Geo-informatics Analysis of groundwater quality for drinking and agriculture purposes; case study; Dakhla Depression

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الملخص العربي: التحليل الجيومعلوماتى لجودة المياه الجوفية لأغراض الشرب والزراعة- دراسة الحالة (منخفض الداخله)

تمت دراسة جودة المياه الجوفية في منخفض الداخلة (مصر) باستخدام تقنيات المعلومات الجغرافية مثل (ARC GIS Software) ، هذا البرنامج هو أداة لرسم الخرائط وتحليل البيانات المكانية ويستخدم أيضًا لاسترداد معلومات جودة المياه الجوفية. لهذه الدراسه تم اختيار ٣٩ بئراً ، لكل بئر اثنا عشر معامل فيزيائية كيميائية تم تحليلها بما في ذلك التوصيل الكهربائي ، الكالسيوم (Ca2 +)، المغنيسيوم (Mg2 +) ، الصوديوم (Na +) ، البوتاسيوم (K +) ، البيكربونات (HCO3-) ، الكلوريد (Cl-). ، الكبريتات (SO42-)، النترات (NO3-) ، الحديد (Fe2 +) ، والصلابة الكلية .(TH) تم تقييم المياه الجوفية التي تم جمعها لمعرفة مدى ملاءمتها لأغراض الشرب والري تم استخدام الارتباط و PCA لتحليل المعلمات. تم إنشاء خرائط رسم الخرائط لمنطقة الدراسة باستخدام نظام المعلومات الجغرافية بواسطة Interpolation على سطح نقطي من النقاط (مواقع الآبار التي تحتوي على بيانات السمات لجميع المعلمات) باستخدام تقنية مرجحة للمسافة العكسية (IDW). وأدوات إحصائية متعددة المتغيرات لجميع المعاملات المذكورة أعلاه. يمكن استخدام الخرائط التي تم إنشاؤها لتصور وتحليل وفهم العلاقة بين جميع المواقع. تم العثور على معظم الآبار لتكون ضمن الحد المسموح به يمكن أن يساعد تحليل الارتباط والمكونات الرئيسية في اختيار أهم العوامل لتحديد حالة جودة المياه. دعمت الأدوات المتاحة في بيئة نظم المعلومات الجغرافية الدراسة في تكامل البيانات مع هياكل بيانات مختلفة للغاية لتقييم موارد المياه الجوفية. تم أخذ النتائج التحليلية لإنشاء التوزيع المكاني العددي للمعاملات باستخدام بيئة نظام المعلومات الجغرافية (GIS)

الكلمات المفتاحية: الجيومعلوماتيه، المياه الجوفيه، ترجيح المسافه العكسيه الموزونه، الاستيفاء والتعميم

Abstract:

Groundwater quality in the Dakhla Depression (Egypt) has been studied using Geo-informatics Techniques As (ARC GIS Software), This software is a tool for mapping and analyzing spatial data and is also used to retrieve groundwater quality information. For this study, 39 wells were selected, for each well twelve physicochemical parameters were analyzed including electrical conductivity, Calcium (Ca2+), Magnesium (Mg2+), Sodium (Na+), potassium (K+), bicarbonate (HCO3-), Chloride (Cl-), Sulphate (SO42-), Nitrate (NO3-), Iron (Fe2+), and Total Hardness (TH). (the sub-laboratory of the General Administration of Groundwater in Dakhla, 2015) . The collected groundwater was evaluated for its suitability for both drinking and irrigation purposes.

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Correlation and PCA have been utilized to analyze the parameters. Cartographic maps of the study area have been created using GIS by Interpolates a raster surface from points(wells locations which contain attributes Data For all parameters) using an inverse distance weighted (IDW) technique. and multivariate statistical tools for all the above parameters. The created maps can be used to visualize, analyze, and understand the relationship among all locations. Most of the wells were found to be within the permissible limit. Correlation and principal component analysis can help in selecting the most significant parameters to determine the status of water quality. The tools available in the GIS environment supported the study in the integration of data with very different data structures to the assessment of groundwater resources. the analytical results were taken to generate the numerical spatial distribution of the parameters using the geographic information system (GIS) environment **(A. ABBASNIA ET AL, 2018)** .

Keywords: GEO-informatics, groundwater quality, IDW, spatial distribution.

Introduction:

Groundwater is the only source of water in the New Valley, and it represents the lifeblood of the New Valley, as it is one of the arid regions due to the scarcity of rain and the distance from the Nile River water (Yahya Elmansy,et al,2020). All aspects of life depend only on groundwater, and as the population increases, water needs increase.

