American Journal of Engineering Research (AJER) **2023**
American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-12, Issue-7, pp-35-43
www.ajer.org
Research Paper Open Access

Assessment of Drinking Water Human Health Risk by Nitrate Pollution Indexes: A case Study for the Ground Water Wells in the Western Part of Jifarah Plain Area, Libya.

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ABSTRACT: *High nitrate values in ground water wells has the potential to cause a series of harmful effects on the human health. The objective of the present study is to assess the drinking water health human risk by nitrate in the ground water wells of the Western part of Jifarah plain area as a representative to be a base line for following studies and criteria for the public health. Thirty ground water samples collected in December 2022 and analyzed for nitrate. The results showed that the concentrations of nitrate varied from 11.7 to 57.22 mg / l with a mean value of 34.42mg / l. The results also showed that a round 16.66 % (5samples) had high levels of nitrate. The levels crossed the permissible limit recommended by the world health organization (50 mg/l).From the findings the Nitrate Pollution Index (NPI) and the Modified Nitrate Pollution Index (MNPI) were estimated and the ground water samples were classified into; unpolluted, light pollution, and Moderate pollution. This study revealed that the high values of nitrate are probably due to the agricultural activities such as, fertilizers application for a long period that had negative influence on the ground water nitrate or due to the discharge of untreated wastewater into the ground. Furthermore, the septic tanks and sewers become overloaded during the wet season. It`s also revealed that the most of the ground water wells are suitable and can be used for drinking purposes. The remains should undergo to the treatment to reduce the high levels of nitrate. Residents in the study area have to be educated environmental awareness on the health and water quality. Regular analysis should be carried out to monitor the concentration of nitrate in the ground water in the study area.*

KEYWORDS: *Jifarah plain, Libya, nitrate, index, ground water, pollution.*

Date of Submission: 16-07-2023 Date of acceptance: 31-07-2023

I. INTRODUCTION

Most of nitrogen of the earth (> 98 %) is found in the lithosphere, either in crust of the earth, in igneous and sedimentary rocks, oceanic sediments or in soils. 2 % of it is in the atmosphere, the hydrosphere and biosphere. The form of nitrogen in the atmosphere is mainly inert gas, and comprises 78 % of its volume. In the hydrosphere, nitrogen occurs in dissolved forms, some of which are organic, but more commonly in simple inorganic forms. In the biosphere that consists of living plants and animals, it occurs mainly in in organic forms that are often complex, but also in simple inorganic forms. The content of most soils and ranges between 200 and 4000mg/kg with an average of 1400 mg / kg soil [1].

Nitrate is one of the most common pollutants in the ground water worldwide, and its presence in high concentrations has negative influence on the water quality [2, 3]. It can be transported to the ground water via different sources such as, fertilizers application, septic tanks and wastewater effluents [4 – 6]. [7, 8] high values of nitrate in drinking water can cause infant methemoglobinemia (Blue baby syndrome). The pregnant women who consume water with high levels of nitrate are at high risk of having children with congenital abnormalities [9]. Whereas, [10] assessed the ground water quality, and associated health risk from nitrate pollution and found that its levels ranged between 1.9 and 750 mg/l with an average of 148.7mg/l. Similarly, the concentrations of nitrate of the Pliocene – Quaternary aquifer in the zone of Elberka, Tunisia ranged between 5.58 and 31mg/l [11].

While, [12] assessed the ground water nitrate and found that its values flocculated between 0.0 and 109 mg /l. with a mean value 2.97mg/l.

