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Valuation of water quality for livestock and poultry watering: a case study of groundwater in some areas of Mosul city, Iraq

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Abstract. Present study aimed to assess the quality of groundwater for livestock and poultry watering in some areas of the left side of Mosul city, and give a clear picture of the degree of pollution of these water sources, where samples are collected randomly from 11 wells (five replicates per well), to measure the physical, chemical and bacteriological properties using the subindex model with the use of international standards for the permitted levels of livestock and poultry watering, as a result of the impact of water quality on the productivity of meat, milk and eggs and thus affect the national economy. The results indicated that 55% of the studied water samples of good water quality category, while 36% of the samples of poor quality, this deterioration in quality is mainly due to the high number of TPC and *faecal coliform* bacteria which reached (15×10^3) cells. ml^{-1} and (41) cells. 100 ml^{-1} consecutively. The study recommended exposing this type of water to solar radiation with special basins in order to kill bacteria and improve water quality.

Keywords: Groundwater of Mosul city, water quality for livestock, poultry watering

1. INTRODUCTION

Water is a blessing of God's creation because of its great importance to the life of all living beings since civilizations have developed since ancient times near water resources such as the Nile Valley civilization and Mesopotamia. Human need of water for domestic purposes, drinking, irrigation, watering livestock and poultry for the production of meat, dairy, dairy products, eggs, etc., as well as the utilization of animal skins and wools for industries such as clothing, bags, shoes, etc. For the human need of water for various purposes, drinking, domestic, irrigation, watering livestock and poultry for the production of meat, dairy, dairy products, eggs, etc., as well as the utilization of animal skins and wools for industries such as clothing, bags, shoes, etc. Therefore, animal husbandry and livestock care is the source of the economy in any country, as well as part of food security, Tampering and lack of attention to water resources such as wastewater discharge, agricultural and industrial wastewater, animal and livestock waste, etc. have led to deterioration of water quality in most regions of the world, especially developing countries, including Iraq, which reflected negatively on the lives of citizens and their property from agricultural and animal wealth. (Al-Sanjary and Al-Saffawi, 2018). Water makes up between 50 to 80% of the animals weight, depending on the age and the thickness of the fatty layers, which contributes directly or indirectly in all chemical and physiological processes that occur within the body of animals and livestock because it helps in the digestion process and the movement of food through the digestive system and the processes of absorption materials and regulate the osmotic pressure of blood and transfer of hormones, it also forms a large percentage of secretions such as saliva, milk, etc. Water also plays an important role in mitigation body temperature through evaporation of water through the respiratory tract and skin surface (Lardner et al., 2005). The water sources for the ruminant animals include water from metabolic processes called metabolic water, water in food and water that animals drink.

The amount of water needed by animals and livestock depends on the following factors (Lardner et al, 2005; Umar et al, 2014):

1. Animal size.
2. Quantity of dry matter intake.

3. Age and growth stage

In developing countries, there is a belief that animals and poultry can drink any water quality but the truth is, the drinking water of poor quality only when they do not have another option. Livestock and poultry are sensitive to the taste and smell of water, which may limit their water consumption and may lead to reduced weight and productivity of animals (Deshmukh, 2013; Umar et al., 2014).

In a study conducted by Willms et al. (2002) on the impact of the quality of drinking water on the calves that indicated to increase the weight of calves watered clean water by 23% as compared to those left to drink poor quality water from ponds and swamps.

Researchers (Sharma et al., 2017; Kewalramani et al., 2018; Tausifi et al., 2018) also indicated that cattle consumed for high salinity water decreased their weight and milk production compared to those drinking natural water, this effect is increased in the summer season compared to winter, attributed to the fact that the lower temperatures of the winter weather reduce the negative effects of salts on the health and productivity of livestock. Watering pregnant and lactating cattle also warns of high saline water because of its negative impact on the health of animals and the fetus, as well as the negative impact on the health and productivity of poultry (especially turkeys), and these health risks are likely to lead to death (Marx and Jaikaran, 2007).

For example, high levels of sulfate in drinking water (more than 2000 mgL⁻¹) claim initially to the occurrence of diarrhea and lack of desire to drink water, but the most dangerous of its relation to the development of polioencephalomalacia in the Cow calves (Lardner et al., 2005; Schroeder, 2015). Research has shown that watering animals clean water increases the disease resistance and performs better, and the cost of using clean water is recovered by increasing performance and production in a short time (Umar et al., 2014). Therefore, the study aimed to assess the suitability of groundwater in some areas of the left side of Mosul city for watering livestock and poultry and giving instructions and recommendations for animal breeders.