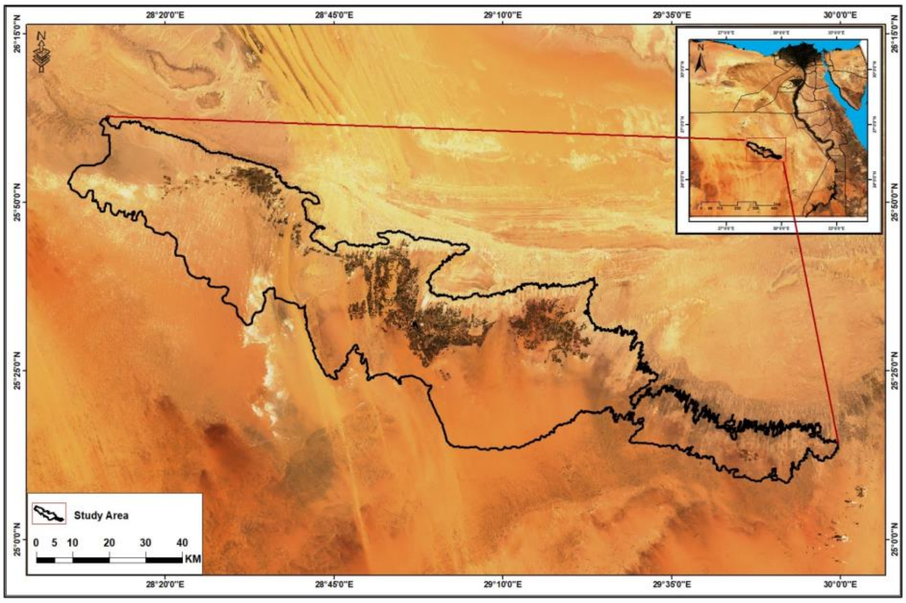
The chemical and physical properties of water vary from place to place depending on the quality of the rocks they are containing, and the purpose of knowing the quality of the underground water at the low level is to determine the quality of the water, thus identifying the utilization kind.

Knowledge of the physical and chemical characteristics of groundwater is also important in the assessment of the water system, the analysis of the Central groundwater Management of Southern Western Sahara sub laboratory of the General Department of groundwater at East Awinat June 2015.

The purpose of knowing the chemical characteristics of the Depression water resources is to determine the appropriateness of their use for various purposes, whether for human or other uses. These elements are known as salts that separate into the water solution into positive and negative groups of ions as a result of the interaction of water with the atmosphere, surface environment, soil, and bedrock until it is stabilized by the aquifer, the highest concentration of which is the long-term water contact with rocks, The ions are divided into positive ions, known as the sodium, calcium, magnesium, and potassium, and their concentration serves to alkaline water and thus they increase the hardness of water, which may be colored by pale blue, but which quickly disappears by boiling water and negative ions, called , carbonate, chloride, sulfate, and nitrate.

Study Area:

Dakhla Depression is one of the sahara desert depressions , it is a city which is located in the New Valley Governorate in Egypt. The Dakhla is located in the middle of the Egyptian western plateau, and it is located west of the Kharga Depression by about 120 km, and from the Nile, about 300 km, Geographically it is located between the two latitudes °٢٥ ٨ ١٨, °٢٦ ٣ ١٣ north, and longitude ٣٧ °٢٨ ٥ □,° ٢٩ □ ٥٩ ٤٥ east, Figure 1, and the area of the low-lying is about 5309 km 2, and this area is located within the contour line 225 m, which encircles the low-lying from all sides, where The lower limit is normal.



Prepared by using ARC GIS 10.4

Figure (1): Study Area

Materials and Methods:

A total of 39 well representing the Dakhla area were selected in our study Table (1), figure 2, groundwater samples were collected from each well in June 2015. These data have not been published earlier. The survey was carried out by the central administration of groundwater to the south of the western desert. where the analyzes are carried out. Physio-chemical parameters were carried out EC, (Ca2+), (Mg2+), (Na), (K+), (HCO3-), (Cl-), (SO42-), (NO2-), (Fe2+), (F-) and (TH) and then compared with the guidelines admitted by the World Health Organization (WHO, 2003; Al-Asbahi, 2005).

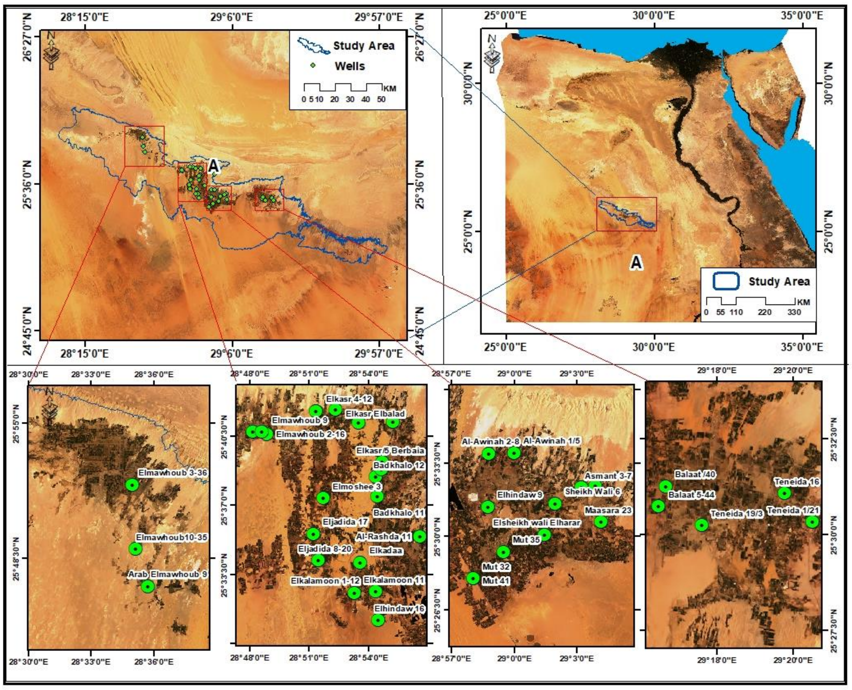


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Figure (2) Groundwater wells (samples) locations in the study area