[13] Reported that the nitrate levels in the irrigated plain of Triffa, North – east Morocco situated between 2 and 153 mg/l, with 73 % of the observations exceeding the level of 50 mg/l recommended by world health organization. Likewise, nitrate concentrations in ground water were measured and the values ranged between 15.9 and 246.90 mg/l [14]. [15] Reported that the main sources of nitrate are related to wastewater disposal (on-site systems and leaky sewers), solid waste disposal (landfill and waste tips. The nitrate concentrations in groundwater in Hormozgan Province, Southern Iran, ranged from 0.3 to 30 mg/l, with an average of 7.37±5.61 mg/l [16]. Nitrate in the ground water in the Tenth of Ramadan area, Egypt, varied from 1.25 to 150mg/l [17]. Equally, [18] carried out a study to assess the chemical composition of the ground water in Diebeniana region, Tunisia, and reported that nitrate contents ranged between 1.3 and 78.3 mg /l with an average of 16.6mg/l. While, [19] assessed the ground water quality with special emphasizing the health risk posed by nitrate contamination. They found that its levels ranged between 7 and 94 mg /l, with an average of 28.94 mg/l. [20] Assessed the health risk of ground water in Hamdaniya District, Southeast of, Mosul, Iraq, with nitrate ions and found that its values varied from 0.41 to 16.4 mg /l. [21] conducted a research to assess the nitrate in ground water in the city of Chandrapur, Maharashtra, India. They noticed that nitrate levels was between 7.5 and 13.6 mg/l in October with an average of 10.91 mg/l, whereas, the concentrations were between 7.5 and 13.8 mg/l with an average of 11.36 mg /l in December.

While, [22] studied the Water wells in Abuja, Nigeria, and reported that there are seasonal variations between the concentrations of nitrate, where, its levels ranged between 0.3 and 33.90 mg /l with mean value of 5.14 mg /l in the dry season. Whereas, the concentrations in the wet season varied from 0.4 to 63.90 mg /l with an average of 14.40 mg /l. In addition, [23] assessed the hydro- chemical properties of ground water wells in a semi – arid region, Central Tunisia, and found that the levels of nitrate ranged between 26.33 and 130 mg /l. While, the nitrate values in the ground water in some rural areas of the Guanzhong Basin, China, ranged between 0.00 and 397 mg /l. with mean value of 92.9 mg /l [24]. Whereas, in the Southern Gabes aquifer, Tunisia, the nitrate was found in the range of 3.62 and 578.1 mg / l [25].

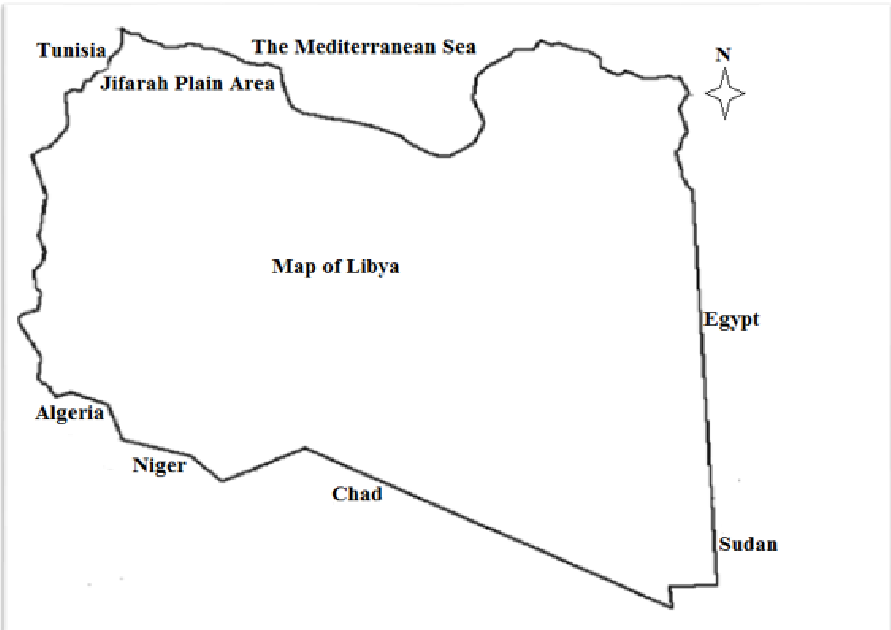
[26] Assessed the concentration of nitrate in the ground water in Eastern Nile Delta, Egypt, and noticed that its values varied between 0.00 and 82.08 mg / l. They also noticed that the contamination sources are sewage disposal and fertilizers application. The content of nitrate in the ground water wells in some areas, East of Nile Delta, Egypt ranged from 0.1 to 337.6 mg/l with a mean value of 47.8 mg /l [27]. Similarly, [28] reported that the nitrate in ground water in the lower ketar watershed, Ethiopia, was in the range of 0.58 to 4.5 mg /l with an average of 1.57 mg / l. Nitrate in the subsurface water in Nanganur region, South India, varied from 25 to 198.7 mg /l with a mean value of 66.14 mg /l [29]. Whereas, [30] studied the ground water chemistry from Wadi Asal, wadi Queih, Egypt, and found that nitrate levels ranged between 0.21 and 4.36. [31] Carried out a study to assess the nitrate levels in the ground water in Semi – arid region, South India, and reported that its values varied from 24 to 78 mg /l with a mean value of 46.45mg /l. Ground water wells in the Northern Yarmouk contain high concentrations of nitrate, where, its levels varied between 1 and 795mg/l with an average of around 46mg/l [32]. While, [33] assessed the groundwater quality and found high values of nitrate ranged between 1 and 61 mg/l. The ground water nitrate in Shebna region, Benghazi City, Libya, varied between 0.42 and 3.89 mg/l [34]. [35] Assessed the ground water nitrate in Columbia County, Wisconsin and reported that the concentration varied between 22.9 and 27.4 mg /l. They also, reported the blue baby syndrome phenomenon during the study period. Similarly, [39] found that the nitrate level in the ground water wells in Alagilat Area, Libya varied between 22.07 and 239.4 mg / l with an average of 121.26 mg/l.

