



Research Article

Application of the sub-indicator model to assess the suitability of groundwater for irrigation of livestock in Nimrud district, Nineveh Governorate, Iraq

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ABSTRACT

**Keyword:**

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This study assessed the quality of groundwater in the Nimrud area located in the southeastern part of Mosul, Iraq for drinking livestock by applying the weighted mathematical model (WQI). The area is characterized by rich agricultural potential especially the breeding of livestock and poultry. Ten wells were selected randomly in the study area during the dry season for sample collection and estimation of physical-chemical properties. The results indicate that 70% of the samples were of poor-quality water for livestock and poultry watering and, the rest were of good quality. This poor quality of water was attributed to the geological nature of the area, which leads to high rates of the studied properties, especially electrical conductivity, sodium and sulfate ions, which reached (5,069ppm, 664ppm, and 1,688ppm) respectively. The study recommended that desalinization and treatment of water be carried out before consumption by livestock for disease resistance and performance.

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INTRODUCTION

Water is basic to the life of all living things as plant and animal cells are composed of large

quantities of water. Most ancient civilisations flourished near water sources; while civilizations grew around the Nile Valley and

Mesopotamia, others like Mayan and Tokugawa civilisations perished due to lack of water. Man has practised breeding and domesticating livestock, which is difficult to practice without the availability of water sources, as it is an important activity to provide food. Foods such as meat, milk, eggs, wool as well as leather for the manufacture of fabrics, clothes, bags and shoes obtained from livestock form an important source of revenue to the national economy while also contributing to food security. However, it is recognised that dumping of sewage, agricultural and industrial wastewater and animal waste into water sources has led to poor water quality in most regions of the world. In developing countries, in particular, the effects of this on the health and safety of human and animal life, specifically on agricultural production have been recognised (Sinjari and Al-Saffawi, 2018).

While animals require clean water as humans, the water needs of livestock depend on size, amount of feed consumed, stage of growth, as well as environmental factors (Beaver *et al.*, 1989; Lardner *et al.*, 2005). Water represents 50-80% weight of animals; although this depends on the age and degree of lipid covering, water is necessary for the physiological processes that occur inside the animal's body, as well as a means of transporting nutrients, hormones and waste, a suitable medium for the occurrence of biochemical reactions. Water helps in digestion and regulating osmotic blood pressure, in addition to being an essential component of body secretions like saliva and milk. Water is important for lowering body temperature in the summer season to maintain the activity and vitality of the animal. This is achieved through the evaporation of water from the animal's respiration and the skin as well (Lardner *et al.*, 2005).

The fact that many people are ignorant of the fact that livestock is sensitive to both the taste and smell of drinking water is worrisome; in

many Third World countries, many people believe that animals can drink any type of water regardless of its quality. However, animals, livestock in particular usually drink poor quality water only when there is no choice, which limits their drinking of water, and thus may cause a decrease in their productivity (Willms *et al.*, 1996 Deshmukh, 2013; Umar *et al.*, 2014.) Research has indicated that heifers with access to clean water gained weight by 23% compared with those consuming untreated water from ponds (Willms *et al.*, 2002). Researchers have shown that cattle that consume high salinity water have decreased milk production than those depending on natural water and milk production also declines in summer compared to winter. The latter may be attributed to the low temperature in reducing the impact of salinity on the health and productivity of animals (Sharma *et al.*, 2017; Kewalramani *et al.*, 2018; Tausifi *et al.*, 2018). Drinking high saline water by pregnant livestock, lactating animals and poultry may negatively affect the health of the fetus and poultry productivity (particularly turkey). These risks can be life-threatening and could lead to death (Marx and Jaikaran, 2007). High sulfate levels in drinking water can initially cause diarrhoea, but also an unwillingness to drink water which leads to Polioencephalomalacia (PEM) in calves (Lardner *et al.*, 2005; Schroeder, 2015). In general, watering livestock with treated safe and healthy water increases their resistance to diseases, (hence better performance), while the costs of treating water are recovered through increasing productivity and performance within a short period (Umar *et al.*, 2014). Therefore, this study evaluates the quality of groundwater in the Nimrud area for livestock use in Iraq.