Table (١) : Average physiochemical analyses for the grounds water and compared with WHO and Irrigation.

variable	unit	Minimum	Maximum	Mean	STDEV	WHO Guideline	Irrigation Water classification
EC	µs/cm	0.17	1.3	0.279744	0.178246	1000-1500	
pH	-	6.2	7.8	7.133333	0.379158	6.9-9.2	
Cl^-	mg/l	22.2	327	42.505128	48.23179	250	
HCO_3^-	mg/l	2.0398	61.195	39.841764	10.43593		
SO_4	mg/l	11.4	112.2	42.176154	19.50549	250	
Na^+	mg/l	9	161	21.346154	23.79214	200	
K^+	mg/l	6	24	13.910256	5.191057	8-20	
Ca^{2+}	mg/l	7.128	56	15.066821	9.243202	200	
Mg2	mg/l	4.811	28.19	7.413538	3.752766	150	
TH	mg/l	0.4	255.67	66.466154	39.076289	500	
Fe^{2+}	mg/l	1	14.1	4.763487	3.103218	0.3	
Mn	ppm	0.01	8	0.45	1.23	0.1	
SAR	meq/L	0.57	4.38	1.04	0.602082		<10 Excellent 10-18 good 18-26 Permissible >26 Unsuitable
TD		107	800	171.10256	109.7820		

Result and Discussions:

The most important concern for farmers during using irrigation water is the proportion of salts in water, Salts have a significant impact on soil properties , productivity and irrigation water salinity reflects the amount of total salt dissolved in water **(Anwar A. Aly,2015),** The amount of total salts dissolved in water is generally lower than 500 mg/L in government observation wells, as evidenced by only two well figure (3) (Ain-Elhassan, Teneida 19/3) the number of total salts dissolved in water greater than 500. The average water salinity (TDS) in Dakhla groundwater was 185.4 mg/L and ranged between 107 and 800 mg/L.

Suitability of the groundwater for irrigation purposes was discussed based on the basic criteria of FAO (1985). It was also observed that the water salinity as a primary indicator for water quality for irrigation was in the acceptable level for irrigation in all places (Tables ١)In general, the studied Dakhla groundwater salinity, chloride, and sodium figures (4,5) concentrations were within acceptable limit for irrigation, The permissible limit of the TDS, Cl, and Na according to FAO (1985) is 500 mg/L, 9.0 meq/L, and 10 meq/L, respectively **(Abbas M. Sharaky and Suad H. Abdoun, 2020).**

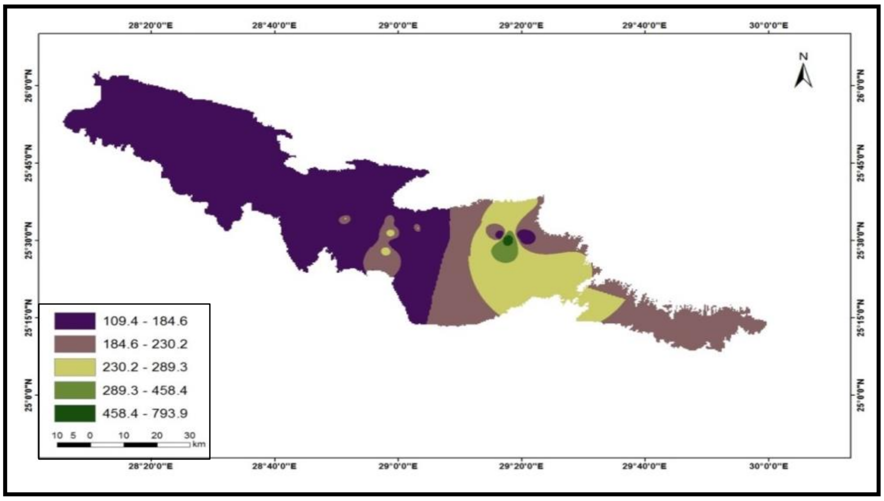

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Figure (3): Distribution of total dissolved salts in groundwater in mg / l.

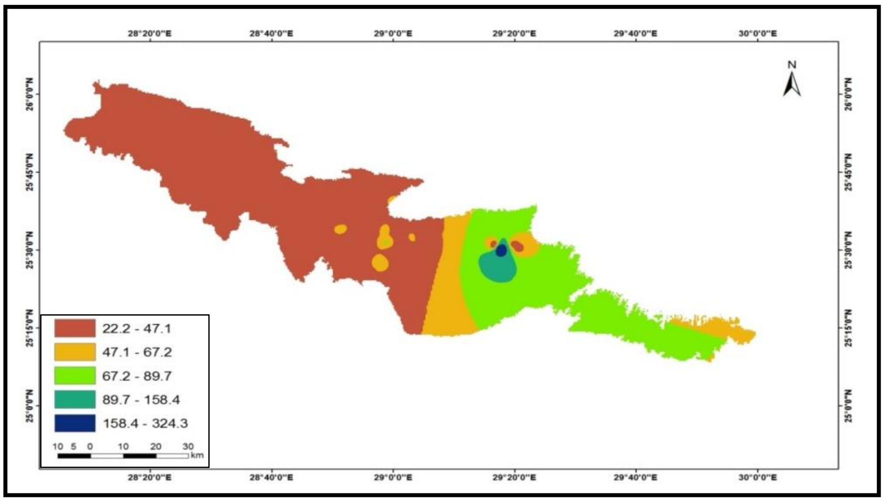

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Figure (4) Distribution of the dissolved chloride element concentration in mg /L.

