Aljabl	29.6	27.7	37.36	0.30	0.004	0.013
S2	Gimbrayh	52	20.4	9.00	0.21	0.013	0.004
S3	Tufin	43.2	28.7	10.11	0.27	0.004	0.027
S4	Almoraib school	34	14.58	10.55	0.80	0.028	0.003
S5	Banaf	38.4	21.38	6.285	1.65	0.003	0.0026
S6	Allobanaha	21.6	19.4	55.77	0.43	0.005	0.002
S7	Gardood Alzipll	30.4	5.35	20.43	1.43	0.001	3.350
S8	Alnilah-Alteib	28	31.6	33.32	0.32	13.76	2.650
S9	Kimsuoro	33.6	23.8	27.45	0.35	23.66	2.220
S10	AljabalAlahmar	25.6	69.5	45.12	0.54	18.12	0.001
S11	Hithem	63.2	25.44	650	0.90	0.03	0.007
S12	Mosque	64	26.4	440	1.30	0.08	0.019
S13	ALmak	68.6	29.28	330	1.07	0.07	0.036
S14	MohiEldein	68.8	28.8	480	1.70	0.07	0.5
S15	Hospital	64.8	25.92	510	1.30	0.06	0.005
S16	ALhiya	81.6	27.84	870	1.00	0.04	0.004
S17	Adam Musa	54.4	26.88	430	1.10	0.08	0.002
S18	Sudatel	68	22.56	490	1.00	0.04	0.007
S19	Gabona	61.6	30.24	460	1.30	0.06	0.003
S20	Fouyla	64.8	25.9	350	1.50	0.03	0.008

The Cations and anions determined in drinking water samples. Magnesium found in range (69.5-5.35 mg/L). This result is in agreement with reported in WHO. Magnesium ranging from (25.44 to 30.24 mg/L). This result is in agreement with reported in WHO. The WHO highest desirable limit for Mg^{2+} and Ca^{2+} were (30 – 50 and 75 – 100) respectively, this result is in agreement with previous reported studies (Cook, *et al*; 1974). The results of Sodium Na^{+} showed all samples fall in WHO and SSMO drinking water standards (200 – 250 mg/L). The results of samples Potassium K^{+} were found on the range from (1.7 -0.9 mg/L) that all samples less than permissible level of drinking water stated by WHO and SSMO. Iron is second most abundant metal in the Earth's crust, counting for approximately 5%. In the drinking water supply, the iron salts are unstable and precipitated as insoluble iron(III) hydroxide, which settles out as a rust-coloured silt. The aeration of iron-containing layers in the soil can affect the quality of both groundwater and surface water (Ronov, A. B.; and Yaroshevsky, A. A. 2013). Iron is a common constituent in soil and ground water. It is present in water either as soluble ferrous iron or the insoluble ferric iron. In high concentration it causes scaling in plumbing fixtures. In the present study, Iron Fe^{2+} sample exhibits a lower than allowed range (0.03 - 0.08 gm/L). Manganese Mn^{2+} varies between (0.002 - 0.5 mg/l) values obtained for all samples within the permissible level as reported by WHO standards table of (WHO) except the sample (S14) outside the standard. While all samples were free of hydrogen sulfate.

Table 3: Results of chemical parameters in water samples of the wells

Sampling code	Sampling site	Cl^{-} ppm	F^{-} ppm	SO_4^{2-} ppm	NH_4^{+} ppm	NO_2^{-} ppm	NO_3^{-} ppm
S1	Soog Aljabl	25.56	1.4	440	0.013	0.0231	13.2
S2	Gimbrayh	25.6	1.9	48	0.004	0.0132	14.8
S3	Tufin	26.3	2.1	42	0.027	0.0165	19.8
S4	Almoraib school	68.7	2.05	11	0.003	1.03	6.65
S5	Banaf	60.99	1.84	43	0.0026	0.0297	8.712
S6	Allobanaha	58.2	2.06	15	0.002	0.0033	3.43
S7	Gardood Alzipll	67.45	2.04	11	3.350	0.007	2.64

Sampling code	Sampling site	Cl^- ppm	F^- ppm	SO_4^{2-} ppm	NH_4^+ ppm	NO_2^- ppm	NO_3^- ppm
S8	Alnilah-Alteib	61.8	1.8	38	2.650	0.02	36.1
S9	Kimsuoro	46.2	0.9	17	2.220	0.01	15.4
S10	AljabalAlahmar	14.91	1.44	125	0.001	Nil	0.88
S11	Hithem	8	0.7	23	0.07	0.026	9.68
S12	Mosque	8	0.95	11.2	0.04	0.046	11
S13	ALmak	8	0.5	9	0.06	0.105	9.24
S14	MohiEldein	8	0.6	18	0.19	0.217	9.68
S15	Hospital	8	1.3	10	0.2	0,059	10.12
S16	ALhiya	23	1.5*	29	0.03	0.039	11.88
S17	Adam Musa	8	0.9	11	0.06	0.092	8.8
S18	Sudatel	8	0.21	15	0.13	0.190	10.56
S19	Gabona	8	0.77	11	0.06	0.039	6.6
S20	Fouyla	8	0.65	10	0.1	0.108	7.48

Chloride concentrations summarized in table (3) ranging from (8-23 mg/L) the results of concentration was also below guideline value which is 250 mg/L. The main source of phosphorus in the environment is from soil and rock weathering. In nature, phosphorus usually exists as part of a phosphate molecule. Phosphorus in aquatic systems occurs as organic and inorganic phosphate. In this study phosphate ranging from (0.15 - 0.35 mg/L), Phosphate values were quite low in all samples the values were in agreement with WHO and SSMO considered 1.5 mg/L which is consistent with that reported by reference (Bhattacharya T., *et al.,* 2012) who reported 32 mg/L. Most of the fluoride found in groundwater is naturally occurring from the breakdown of rocks and soils or runoff and infiltration of chemical fertilizers in agricultural areas. The significance of measuring fluoride lies in its health consequences our study revealed fluoride concentrations ranging from (0.5– 1.5*mg/L), all samples were found below than permissible range, meanwhile, at low concentrations fluoride can reduce the risk of dental cavities, Results are similar to a specification given by (WHO, 1996). Ammonia varies between (0.03 - 0.19 mg/l) and it agrees within SSMO standard and WHO. Nitrite as NO_2 concentrations were below than permissible values which ranging from (0.026- 0.217 mg/L). Nitrate as NO_3 in ground water were increased ranging from (6.6 to 11 mg/L). These indicated that the rocks information increases the nitrate concentration. Sulfate SO_4^{2-} ranging from (9 to 29 mg/L), these indicate that all the samples in agreement with permissible range of WHO and SSMO considered 500 mg/L.

4. CONCLUSION

In conclusion, groundwater wells are one of sources of drinking water in AL Abbasyia area, where chemical analysis of drinking water done for twenty source stations, they had safe drinking water uneven quality. All the samples had safe drinking water with slight rise in turbidity in tow sampling sites S12 and S20 out of permissible value. Samples taken in first autumn with high rise in EC. except sample (S4), (S7). (S10) had safe drinking water with slight rise in TDS, HCO_4 and Mg^{2+} levels. (S1) had safe drinking water with an out permissible value of EC, HCO_4 due to unfit. (S16) had safe and good quality drinking water with slightly rise in EC. A little higher than permissible limit may not great affect in safety or validity of drinking water, but we must increase a quality level of all stations studied by using any of several possible treatment methods.

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Supporting information:

In the text (experimental and preparation methods) and supplementary section.

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