II. METHOGOLOGY

Jifarah plain area located between latitude 32° 30` and longitude 12° 30`, Northwest of Libya. It cover an area of 20000km2 and heavily populated along the coast. The area bounded on the north by the Mediterranean Sea coast; on the south by Nafusa, mountain .It also shares an international boundary with Tunisia to the west Fig.1. The area topographically is a low lying; its topography rises slowly from the sea level along the coast to 200 m at the foot of the escarpment of Nefusa Mountain. The maximum temperature is about 45°C and minimum 20°Cwith an average annual rainfall varies between 300 and 100mm. It has a dry climate with hot summer and cold winter. The main aquifers, which play a major role in the ground water flow in the Jifarah plain are the Upper Miocene, Pliocene and Quaternary, the Middle and lower Miocene, and Triassic formation [37]. Groundwater considered the main source of water supply in the area. The dominant soils are sandy, clay and salty soils. Economically, Jifarah plain is considered one of the most important plains in Libya, the described area is known as an urban and rural area that the society mostly depends on its land resource for the human consumption. A round 60% of the irrigated areas situated in this region. The agriculture considered one of the most important activities in the area where barley, wheat, peanuts, vegetables and fodder crops are grown.

No comprehensive studies have been done to assess the levels of nitrate in the Jifarah plain area. The current study aims to assess the human health risk pollution of nitrate in the ground water wells at Jifarah plain area as a representative region to be a base line for subsequent studies and criteria for the health of the community. The sites of the sample collection equally distributed between three locations of Jifarah plain area namely, in the mountain of Nafusa, at the foot of the mountain, and the Coastal plain.

The Global-positioning system (Garmin`s GPS map 76CSx) was used to locate the ground water wells. Thirty ground water samples were collected in December 2022 from the Cities, and the Towns that are located on those sites. The samples collected from public wells, private wells, water sources in the health centers, and schools. First, the water left to run for few minutes from the wells to pump out the standing water before taking the final samples. The samples were collected in pre cleaned sterilized polyethylene plastic bottles of 1L capacity then the samples were placed in clean containers and immediately put in ice boxes. The iceboxes transported to Tripoli, where the analyses of nitrate carried out by DR 3800 SC VIS Spectrophotometer technique in the laboratories of Sadeem Company for laboratories technology. Software such as, Excel 2013 and sigma plot v 10 were used for the analysis of the Data and visualization of the results. From the current results Nitrate Pollution Index (NPI) indicated by [32] was used to estimate the NPI for samples by the equation (NPI= Cs – HAV/ HAV). Where, NPI = Nitrate pollution Index, Cs = the analytical nitrate concentration value in the ground water sample, HAV= Human Affected Value = 20 mg/l. Furthermore, the modified Nitrate Pollution Index (MNPI) modified by [36] was used to estimate the MNPI by via the equation (MNPI= Cs – NSV/ NSV). Where, Cs = the analytical nitrate concentration value in the ground water sample, NSV= Nitrate Standard Value = (50 mg /l) recommended by (WHO, 2017). The samples were classified based on NPI and MNPI "Tables 1&2" The concentrations of nitrate expressed in mg L -1 and the results were compared with the standard limit recommended by world health organization [38].