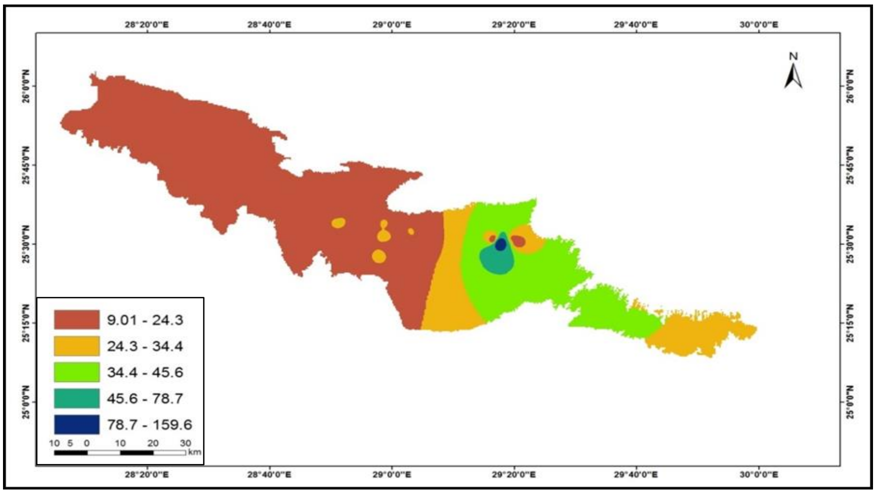

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Figure (5) Distribution of the dissolved sodium element concentration in mg / l.

Hydrogen ion activity (pH):

The pH of groundwater in the study area varies between 6.2 and 7.8with an average of 7.1. in general The pH of ground-waters was within the normal range except (Mut 41, Mut 32, Mut 35, Elhindaw 9, Eljadida 8-20, Elkaysar 15/2) figure (6) table (2), The slight acidity of groundwater may be derived from the dissociation of H_2CO_3 formed from the dissolution of CO_2.

Electric conductivity (EC):

Electric connection of water is the ability of water to conduct electricity through the transmission of electricity in water containing ions of mineral salts, The electric conductivity (EC) of water is directly related to the concentration of total dissolved ionized solids in water, The EC of groundwater in the Dakhla area ranges between 0.17 and 1.3 dS/m with an average value of 0.27 dS/m (Table 1). In general, the EC values are higher in the eastern south area of the Dakhla due to the increase of the salt content of groundwater in this area figure (7).

