Valuation of Drinking Water Human Health Risk Using Nitrate Pollution Index (NPI): A Case Study for The Ground Water of Al-Hamdaniya District. Iraq

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Abstract
This current study aims to assess the health risks of water wells scattered in Hamdaniya district, southeast of the city of Mosul, with nitrate ions that have a serious effects on human health at high levels such as blue child syndrome and cancerous diseases: 20 wells have been identified to collect sixty water samples during the dry season to estimate Nitrate ion levels as well as the calculation of the nitrate contamination index (NPI).The results indicated that the concentration of nitrate ions in the studied water samples ranged between (0.41 to 16.4) mg.l-1 and a rate ranging between (1.23 to (9.66) mg.l-1, this relatively high levels of nitrate in most well water is due to pollution resulting from the use of agricultural fertilizers and sewage water etc., fortunately, there are no health risks to humans when using well water for drinking because the NPI values fluctuated between (-0.98 to -0.22), and thus the quality of the water wells understudy is classified as non-polluted water category.

Keyword: Groundwater quality, humans health risks of nitrates, Qarqosh, Iraq.

1. Introduction

Water is a blessing from God for all beings, as it is necessary for the vital activities of all living things. but tampering with water resources, poor handling, and tampering with this grace led to increased pollution, and thus reflected this pollution on the health, safety and economy of humans (Al-Saffawi, 2018a). The increasing population growth led to an increase in the need for food, which prompted the human being to increase the use of chemical fertilizers to increase agricultural production, which contributed to the increase in the concentration of nitrogen compounds in the water, whether surface or ground, as well as industrial projects and the development that took place in them and the resulting waste dumped into the environment, all of this contributed, directly or indirectly, to increasing the concentration of pollutants (including nitrate ions) in it.(Al-Hamdany and Al-Saffawi.
2018). Although nitrates are a natural pollutant of water, the increased excretion of organic waste (plant or animal), livestock manure, and sewage water lead to the formation of nitrate compounds due to the decomposition processes carried out by microorganisms (Ahmed et al, 2019; Huljek et al, 2019). The presence of increased concentrations of nitrate ions in drinking and food water has serious health consequences for consumers, which increases its health risks and its ability to accumulate in plant tissues and thus its transmission to animals and humans, the final consumer of the food chain (Al-Hamdany et al 2020) . As soon as nitrates enter the mouth, they are biologically reduced to nitrite ions by the bacteria in the oral cavity and under the tongue, and upon descent into the stomach, they may interact with amines and amides to form a group of N-nitroso (NOC) compounds, most of which have a carcinogenic effect in humans and animals, such as, Stomach, Colon, Rrectal, Bladder, Ovarian cancers, thyroid diseases and methemoglobinemia (Blue baby syndrome), etc. Unfortunately, exposure of pregnant women to increased concentrations of nitrates can cross the blood barrier in the placenta, causing health damage to pregnant women and fetuses, such as miscarriage, birth defects, children brain tumors and sudden infant death syndrome (Clausen et al, 2020). The mechanism of methemoglobinemia is represented by the oxidation of ferrous nitrite in the hemoglobin molecule (red blood cells) to the form of ferric Fe+3, causing methemoglobinemia (blue child. Syndrome), which reduces the blood's ability to transfer enough O2 to the cells of the body, especially children who are less Their age for the year, and they are the most vulnerable to methemoglobinemia (Met Hb), as well as the elderly and some patients, and when the (Mt-Hb) ratio reaches 25-50%, it causes Cyanosis, headache and Disorientation, and death occurs when the percentage reaches 60% (Gupta et al, 2008), as shown in the pictures (1). Most of the globally recorded cases occur in village residents who use well water with a high concentration of nitrates, and the risk of developing cancerous diseases increases when eating vegetables with high nitrate levels. Likewise, with thyroid cancer, nitrates work to confuse the gland's work on absorbing iodine, leading to lowering levels of the hormone triiodothyronine (T3) and thyroxine (T4), which

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stimulates the glands to secrete thyroid stimulating hormone (TSH) and this continues to cause hypertrophy, Hyperplasia and Neoplasia (Drozda et al, 2018; Khalil and Hammad, 2019; Al-Hamdany et al, 2020). After addressing the harmful effects of nitrates above, we must focus and conduct extensive studies. We may arrive at an explanation of some disease cases that have increased in recent decades, such as infertility, where one in six couples suffers from fertility problems and many of them are unclear the causes with the increased need for pregnancy with medical and therapeutic assistance causing social burdens (Weselak et al, 2008). Therefore, the current study for assessing the health risks of nitrates in well water to human health came as the first study in the region.

Pictures (1): Symptoms of blue baby syndrome are presented (nit).