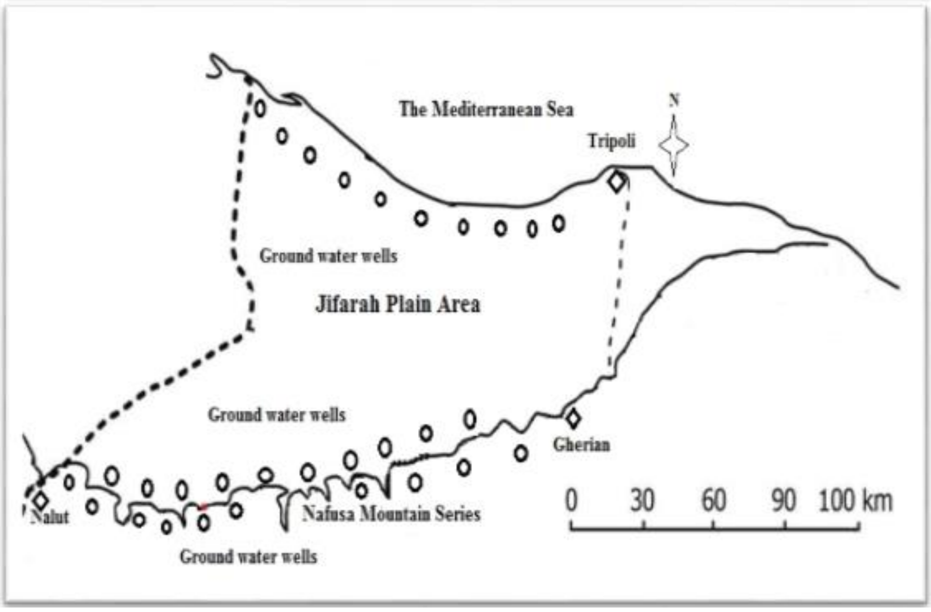


Fig. 1. Map of Libya showing the study area (Jifarah plain area)

Table. 1. Nitrate Pollution Index (NPI) according to (32)

NPI	Value	< 0	0 – 1	1 - 2	2 - 3	>3
	Class	UNP	L.P	M.P	S.P	V.S.P

UnP = Unpolluted, L.P = Light Pollution, M.P = Moderate Pollution, S.P = Significant Pollution, V.S.P = Very Significant Pollution.

Table. 2. Modified Nitrate Pollution Index(MNPI) according to (36)

MNPI	Value	< 0	0 – 2.5	2.5 - 5	5 – 7.5	>7.5
	Class	UNP	L.P	M.P	S.P	V.S.P

UnP = Unpolluted, L.P = Light Pollution, M.P = Moderate Pollution, S.P = Significant Pollution, V.S.P = Very Significant Pollution.