## **MATERIALS AND METHODS**

### **Study Area**

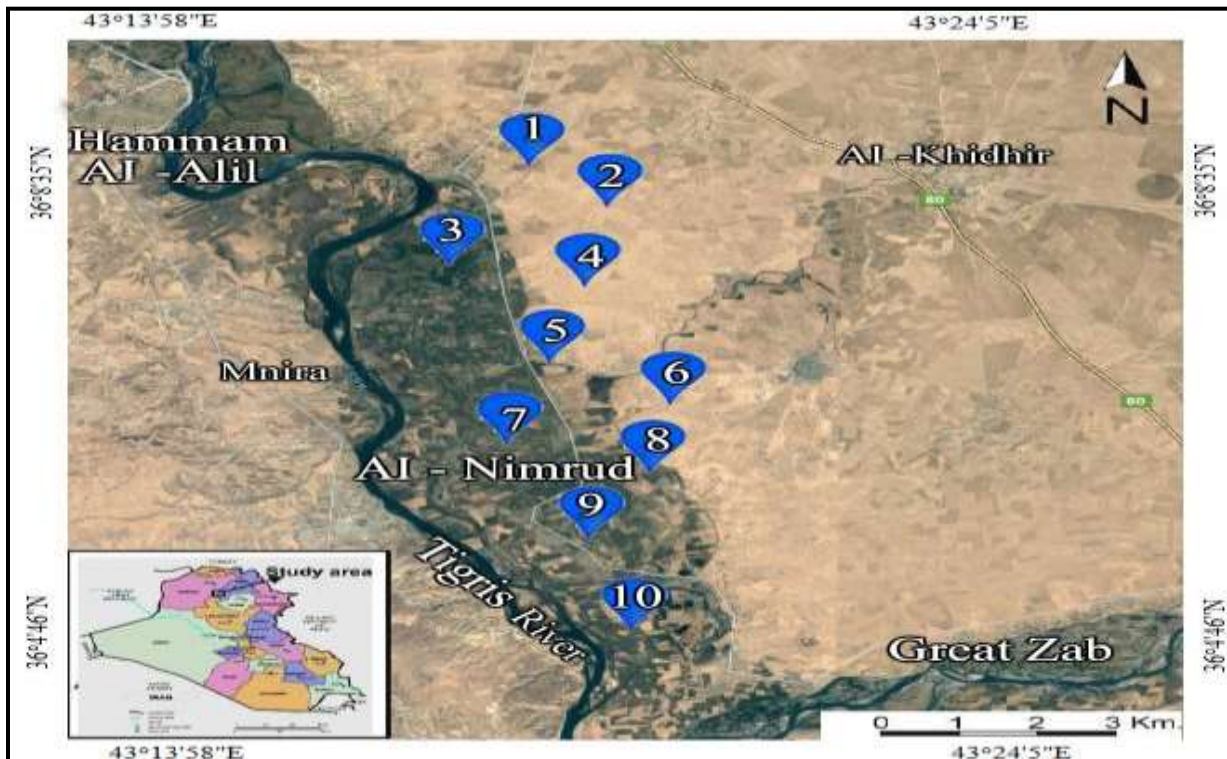
The Nimrud sub-district of Iraq is an agricultural area characterized extensive livestock production. It is situated southeast of

Mosul and located between latitudes 36° 4' 46''N and 36° 8' 35''N, and longitudes 43° 13' 58'' and 43° 24' 5'' E (Figure 1) with an elevation of 320 m above sea level. Geologically, Nimrud District of Iraq is underlain by the presence of Al-Fatha (Lower Fars) which are composed largely of evaporated salts, anhydrite (CaSO<sub>4</sub>), gypsum (CaSO<sub>4</sub>.2H<sub>2</sub>O), limestone and marl etc. These salts and minerals together affect the quality of groundwater (Al-Hamdani and Saffawi, 2018; Sardar *et al.*, 2018).