2. Material and Methods

I. Explanation of the study area: The Hamdaniya district (Qarqosh) of the Nineveh governorate is distinguished as areas of an agricultural nature that depend mainly on the Groundwater scattered in the region for various uses. As for the topography of the region, the hills are spread in the northeastern parts and its lands are flat with some slight slopes in the southwestern parts (Al-Saffawi and Taalat, 2018) and confined between longitudes (44.3 "21'43 ° to 23" 23'43 °) east and two latitudes (48.3 "16'36 ° north); 20 wells were randomly selected, which are from The type of depth that exceeds its depths of 20 meters (Al-Saffawi and Ibn-Abubaker, 2019), as shown in Figure (1).

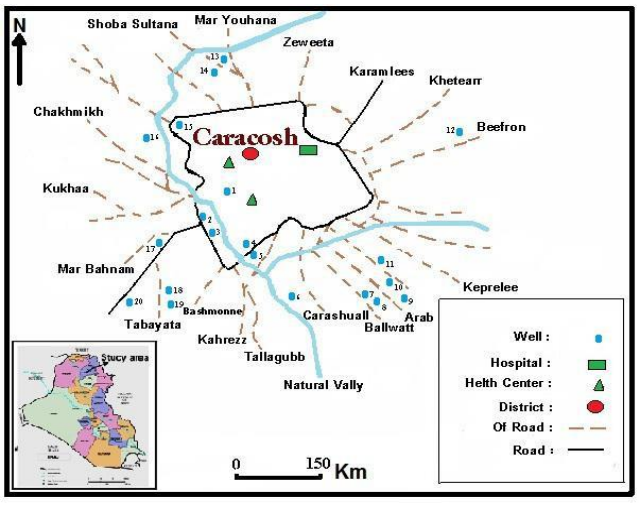

Figure 1: Al-Hamdaniya district, southeast of the city of Mosul in northern Iraq

is shown studied wells.

As for the geology of the region, it contains the Palaspi formation (Middle-upper Eocene), which is rich in limestone, and the formation of Al-Fatha (Middle-Miocene), which contains limestone, gypsum, anhydrite and evaporated salts, as well as yellow marl etc. (Al-Yousbakey et al, 2018; Al-Hamdani et al, 2021).

II. Methodology: Sixty water samples were collected from twenty wells distributed in the study area randomly starting from April until June using clean bottles of polyethylene washed with literally well water before filling. Ultraviolet screening methods were estimated by taking 50 ml of the sample and adding 1 ml of HCl (1N) with shaking to homogeneity of the sample, and the measurement is done by a UV spectrophotometer at a wavelength of 220 and 275 nm. After subtracting the two readings, the concentration is found in comparison with the standard curve as indicated by APHA, 1998. 2017))

III. Calculation Nitrate pollution index (NPI)

he current study was using the nitrate pollution index indicated by (Obeidat et al, 2012; Al-Hamdany et al, 2020) using the following equation:

NPI= Cs – HAV/ HAV

Where:

Cs: represents the concentration of nitrate ions in the water sample.

HAV: is the limit value of human sources (Human Affected Value) equal to 20 ppm. Then, the water quality is classified into five categories according to the NPI values

as indicated in Table (1).

Table (1): Classification of water quality according to NPI values.						
NPI	Values	< 0.0	0.0-1.0	1.0-2.0	2.0-3.0	> 3.0
	Class	Un P.	L. P.	M. P.	S. P.	V. P.
L.P.: Light Pollution., M.P: Moderate Poll., S.P.: Significant poll., V.P: Very poll.						

3. Results and discussion

The problem of nitrate contamination of drinking water is one of the main problems facing humans in most regions of the world, especially the third world countries due to limited control over water resources and sewage drainage, agricultural fertilizers, human and animal wastes that reach the water, whether it is surface or groundwater, and often concentrations of nitrate ions (NO_3) in groundwater are higher than in water of rivers and streams (Al-Saffawi 2018). Fortunately, the concentration of nitrate ions in the groundwater of the Hamdaniya district is still within the limits permitted by the World Health Organization (WHO. 2017), as the results are shown in Table (2) indicate that the concentrations ranged between (0.41 to 16.4) ppm, and at the rate fluctuates between (0.43 ± 0.03 to 15.7 ± 0.53) ppm.