III. RESULTS AND DISSCUTION

The findings of nitrate analysis in the ground water samples of Jifarah plain area are displayed in Fig.2. The concentrations of nitrate in the samples varied between 11.7 and 57.22 mg /l with an average of 34.42 mg /l. The lowest concentration was measured in Nalut City. Whereas, the highest one was noticed in the Town of Zilten. The detailed outcomes are displayed in Fig.3 and Table.3. Nitrate levels in the ground water samples those were collected from the Cities and Towns located on the Coastal plain ranged between 31 and 57.22 mg / l with an average of 44.08 mg / l. The highest value of nitrate was noticed in the City of Zilten and the lowest value was measured in Alzawia City. The results from the ground water samples collected from the Cities and Towns at the foot of Nafusa Mountain showed nitrate values less than the levels that measured in Coastal plain area" Table 3". Where, the concentrations of nitrate ranged from 12.8 to 49.8 mg / l with an average of 29.47 mg / l. The lowest value was seen in the Town of Shakshuk and the highest one was recorded in the Town of Arrabtah. Whereas, the Cities and the Towns that located in Nafusa Mountain showed the lowest levels of nitrate in the ground water of the study area. Where, the values of nitrate were between 11.7 and 52.8 mg / l with an average of 29.7 mg / l. The lowest and the highest levels were observed in the ground water samples collected from Nalut and Alqwasim Cities respectively. The concentrations of nitrate that measured in the present study were higher than the levels found by [30, 34] but they were less than the nitrate concentrations obtained by [24, 27, 29].

As can be seen from Table. 3 the concentration of nitrate in the samples collected from the ground water wells on the coastal plain are higher than those samples collected from the wells located on the South of Jifarah plain area. This suggest that agricultural activities such as, fertilizers application for a long period had negative influence on the ground water or due to discharge of untreated wastewater into the ground in the study area. Furthermore, the septic tanks and sewers become overloaded during the winter season, similar, results was obtained by [15, 26]. The results revealed that 16.66 % of the taken samples (5 samples) crossed the acceptable limit of (50 mg / l nitrate) recommended by the world health organization [38]. Whereas, 83.34 % of the samples (25 samples) had nitrate, levels less than the permissible limit (50 mg / l).

The current results of the nitrate pollution index (NPI) Table. 4 showed that 16.66% (5 samples) fell in the class of unpolluted samples, 46.66% (14 samples) were classified as lightly polluted, and 36.66% (11 samples) were fell in the class of moderate pollution. Regarding the modified nitrate pollution index (MNPI) the results displayed in Table. 5 showed that only 16.66% of the samples (5 samples) fell in the class of unpolluted waters. On the other hand, 83.34% of the samples (25 samples) classified as lightly polluted waters.

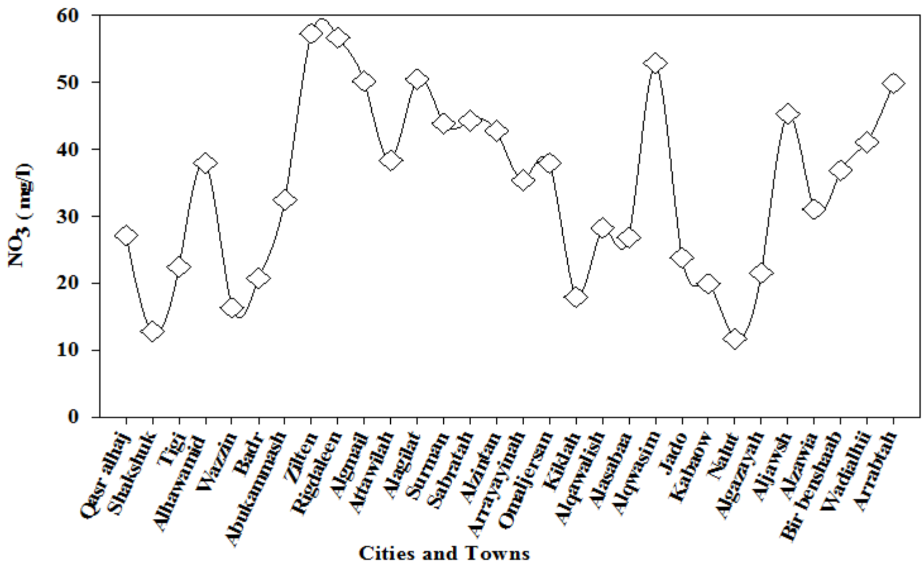


Fig. 2. Concentrations of nitrate in the ground water in the Cities and Towns of the study area