2. MATERIALS AND METHODS

The study was conducted on groundwater of Al-Gameaa and Al-Zeraee quarters in left side of Mosul city, Northern part of Iraq, and as a result of the great destruction of infrastructure in the city in recent years led to the spread of wells for various purposes, including watering animals and poultry as shown in (Table 1 and Fig. 1). As for the geological formations of the region is characterized by the spread of the formation of Al-Fatha (lower Fars), which mainly contains evaporated salts, gypsum (CaSO₄.2H₂O) and anhydrite (CaSO₄), limestone and marl etc. Which leads to the deterioration of the water quality of groundwater passing through it (Al-Hamdani and Al-Saffawi, 2018). In the current study, 55 water samples were collected from eleven wells seven of them in the Al-Gameaa quarter and the rest in the Al-Zeraee quarter, Water samples were collected in polyethylene containers that were cleaned with distilled water and washed with water sample before filling (APHA, 2017), for the period of January to April 2018 at a rate of five replicates, to measure the following qualitative characteristics: Temp °C, pH, Electrical conductivity (EC₂₅), Total alkalinity, Total hardness, Chloride, Sulfate, Nitrate and phosphate, as well as bacterial tests such as total number of bacteria (TPC) and Fecal coliform bacteria based on Global Standard Methods (APHA, 2017).

Table 1: Coordinates and depth of the studied wells on the left side of the city of Mosul

Sites	Well No.	latitudes	Longitudes	Depth m
Al-Zeraee quarter	1	36°38'92"	43°18'56"	42
	2	36°38'93"	43°18'71"	36
	3	36°38'73"	43°18'70"	5.0
	4	36°38'74"	43°18'72"	14
	5	36°38'91"	43°18'29"	48
	6	36°38'93"	43°18'97"	33
	7	36°39'02"	43°18'76"	45
Al-Gameaa quarter	8	36°35'63"	43°14'87"	13
	9	36°35'58"	43°14'91"	13
	10	36°35'48"	43°14'56"	23
	11	36°35'39"	43°14'44"	9.0

2.1. Estimation of water quality index (WQI):

Subindex model (Sli) was applied on twelve parameters for the calculation of water quality index (WQI) based on the standard permitted limits for livestock and animals watering as shown in Table 2 and according to the following steps (Chourasia, 2018; Boateng et al., 2017):

Figure 1: Map of the left side of the city of Mosul showing the locations of studied wells.

2.1.1. First Step:

Each of the eleven parameters has been assigned a weight (w_i) according to its relative importance ranges from 5 to 1, the maximum weight of 5 has been assigned to the parameter of Nitrate, Total number of bacteria (TPC) and Fecal coliform (FC) due to its importance and its effects on the general health of livestock and poultry and their productivity, while chlorides is given the minimum weight of 1 because of its low concentration in the studied groundwater and no effect on animals.

Table 2: Standard limits (S_i), weight (w_i) and the relative weight (W_i) of each parameter for livestock and poultry watering

Parameters	S_i^*	w_i	W_i
Tempt. °C	20-28	3	0.075
pH	6.0-8.5	4	0.100
EC ₂₅ $\mu\text{S.cm}^{-1}$	1600	4	0.100
T. Alkalinity	1000	2	0.050
Ca ⁺²	1000	2	0.050
Mg ⁺²	500	2	0.050
Na ⁺¹	300	3	0.075
Cl ⁻¹	300	1	0.025
SO ₄ ⁼	500	4	0.100
NO ₃ ⁻¹	133	5	0.125
TPC cell. ml ⁻¹	10	5	0.125
F. C cell. 100 ml ⁻¹	10	5	0.125
Σ		40	1.000

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

2.1.2. Second Step:

Relative weigh is calculated from the following equation (Howladar et al., 2017):

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

Where, W_i : Relative weight; w_i : weight of the property

2.1.3. Third Step:

Find the rate values of quality rating (q_i) as in the following equation:

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

As: C_i : the value of the measured property. S_i : the standard limit of the property.

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2.1.4. Fourth Step:

Calculate the values of Subindex (Sli) and water quality index (WQI) as in the following equations:

$$Sli = W_i \times q_i \quad (3)$$

$$WQI = \sum Sli \quad (4)$$

The calculated WQI values divided into five categories (Table 3) for livestock and poultry watering (Boateng et al., 2017).

Table 3: Classification of drinking water according to values

WQI values	<50	50-100	100-200	200-300	>300
degree	I	II	III	IV	V
category	Excellent	Good	Poor	Very poor	Unsuitable

3. RESULTS AND DISCUSSION

3.1. Physical properties

The results are shown in Table 4 indicate that the temperature changes in ground water are very limited; the rates ranged between (24.3, 16.4) °C and are within the limit for watering animals (Socha et al., 2003), cold water is reducing thermal stress in summer by lowering the body temperature and rates of breathing in the warm atmosphere, which leads to increased intake of food, thereby increasing the milk productivity of cattle milk and increase the weight of beef cattle, as well as the case of poultry (Wilks et al., 1990).

As for the electrical conductivity, which reflects the quantity and quality of dissolved ions in water (Al-Hamdani and Al-Saffawi, 2018), the average values ranged from (2697 to 1105) $\mu\text{S} \cdot \text{cm}^{-1}$, these differences are due to the nature of the geological formations through which the water passes. The groundwater passing through the layers rich in evaporated salts is characterized by high salts values (Al-Hamdani and Al-Saffawi, 2018). According to Chourasia (2018), 73% of the studied samples exceed the permissible limits for drinking animals which may affect in the livestock and poultry productivity.

Table 4: The average results of the groundwater analysis of the left side of Mosul city (mgL^{-1}) except EC25 ($\mu\text{S} \cdot \text{cm}$).