I Table (2): Results of nitrate ion concentration (ppm), and nitrate pollution ndex values (NPI*) for groundwater of Al-Hamdania district.													
Wells	*min*	*max*	*mean*	*±Sd*	-NPI	Class	Well	*min*	*max*	*mean*	*±Sd*	-NPI	Class
1	4.86	4.93	8.89	0.03	0.56	Unp.	11	1.80	5.12	3.85	1.47	0.81	Unp.
2	5.40	5.70	5.57	0.12	0.72	Unp.	12	1.25	2.03	1.71	0.34	0.91	Unp.
3	6.85	7.10	6.98	0.10	0.65	Unp.	13	10.4	15.9	11.9	5.03	0.41	Unp.
4	3.80	4.20	4.00	0.16	0.80	Unp.	14	1.00	1.11	1.06	0.05	0.95	Unp.
5	3.42	3.56	3.49	0.06	0.82	Unp.	15	1.24	3.17	2.39	0.83	0.88	Unp.
6	2.73	3.27	3.00	0.22	0.85	Unp.	16	0.85	0.95	0.90	0.04	0.96	Unp.
7	2.86	3.10	2.99	0.10	0.85	Unp.	17	0.47	0.52	0.50	0.02	0.98	Unp.
8	3.87	4.10	3.99	0.10	0.80	Unp.	18	0.93	1.06	0.99	0.05	0.95	Unp.
9	15.1	16.4	15.7	0.53	0.22	Unp.	19	0.81	0.91	0.86	0.04	0.96	Unp.
10	2.24	2.48	2.32	0.10	0.88	Unp.	20	0.41	0.47	0.43	0.03	0.98	Unp.
** Un P: Un Polluted....., * All NPI values were below zero .*													

These results are relatively close to the findings of (Al-Saffawi, 2019b) for groundwater in the Nimrud district, southeast of Mosul, Iraq, which ranged between (1.2 to 19.0) ppm, (Talat et al, 2019) study of groundwater in some neighborhoods on the left side of Mosul city, which ranged between (1.0 to 12.0) ppm, the study of (Al-Sanjari et al, 2019) for groundwater in the village of Gleewkhan, south of Mosul city, ranging between (0.11 to 10.8) ppm, the study conducted by (Jaafar and Al-Saffawi, 2020) for the quality of groundwater northeast of Mosul city, which ranged from (0.99 to 13.0) ppm, and finally the results were also relatively more than the results reached by (Al-Saffawi and Awad, 2020) for groundwater in the village of Abu Wagna, northwest of Mosul city, which did not exceed the nitrate ion concentration rates of 1.638ppm. But when

The high levels of nitrate ions in some of the studied waters, especially wells (3, 9,
13) are attributed to contamination with organic matter and excreta such as human and livestock faeces that reach the water because most of them are hand dug and uncovered, and these wastes may be exposed to biodegradation processes by living organisms (Nitrification processes) where the amino acids decompose to form ammonia which is attacked by Nitrosomonas bacteria to form nitrites, and then nitrite is biologically oxidized by Nitrobacter to nitrate, as shown in the following equations (Al-Hamdany et al, 2020b):

$$R\text{-}NH_2 \longrightarrow OH^- + NH_4^+$$

$$NO_2^- + O_2 \longrightarrow 2NO_3^-$$

As for the rest of the well's water, especially (16, 17, 18, 19, and 20), they were
characterized by a low concentration of nitrates, the reason may be due to the possibility that nitrogenous and organic compounds may be difficult to reach the water, or because nitrates are reduced to nitrite and thus lose it in the form of nitrogen gas when oxygen is lacking by pseudo-bacteria, and this process is called denitrification, as in the following equations (Al-Mashadany, 2019; Al-Hamdany et al, 2020)

$$6NO_2^- + 3CH_3OH \longrightarrow 3N_2 + 3CO_2 + 3H_2O + 6OH^-$$

$$6NO_3 + 5CH_3OH \quad 3N_2 + 5CO_2 + 7H_2O + 6OH^-$$

$$8NO_3 + CH_4 + 8H^+ \quad 4N_2 + 5CO_2 + 14H_2O$$

Fortunately, the values of the nitrate pollution index (NPI) shown in Table (1), the values for all wells were negative, meaning below zero, as they ranged between (-0.98 to -0.22). Thus, the studied water is classified from the category of non-polluted water when used for drinking concerning the health risks of nitrate ions. These values are similar to the results obtained by (Al-Hamdani et al, 2020) for groundwater in some neighborhoods on the left side of Mosul city, which fluctuated between (-0.9 to -0.5). Finally, the low concentrations of nitrates and nitrites have a protective effect on the heart and blood vessels due to increased vascular elasticity in addition to their role in regulating blood pressure and vascular homeostasis (Parvizishad et al, 2017).

Conclusioalthough the concentration of nitrate ions in the studied water fluctuated from

low to relatively high, it is considered safe and non-polluting for nitrate ions. To protect the health and safety of consumers, we recommend that you treat this water by exposing it to sunlight to eliminate bacterial contamination and make it suitable for human drinking (Al-Saffawi and Al-Ma'atidi, 2018).

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