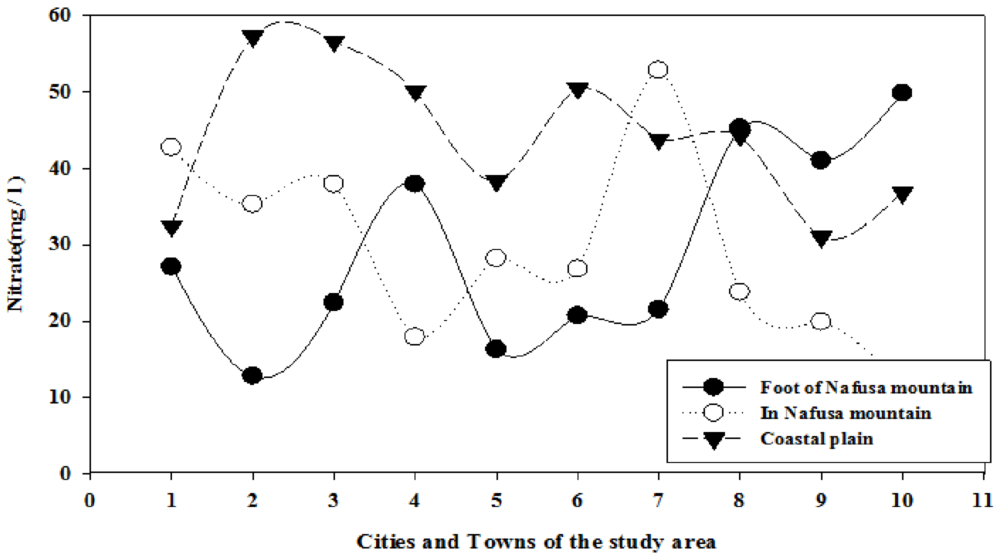


Fig. 3. Concentration of nitrate in the ground water in different sites of the study area

Table. 3. Concentrations of Nitrate (mg / l) in the ground water wells of Jifarah plain area

Coastal plain		Foot of Nafusa Mountain		In Nafusa Mountain	
City / Town	Conc	City / Town	Conc	City / Town	Conc
Abukammash	32.40	Qasr alhaj	27.10	Alzintan	42.70
Zilten	57.22	Shakshuk	12.80	Arrayayinah	35.30
Rigdaleen	56.60	Tigi	22.40	Omaljersan	37.90
Algmail	50.09	Alhawamid	37.90	Kiklah	17.90
Attawelah	38.30	Wazzin	16.30	Alqawalish	28.20
Alagilat	50.40	Badr	20.70	Alasabaa	26.80
Surman	43.80	Alagazayah	21.50	Alqwasim	52.80
Sabratah	44.21	Aljawsh	45.23	Jado	23.80
Alzawia	31.00	Wadi alhii	41.00	Kabaow	19.90
Bir benshaab	36.80	Arrabtah	49.80	Nalut	11.70
Mean	**44.08**	**Mean**	**29.47**	**Mean**	**29.70**

Table. 4. Concentration of Nitrate (mg/l) & Nitrate pollution Index (NPI) in the samples

Coastal plain				Foot of Nafusa mountain				In Nafusa mountain			
City / Town	Conc	NPI	Class	City / Town	Conc	NPI	Class	City / Town	Conc	NPI	Class
Abukammash	32.40	0.62	L.P	Qasr alhaj	27.10	0.36	L.P	Alzintan	42.70	1.14	M.P
Zilten	57.22	1.86	M.P	Shakshuk	12.80	-0.36	UnP	Arrayayinah	35.30	0.77	L.P
Rigdaleen	56.60	1.83	M.P	Tigi	22.40	0.12	L.P	Omaljersan	37.90	0.90	L.P
Algmail	50.09	1.51	M.P	Alhawamid	37.90	0.90	L.P	Kiklah	17.90	-0.11	UnP
Attawelah	38.30	0.92	L.P	Wazzin	16.30	-0.19	UnP	Alqawalish	28.20	0.41	L.P
Alagilat	50.40	1.52	M.P	Badr	20.70	0.04	L.P	Alasabaa	26.80	0.34	L.P
Surman	43.80	1.19	M.P	Alagazayah	21.50	0.08	L.P	Alqwasim	52.80	1.64	M.P
Sabratah	44.21	1.21	M.P	Aljawsh	45.23	1.26	M.P	Jado	23.80	0.19	L.P
Alzawia	31.00	0.55	L.P	Wadi alhii	41.00	1.05	M.P	Kabaow	19.90	-0.01	UnP
Bir benshaab	36.80	0.84	L.P	Arrabtah	49.80	1.49	M.P	Nalut	11.70	-0.42	UnP
Mean	**44.08**	**-----**	**------**	**Mean**	**29.47**	**------**	**------**	**Mean**	**29.70**	**-----**	**---------**