**Collection and Processing Samples**

Water samples were collected during the dry season (four replicates) at a rate of one sample per month from each well using clean polyethene bottles. Some physical characteristics such as taste, odour and colour were also observed in the field while inquiring

of the local population about any phenomenon observed in the water. These samples were transferred after being kept in a cooler box and away from light until reaching the Environment and Pollution Laboratory at the College of Education for Pure Sciences, the University of Mosul for analysis. All of the physical and chemical parameters including acidity as measured by the power of Hydrogen (pH) total dissolved solids (TDS), total hardness, and concentration of calcium, magnesium, sodium, potassium, sulfate, chloride and nitrate ions were determined using international standard methods (APHA, 1998, 2017). To assess water quality for watering livestock, the water quality index was calculated using the Weighted Mathematical Model used by many researchers (Boateng *et al*, 2016; Ramadhan *et al*, 2018; Dawood *et al*, 2019). This was applied to 10 parameters.



**Figure 1:** The Study Area Showing Sample Points

Figure (1): Represented the sites of studied wells at the Nimrod subdistrict.

The following four stages were used to calculate the WQI:

**1. Stage I:**

The weight *w<sub>i</sub>* was assigned to each parameter in proportion to its importance, ranging from 1-5, for nitrate, which has a weight of five for its importance and its effects on livestock, while one weight for potassium is given for its lack of presence and its effect on health as shown in Socha *et al.* (2003), Waldner and Looper, (2001) and South Africa, (1996) in Table 1 cited in Al-Saffawi, Al-Assaf and Talat (2020).

**2. Stage II:** Relative weight was calculated according to the equation (1):

$$W_i = \frac{w_i}{\sum_{i=1}^n w_i} \quad \text{-----(1)}$$

Where:

W<sub>i</sub>=relative weight

w<sub>i</sub>= weight of the parameter.

**3. Stage III:** to determine the quality rating (q<sub>i</sub>) from equation (2):

**Table 1:** Water Quality Parameters and their Values used in Calculating WQI

Parameters	Si*	w <sub>i</sub>	Relative W <sub>i</sub>
Temp <sub>t</sub> . °C	20-28	3	0.09090909
pH	6.0-9.0	4	0.12121212
EC <sub>25</sub> µS.cm <sup>-1</sup>	1600	4	0.12121212
T. Alkalinity	1000	2	0.06060606
Ca <sup>+2</sup>	1000	2	0.06060606
Mg <sup>+2</sup>	500	2	0.06060606
Na <sup>+1</sup>	300	3	0.09090909
K <sup>+1</sup>	20	1	0.03030303
Cl <sup>-1</sup>	300	3	0.09090909
SO <sub>4</sub> <sup>=</sup>	500	4	0.12121212
NO <sub>3</sub> <sup>-1</sup>	133	5	0.15151515
<b>Σ</b>		33	0.99999999

(\*Socha *et al.*, 2003; Waldner and Looper, 2001; South African, 1996)

$$q_i = \frac{C_i}{S_i} \times 100 \quad \text{----- (2)}$$

where:

C<sub>i</sub>= value of the measured property

S<sub>i</sub>= standard limit of the parameter.

**4. Stage IV:** Calculation of sub index: the values of S<sub>li</sub> and WQI were calculated from the equations (3, 4):

$$SL_i = W_i \times q_i \quad \text{----- (3)}$$

$$WQI = \sum SL_i \quad \text{----- (4)}$$

The result was compared with the classification values of water quality on Table 2 as suggested by Al-Saffawi and Alshuuchi (2018).