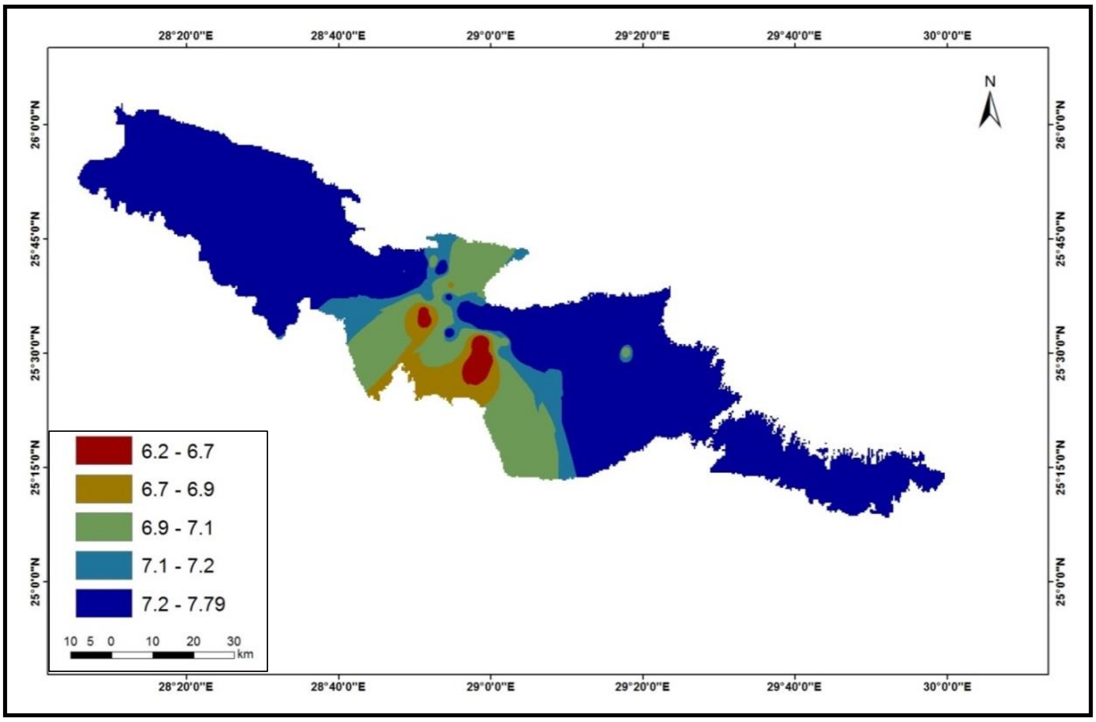

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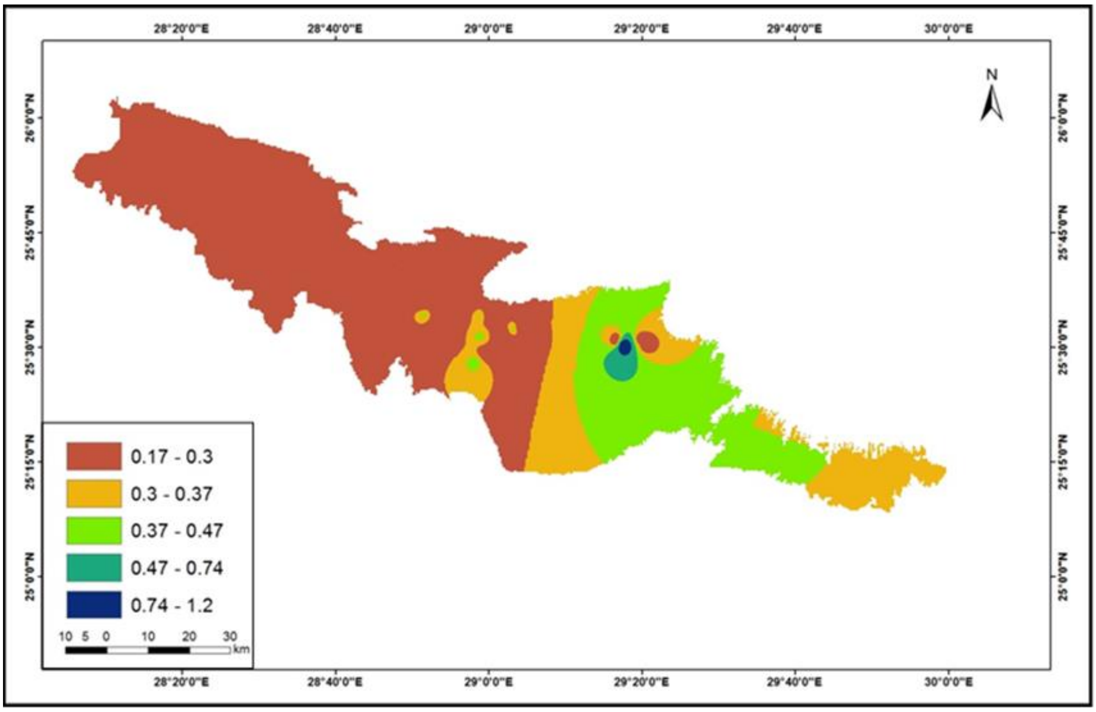
Figure (6) distribution of the degree of hydrogen ion concentration in mg / L.

Table (2)Classification of underground water in Dakhla according to international standards