NPI= Nitrate Pollution Index , UnP = Unpolluted, L.P= light pollution, M.P = moderately pollution.

Table. 5. Concentrations of Nitrate (mg / l) & modified Nitrate pollution index (MNPI)) in the samples

Coastal plain				Foot of Nafusa mountain				In Nafusa mountain			
City / Town	Conc	MNPI	Class	City / Town	Conc	MNPI	Class	City / Town	Conc	MNPI	Class
Abukammash	32.40	-0.352	UnP	Qasr alhaj	27.10	-0.458	UnP	Alzintan	42.70	-0.146	UnP
Zilten	57.22	0.144	L.P	Shakshuk	12.80	-0.744	UnP	Arrayayinah	35.30	-0.294	UnP
Rigdaleen	56.60	0.132	L.P	Tigi	22.40	-0.552	UnP	Omaljersan	37.90	-0.242	UnP
Algmail	50.09	0.002	L.P	Alhawamid	37.90	-0.242	UnP	Kiklah	17.90	-0.642	UnP
Attawelah	38.30	-0.234	UnP	Wazzin	16.30	-0.674	UnP	Alqawalish	28.20	-0.436	UnP
Alagilat	50.40	0.008	L.P	Badr	20.70	-0.586	UnP	Alasabaa	26.80	-0.464	UnP
Surman	43.80	-0.124	UnP	Alagazayah	21.50	-0.570	UnP	Alqwasim	52.80	0.056	L.P
Sabratah	44.21	-0.116	UnP	Aljawsh	45.23	-0.095	UnP	Jado	23.80	-0.524	UnP
Alzawia	31.00	-0.380	UnP	Wadi alhii	41.00	-0.180	UnP	Kabaow	19.90	-0.602	UnP
Bir benshaab	36.80	-0.264	UnP	Arrabtah	49.80	-0.004	UnP	Nalut	11.70	-0.766	UnP
Mean	**44.08**	-------	------	**Mean**	**29.47**	---------	-------	**Mean**	**29.70**	--------	------

MNPI = Modified Nitrate Pollution Index, UnP = Unpolluted, L.P = Light pollution.

IV. CONCULSION AND RECOMMENDATIONS

The objective of this study was to assess the drinking water human health risk of nitrate in ground water in sites of the Western part of Jifarah plain area. Our results showed that the nitrate concentrations varied from 11.7 to 57.22 mg / l with an average of 34.42 mg/l. The results also showed that around 16.66% of the samples had high levels of nitrate. These levels crossed the permissible limit recommended by the world health organization (50mg/l). On the bases of the current findings, the Nitrate Pollution Index (NPI) and the Modified Nitrate Pollution Index (MNPI) were estimated and the ground water samples were classified into; unpolluted, light pollution, and Moderate pollution. The current study revealed that the high levels of nitrate probably due to fertilizers application or due to the discharge of untreated wastewater. However, we recommend that water treatment plants should be used to manage the wastewater; programs should be introduced to educate the residents' environmental awareness on the health and water quality. We also recommend that periodical analysis should be carried out to monitor the levels of nitrate in the ground water wells in the study area and around the whole Country.

ACKNOWLGHMENT

The author sincerely wishes to thank his family for their encouragement. The author also expresses his gratitude to Hossain M. Alakruoti for his help.

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