Table 2: Classification of water quality according to calculating values of (WQI).					
WQI value	< 50	50 - 100	101 - 200	201 - 300	> 300
category	Excellent	Good	Poor	Very poor	Unfit

## RESULTS AND DISCUSSION

### Physical Properties

Through the field survey of the groundwater studied, most of the water studied was transparent, colourless and odourless, but had a bitter taste and relatively high salt, as residents indicated that the livestock newly arrived in the area. This water is not easily tolerated and this is accompanied by cases of diarrhoea for livestock, but with time the livestock adapt and cases of diarrhoea gradually decreased.

Water temperature has a significant important influence in ascertaining the quality of livestock. This tends to affect the livestock feed and water intake, milk yield, respiration rate and general performance etc. (Pereyra *et al.*, 2010; Umar *et al.*, 2014). Results further indicate that the water studied has only a slight fluctuation in temperature (Table 3); the temperature ranged between 19.3°C and 22 °C,

with a standard deviation, not exceeding 2°C. This is within the desired limits of livestock, so this property of groundwater will encourage animals to drink water both in summer and winter (Pereyra *et al.*, 2010; Huuskonen *et al.*, 2011)

As for salinity, most samples exceeded the recommended limits for livestock watering, which ranged from (1,835 to 5,068) uS. cm<sup>-1</sup>. This increase in values is attributable to the nature of the geology of the area, which is rich in salts, gypsum and anhydrite. (Al-Saffawi, 2019; Al-Saffawi *et al.*, 2020). High, level of water salinity leads to increased salivation, seizures, vomiting, diarrhoea, blindness etc. Rumen could provide a buffer for salinity but could lower water consumption if the concentration is high. Avian species respond to excessive salinity by showing reduced food and water intake, so reproductive rates and weight gain are also reduced Valtorta

**Table 3:** Average\* results and standard deviations of the physical and chemical characteristics of the studied groundwater

Parameter wells		Temp	pH	EC <sub>25</sub>	T.alk	Ca	Mg	Na	K	Cl	SO <sub>4</sub>	NO <sub>3</sub>
1	mean	21	6.89	3574	326	514	293	440	7.0	406	1328	5.2
	±Sd	1.42	0.25	720	100	74.6	30.3	54	1.9	39.7	269	3.5
2	mean	21.6	7.02	4160	348	505	275	459	63	315	1371	9.3
	±Sd	1.02	0.10	400	120	55.8	38.4	56	2.7	12.4	116	6.8
3	mean	22	7.59	1850	187	152	119	123	3.9	181	467	4.5
	±Sd	1.41	0.02	774	77	53.2	32	7.0	2.3	11.0	93	2.4
4	mean	21.2	7.03	3970	384	275	222	333	39.0	289	1147	7.7
	±Sd	1.17	0.20	410	23	73.6	44.4	105	2.3	16.3	290	2.3
5	mean	22	7.42	1640	225	87	123	547	11.3	273	916	3.4
	±Sd	1.02	0.22	93	23	21.4	10.3	98	2.0	8.90	106	1.2
6	mean	20	7.46	2671	179	173	181	664	7.8	498	1470	3.3
	±Sd	2.33	0.09	306	58	44	26	122	0.8	93	61	2.3
7	mean	19.3	7.59	3629	283	208	179	461	7.5	311	1098	4.0
	±Sd	1.40	0.06	300	49	29	28	31	1.0	35	53	2.1
8	mean	20.7	7.39	3044	454	302	381	553	11.0	396	1688	6.8
	±Sd	1.89	0.18	268	77	52	24	33	1.6	19	43	2.4
9	mean	21	7.10	5069	123	159	134	109	1.3	124	553	10.8
	±Sd	0.89	0.18	463	23	48	27	30	0.3	17	80	2.9
10	mean	21.3	7.33	1835	371	281	243	346	4.0	303	1049	7.9
	±Sd	1.47	0.12	748	85	46	26	28	1.8	14	67	1.0