Well Name	Cations				Anions			Fe pp	Mn ppm	PH	EC	SA R	TDS PPM	USDA 1954	FAO 1992
	N	K	C	Mg	C	Hc	so4								
Al-Rashda	9	19	8.	6.5	22.	48.4	23.1	2.4	0.25	7.4	0.19	0.57	115	C1-S1	Not
Elsheikh	22	16	12	7.22	37	35.7	48.9	5	0.4	7.2	0.28	1.32	170	C2-S1	Not
Sheikh	12	12	10	5.7	23.	45.8	24	3.8	0.3	7	0.19	0.74	115	C2-S1	Not
Teneida 16	20	20	8	5.8	32.	58.6	20.0	1.3	0.3	7.4	0.23	1.31	140	C1-S1	Not
Teneida	13.	24	8	7.29	34.	40.7	11.4	1.3	0.15	7.5	0.21	0.83	130	C1-S1	Not
Teneida	16	21	56	28.1	32	38.2	112.	9.6	0.35	6.9	1.3	4.38	800	C3-S1	Little
Asmant 2-	12	23	8.	5.7	28.	45.8	30	3.1	0.3	7.5	0.22	0.77	132	C1-S1	Not
Asmant 3-	34	7	27	9.14	68	40.7	56.1	3.5	0.2	7.8	0.4	1.43	240	C1-S1	Not
Maasara	13	18	9.	5.29	23.	45.8	33	2.9	0.3	7.3	0.22	0.84	135	C1-S1	Not
Mut 41	30	8	26	10.5	60.	38.2	77.1	9.2	0.4	6.4	0.42	1.24	255	C2-S1	Not
Mut 32	12.	18	9.	5	22.	35.6	32.7	2.2	0.06	6.7	0.20	0.83	120	C1-S1	Not
Mut 35	10	18	7.	6.25	25.	15.2	56.1	3.8	0.3	6.5	0.22	0.64	136	C2-S1	Not
Ain-	13	22	52	22.8	23	22.9	161.	10.2	0.5	7.3	1.06	4	640	C3-S1	Little
Elhindaw 9	33	7	28	11.0	71	38.2	69	8.6	0.4	6.2	0.43	1.33	260	C2-S1	Not
Elhindaw	13.	15	12	7.5	22.	50.9	40.2	4.8	0.08	7.1	0.25	0.75	155	C1-S1	Not
Badkhalo	10	17	7.	5.29	22.	43.3	19.2	2	0.2	7.3	0.19	0.67	115	C1-S1	Not
Badkhalo	10	17	7.	5.29	23.	43.3	19.8	4.2	0.1	7	0.18	0.67	113	C1-S1	Not
Elkadaa	20	12.	9.	5.29	34.	2.03	54	6.8	0.2	6.9	0.25	1.29	150	C1-S1	Not
Eljadida 8-	36	7	24	9.6	68.	30.5	67.5	9.8	0.3	6.5	0.39	1.56	235	C2-S1	Not
Elmoshee	10	15	8	5.3	23.	38.2	27.9	3.4	0.02	7.2	0.18	0.67	113	C1-S1	Not
Elkasr /	20	10	19	8.66	41.	40.7	51.9	1.6	0.2	6.9	0.28	0.95	173	C2-S1	Not
Elkasr/5	12	18	10	5.8	24.	21.6	48	1	0.01	6.9	0.21	0.74	131	C1-S1	Not
Elkasr /20	10	13.	11	7.2	23.	48.4	24.5	14	0.2	7.5	0.19	0.57	117	C1-S1	Not
Elkasr	22	8	20	7.6	41.	40.7	55.2	6.2	0.2	6.9	0.30	1.05	180	C2-S1	Not
Elkasr 4-	21	11	20	7.29	40.	43.3	52.3	2.8	0.02	7.3	0.28	1.02	170	C2-S1	Not
Elmawhoo	11	15	11	5.8	23.	51.4	27	2.9	0.2	7.7	0.20	0.66	124	C1-S1	Not
Elmawhou	23	9	21	6.3	38.	43.3	54	2.8	0.3	7.7	0.29	1.12	175	C2-S1	Not
Elmawhou	18	8	18	5.3	30.	43.3	46.2	14.1	0.4	7.3	0.25	0.95	150	C1-S1	Not
Arab	18	9	15	6.25	32.	35.6	45	6.1	0.4	7.5	0.25	0.96	155	C1-S1	Not
Elmawhou	22.	7	22	8.51	44.	38.2	59.4	4.9	0.3	7	0.31	1.03	188	C2-S1	Not
Elmawhou	44	11	21	11.5	65.	48.4	72	3.7	0.3	7.3	0.41	1.91	250	C2-S1	Not
Elkaysar	15	11	15	7.29	33.	43.3	27.3	6	0.05	6.8	0.23	0.79	140	C1-S1	Not
Elkalamoo	20	13.	9.	6.2	32.	38.2	39.9	5.2	0.02	7.4	0.25	1.24	150	C1-S1	Not
Elkalamoo	12.	23	9.	4.8	25.	25.4	42.9	3	0.02	6.9	0.21	0.82	130	C1-S1	Not
Eljadida 17	18	13.	9.	5.3	29.	35.6	39	5	0.35	6.6	0.22	1.16	135	C1-S1	Not
Arab	24	8	20	10.2	52.	40.6	47.1	6	0.9	6.9	0.30	1.09	185	C2-S1	Not
Al-Awinah	30	9	23	9.7	63.	43.3	55.2	4.4	0.4	7.4	0.38	1.32	231	C2-S1	Not
Al-Awinah	9	19.	7.	5.29	22.	38.2	27	4.2	0.4	7.4	0.17	0.62	107	C1-S1	Not
Balaat 5-	11	20	9.	6	28.	48.4	17.4	3	0.45	7.5	0.2	0.7	120	C1-S1	Not
Balaat /40	19	16	8.	6.25	28.	61.1	22.0	2.6	0.4	7.4	0.23	1.2	139	C1-S1	Not



Prepared by using ARC GIS 10.4 , depending on the analyzes of the sub-laboratory of the General Administration of Groundwater in Dakhla.

Figure (7): Distribution of the degree of electrical conductivity of groundwater in S / M

Heavy metals:

The concentrations of Fe^{2+}, Mn^{2+} were determined for all well, The range of concentrations of iron was between 1 and 14.1 ppm with an average value of 4.7 ppm table (2), figure (8).