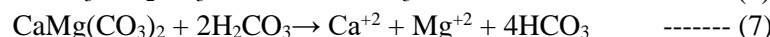
\*The average represents four replicates

### Chemical Properties

pH indicates the balance between acidity and alkalinity of water. The values of groundwater could be influenced by the nature and solubility of salts and oxides forming earth rocks. Results presented in Table 3 show a range of values between 6.89 and 7.59. The decrease and pH fluctuation are due to the Acid Neutralization Capacity (ANC) of Iraqi water and soils. Both soils and water of Iraq have been reported to be rich in carbonate and bicarbonate salts (Al-Saffawi, 2018; Al-Hamdani *et al.*, 2021). This

is confirmed by the high levels of total alkalinity resulting from the presence of bicarbonate ions hence the pH values are not higher than 8.3 (Al-Sardar *et al.*, 2018).

The results also indicate an increase in the total alkalinity (T. A) concentration, which amounted to  $454 \pm 77$  ppm, the relative increase in the values could be due to the reactions of water containing carbon dioxide as it passes through the earth layers with insoluble calcium carbonate to form dissolved bicarbonate as shown in equations 5, 6 and 7 by Talat *et al.*, (2019):





The water samples studied also indicate a near equilibrium state. If the pH value of water used by livestock is less than 5.5 (high acidic condition), acidosis and reduced feed intake may occur, while values greater than 9 (alkaline condition) could result in gastrointestinal problems, diarrhoea, low feed conversion efficiency and reduced water and feed consumption (Gurran, 2014). For cations, the levels of calcium and magnesium ions were relatively high but did not exceed the recommended levels for livestock, which amounted to 514ppm - 381 ppm. This increase may be attributed to the nature of the geology of the region and following the reactions described in the chemical reaction equations described above (Al-Saffawi and Al-Sardar, 2018).

For sodium ions, 80% of samples exceeded the recommended limits for use by livestock, while the levels of potassium ions are within the limits. Sodium does not constitute a major threat to livestock, but its association with sulfate is a source of great concern and this situation applies to the current study, which ranged between 109ppm and 664 ppm and thus increasing the complexity of the problem of high concentration of sulfate of up to 1688 ppm. In general, the effect of sodium content in water on animal productivity and health depends on the animal type and age. For example, poultry (especially chicks) tolerate an acceptable level of sodium at 50 ppm, but an increase in this concentration will negatively affect performance, and health and may lead to general paralysis, convulsions violent renal tubular degeneration, and hypertension associated with vascular disease and death (Castro *et al.*, 2009).

Also, for sulfate and chloride ions, 100% and 60% of the water samples respectively exceeded the permissible limits for livestock watering ranging

between 1,699 ppm and 406 ppm. High concentrations of sulfate ions may decrease productivity due to the laxative effect and reduced absorption of soluble nutrients (Socha *et al.*, 2003; Kewalramani *et al.*, 2018). As for nitrate ions in groundwater, they were within the tolerable limits for livestock consumption as shown in Table 1. Because high concentrations of nitrates in drinking water have negative effects on the health of livestock, the biological reduction of nitrate ions ( $\text{NO}_3^{-1}$ ) to nitrite ( $\text{NO}_2^{-1}$ ) interacts with haemoglobin in the blood to form methemoglobin; this reduces the ability of the blood to transport oxygen to all parts of the body, leading to the emergence of cases of weakness, convulsions, hypersensitivity, shortness of breath, rapid pulse, increased breathing, urination and cyanosis etc.

#### **Evaluation of water quality for watering livestock and poultry**

The water quality index was applied to eleven parameters shown in Table 1, to assess the quality of well water for consumption by livestock. The results of the WQI values shown in Table 4 indicate that the values range between 62 and 140; so only 30% of the well water samples studied were of good quality, while 70% were of bad/poor quality. This deterioration in the quality of water could be due to the high electrical conductivity value. As well as the concentrations of sodium ions and sulfate from the permissible limits for livestock poultry watering. This increase in the parameter values led to an increase in the quality rating ( $Q_i$ ) values for electrical conductivity, sodium and sulfate ions to reach (316, 442.6, 337.6), and thus the sub-index ( $S_{li}$ ) values increased to 38.40, 40.24, 40.92, respectively, which was reflected in an increase Water Quality Index

**Table 4:** The average values of Rating quality, subindex and water quality index for watering livestock and poultry at the Nimrud area

Parameter Wells		Temp	pH	EC <sub>25</sub>	T.Alk.	Ca	Mg	Na	K	Cl	SO <sub>4</sub>	NO <sub>3</sub>	WQI	
													values	status
1	Qi	75.0	91.87	223.4	32.60	51.40	58.60	293.3	35.00	135.3	265.6	3.909	126	Poor
	Sli	6.82	11.14	27.08	1.975	3.115	3.552	26.67	1.061	12.30	32.19	0.592		
2	Qi	77.0	93.60	260.0	34.80	50.50	54.60	306.0	315.0	105.0	274.2	6.992	140	Poor
	Sli	7.00	11.35	31.52	2.109	3.061	3.309	27.82	9.545	9.545	33.24	1.059		
3	Qi	79.0	101.2	115.6	18.70	15.20	23.80	82.00	19.50	60.33	93.40	3.383	62	Good
	Sli	7.18	12.27	14.02	1.133	0.921	1.442	7.455	0.591	5.485	11.32	0.513		
4	Qi	76.0	93.73	248.1	38.40	27.50	44.40	222.0	195.0	96.33	229.4	5.789	120	Poor
	Sli	6.91	11.36	30.08	2.327	1.667	2.690	20.18	5.909	9.758	27.81	0.877		
5	Qi	79.0	98.93	102.5	22.50	8.700	24.60	364.7	56.50	91.00	183.2	2.556	101	Poor
	Sli	7.18	11.99	12.42	1.364	0.527	1.491	33.15	1.712	8.273	22.21	0.387		
6	Qi	71.0	99.47	166.9	17.90	17.30	36.20	442.6	39.00	166.0	294.0	2.481	136	Poor
	Sli	6.46	12.06	20.23	1.085	1.048	2.194	40.24	1.182	15.09	35.64	0.376		
7	Qi	69.0	101.2	226.8	28.30	20.80	35.80	307.3	37.50	103.4	219.6	3.008	116	Poor
	Sli	6.27	12.27	27.49	1.715	1.260	2.170	27.94	1.136	9.424	26.62	0.456		
8	Qi	74.0	98.53	190.3	45.40	30.20	76.20	368.7	55.00	132.0	337.6	5.113	140	Poor
	Sli	6.73	11.94	23.06	2.752	1.830	4.618	33.52	1.667	11.99	40.92	0.775		
9	Qi	75.0	94.67	316.8	12.30	15.90	26.80	72.67	6.500	41.00	110.6	8.120	86	Good
	Sli	6.82	11.48	38.40	0.745	0.964	1.624	6.606	0.197	3.727	13.41	1.230		
10	Qi	76.0	97.73	114.6	37.10	28.10	48.60	230.7	20.00	101.0	209.8	5.940	97	Good
	Sli	6.91	11.85	13.90	2.248	1.703	2.945	20.97	0.606	9.182	25.43	0.900		



## CONCLUSION

The study concludes that most of the water obtained from the sampled wells is of poor quality when used for watering livestock, which will affect the productivity of both milk and meat in the district. The fact that only a third of the wells discharge wholesome water for livestock use is disturbing. It was discerned that the geology of Nimrud is largely responsible for this deterioration in the quality of water. Therefore, we recommend that

desalination of water sources be given high priority, so water used for animal consumption be tested before use. We also recommend treatment of water because research has shown that livestock consumption of good quality water affects increased disease resistance and performance has become improved, and the cost of providing clean water can be offset by increase in performance within a brief time period.

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