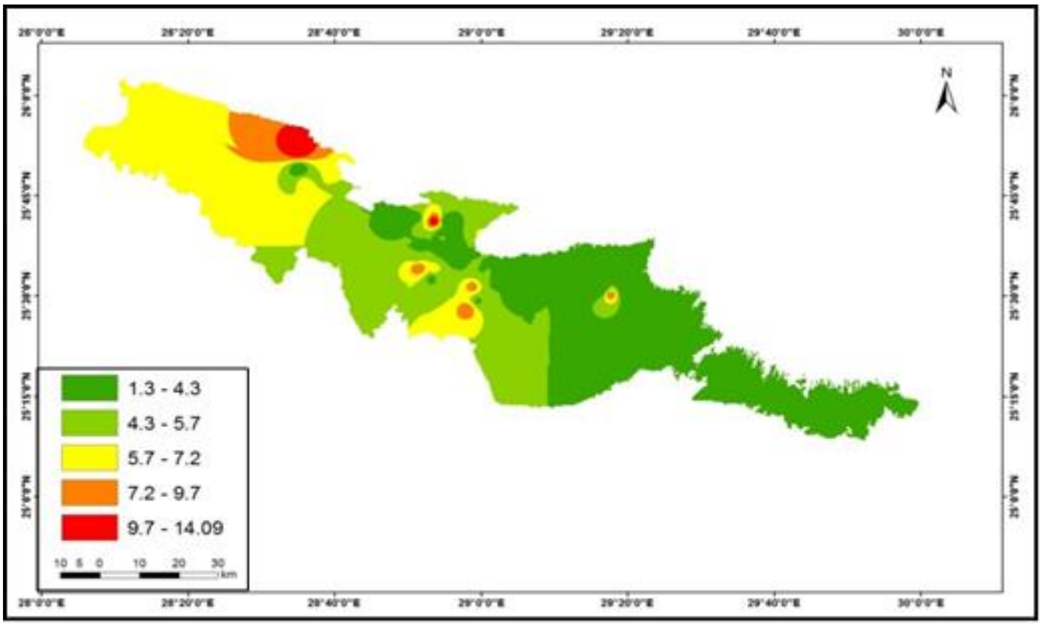


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Figure (8) distribution of the iron element concentration in mg / L

Concentrations of Mn lower than 0.1 ppm is usually acceptable for drinking water (WHO 2011). The average of manganese concentrations measured in groundwater in the Dakhla area was higher than the recommended WHO which recorded range between 0.01 and 8 ppm and average 0.45 ppm .figure (9), We found that the concentration of iron and manganese were than the required standards. Which makes this water need to be treated before use, and most of these scarce elements in the groundwater are attributed to the decomposition of the rock deposits that make up the underground reservoir, and the use of chemicals in agriculture such as fertilizer or pesticides; As the dissolved elements from this source may reach groundwater due to their leakage into the ground.

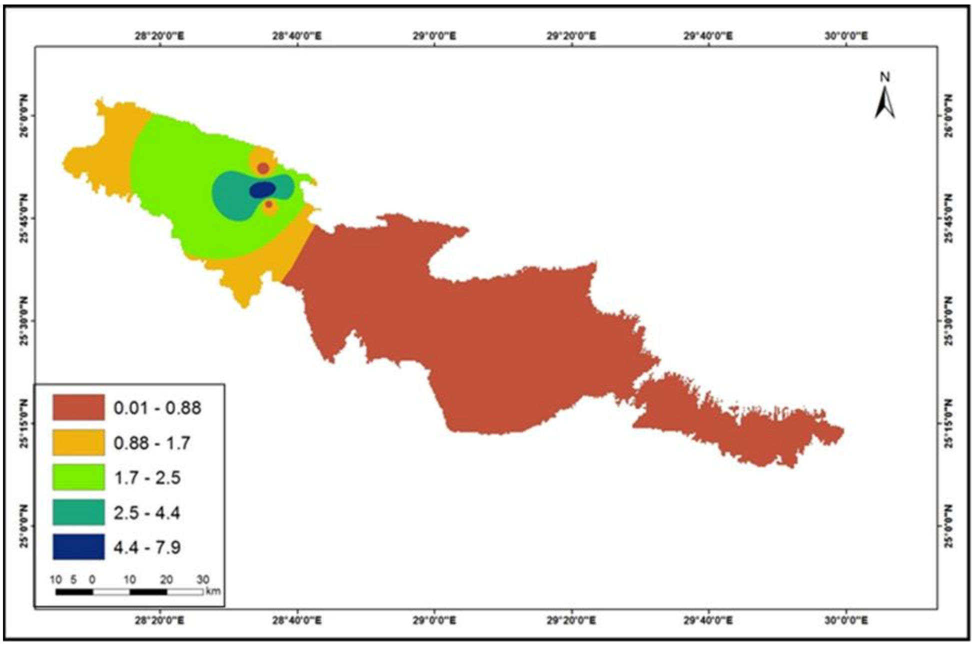

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Figure (9) Distribution of Manganese Element Concentration in mg / L.

Conclusion:

In order to use water to for several purposes, the percentage of impurities in it must be very small so that it does not cause any damage to humans, animals or plants, and the proportions of positive and negative ions and dissolved total salts determine the validity of the water and the permissible concentrations in water are determined based on studies It includes the human and plant need of these elements so that they are consumed without causing harm.

As a result of the difference in the degree of influence of these concentrations in different living organisms, it must be noted that the quality of water inside the low-lying varies from region to region, and there is a clear variation in the concentration of the main chemical elements from one area to another and from a well to another within the study area, but in general, the concentration of those elements is less than The permissible limits internationally which make the low water suitable for different purposes and uses, but it must also be pointed out that the high percentage of scarce elements, especially iron and manganese elements in some wells in the depression, so this water must be treated before use so as not to affect humans , Soil or animal, water uses have been divided into:

A-Groundwater uses for drinking purposes:

The drinking water depends on its content, the type of dissolved salts and their quantity. The chemical properties of the wells studied were compared with the international standard set by the World Food and Agriculture Organization, as shown in the table (2) that clarifies the classification of water salinity according to the FAO system (1992), which It includes limits for the concentration of salts not exceeding 500 mg /l, and limits for the degree of electrical conductivity.

By comparing the results of analyzes of the wells samples of the sites with the international Standards as evidenced by the table (2) that shows the classification of groundwater for the low-lying according to international standards, and by studying the table it is clear that the underground water is valid for drinking as the concentration of salts and the degree of electrical conductivity in most of the wells did not exceed the permissible limits With it globally, as the concentration of salts in most wells is less than 500 mg / l, and the degree of electrical conductivity did not exceed 0.7 S / m, except for a very small number of control wells in which the concentrations exceeded the permissible limits, such as a well (Teneida 3 / 19) , The salt concentration exceeded the permissible limits, it reached about 800 mg / l, and the degree of electrical conductivity reached about 1.3 S / m, as well as (Ain Al Hassan), where the concentration of salts reached about 640 mg / l, and the degree of electrical conductivity reached 1.06 S / M .

B- Agricultural use:

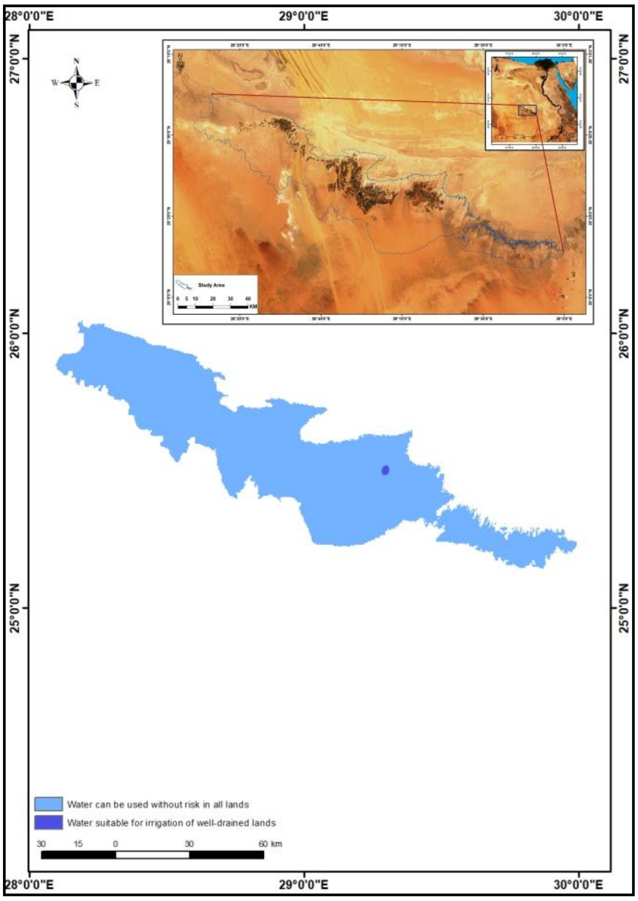
The quality of irrigation water denotes its mineral composition and also illustrates its effects on plants and soil. It is correlated with the type of soil and plant ecosystem and their management (Khanoranga, Sofia Khalid,2018). The quality of the water allocated to irrigation is determined according to the quality and seasons of the year and an assessment of the validity of the water for irrigation based on several units that include the concentration of sodium ion, its absorption ratio, and the composition of the main and salty elements. The concentration of sodium in agricultural use of groundwater is of great importance due to its harmful impact on the properties of natural soils, If its concentration increases, the permeability of the soil will decrease, and the degree of sodium concentration in irrigation water affects the percentage of sodium exchanged in the soil. Therefore, groundwater is classified based on the percentage of sodium absorption, and when comparing the concentration of salts and the degree of electrical conductivity of a group Wells with the international specifications of the World Food and Agriculture Organization and the American Salinity Factory (USDA,1995), as shown in the table (2) It became clear that all the control wells are suitable for irrigation and agricultural use, as the water in most of the wells is characterized as unsalted water and low salinity, which makes them suitable for irrigation for most of the Crops, since the percentage of salt concentration in most wells was less than 1500 mg / l, and the degree of electrical conductivity did not exceed 2 dSi / m, and the rate of sodium absorption was less than 10 cents mol / l.

And depending on the classification of water according to its suitability for irrigation and according to its salinity in Egypt table (3) and figure (10) , It was found that the study area falls into the first and second categories, and that most of the study area is suitable for irrigation, as the area of land suitable for irrigation is without danger 5295.9 km2 which represent 99.7 % from total area , While the area of the low-risk water area is cover 13.8 km2 which represent 0.3 %.from total area.

Table (3) Classification of water according to its suitability for irrigation according to its salinity in Egypt

The validity of irrigation	Total dissolved salts (ppm)	Degree of electrical conductivity (millimouse/cm)	Severity category
It can be used without risk in all lands	Less than 500	Less than 0.75	Very low
It is suitable for irrigation of well-drained lands	500-1100	0.75=1.75	low
It can be used in lands with good permeability and drainage	1100-2000	1.75-3	medium
It can only be used with highly salt-tolerant crops in well-permeable and well-drained soils	2000-3200	3-5	dangerous
Not suitable for irrigation except in very special circumstances	3200 and more	٥and more	Very dangerous

Source : Suliman , 1983, p.16.



Prepared by using ARC GIS 10.4 , depending on the analyzes of the sub-laboratory of the General Administration of Groundwater in Dakhla.

Figure (10) Classification of water according to its suitability for irrigation

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