Paeamet. Wells	T. C°	pH	EC	T.Alk	Ca	Mg	Na	Cl	SO ₄	NO ₃	TPC ¹	F.C ²
1 <i>mean</i>	21.0	7.11	2108	276	355	139	15.2	97	202	11.6	2.00	56.0
$\pm \text{Sd}$	2.10	0.46	373	20.0	104	63	8.7	15	93	0.28	1.86	4.60
2 <i>mean</i>	22.3	7.14	2476	333	463	167	23.5	145	256	11.7	0.91	14.0
$\pm \text{Sd}$	1.4	0.47	363	17	114	20	14	20	139	0.39	0.85	5.0
3 <i>mean</i>	16.4	7.08	1412	318	136	78.2	5.10	47	120	1.50	3.0	41.0
$\pm \text{Sd}$	2.5	0.2	215	31	12	28	2.3	13	56	0.19	2.1	5.0
4 <i>mean</i>	21.3	7.44	1105	384	82.2	176	8.30	67	119	1.42	2.0	33.0
$\pm \text{Sd}$	1.00	0.34	209	182	32	44	2.8	5	39	0.15	2.3	3.20
5 <i>mean</i>	22.7	7.14	2296	437	263	237	31.1	161	253	1.50	0.91	14.8
$\pm \text{Sd}$	0.9	0.25	261	48	8.0	44	21	16.0	159	0.22	0.72	6.90
6 <i>mean</i>	22.6	7.08	2313	342	225	209	49.2	102	281	4.80	0.47	4.60
$\pm \text{Sd}$	1.10	0.13	514	9.0	86	61	6.9	11	107	0.89	0.35	3.60
7 <i>mean</i>	22.3	7.36	1851	272	112	182	20.0	80	194	8.90	1.00	0.0
$\pm \text{Sd}$	1.1	0.33	340	10	52	49	1.6	13	67	0.26	0.59	0.0
8 <i>mean</i>	24.3	7.23	2120	452	132	216	49.0	127	201	3.40	0.83	15.0
$\pm \text{Sd}$	1.1	0.42	477	38	54	91	15	19	109	0.93	1.23	8.00
9 <i>mean</i>	21.6	7.32	2697	372	172	314	60.0	168	354	3.12	1.00	17.0
$\pm \text{Sd}$	1.5	0.41	669	43	108	145	18	8.0	114	0.66	0.97	8.00
10 <i>mean</i>	20.8	7.53	1872	367	160	239	19.0	87	184	3.40	2.0	4.60
$\pm \text{Sd}$	3.3	0.48	320	28.0	50	24	4.4	3	71	1.97	2.01	2.60
11 <i>mean</i>	21.9	7.47	1321	284	68.1	81.5	9.0	40	84	2.86	3.0	19.6
$\pm \text{Sd}$	2.2	0.39	185	61	30	17	0.5	3	24	0.55	1.57	8.0

1TPC: Total plate count: $\times 103 \text{ cell} \cdot \text{mL}^{-1}$, 2F. C.: Fecal coliform cell. 100 mL^{-1}

3.2. Chemical Properties

PH is an indicator of the equilibrium level between acidity and water alkalinity (Pal et al., 2018), and the results of the study based on the Table 4 indicate that the values ranged between (7.53-7.08). The decline in the fluctuation of the values was attributed to the Acid Neutralization Capacity (ANC) of Iraqi water and soils rich in bicarbonate and carbonate salts (Ramadhan et al, 2018), if values fall below pH = 5.5 will lead to the occurrence of problems related to Acidosis and thus impact on the productivity of livestock, such as the low amount of milk, as well as the

percentage of fat in it, while the high values of pH more than 8.5 cause problems of Alkalosis such as lack of vitamin B and amino acids, as well as disorders indigestion and diarrhea with the lack of drinking water and eating the feed and thus influence the productivity (Curran and Robson, 2007; Grant, 1996).

This ability is confirmed by a high concentration of the total basal which amount to (452) mgL^{-1} caused by bicarbonate ions because pH values did not exceed 8.3 (Al-Saffawi, 2019). The increase in total alkalinity concentration is due to the reactions occurring in water in the ground layers of calcium CaCO_3 and magnesium $\text{CaMg}(\text{CO}_3)_2$ with H_2CO_3 as in the following equations (Al-Hamdani and Al-Saffawi, 2018; Kablan et al., 2018):

For the same reason above the concentrations of calcium and magnesium ions are high which averaged reach to (315-463) mg.l^{-1} respectively. Magnesium activates many of the enzymes necessary for energy production reactions and the synthesis of nucleic acids and protein, as well as the impact of the protective incidents of sudden death resulting from Ischemic Heart Disease, Stroke, blood pressure and the impact of magnesium in the prevention of diseases Cancers (Al-Saffawi and Al-Sardar, 2018). The high values in some studied wells are due to the geological nature of the area and the presence of lower faris formation containing gypsum, anhydrite and limestone rocks (Al-Saffawi et al., 2008).

Increasing the concentration of chloride and sulfate ions in livestock and poultry drinking water leads to reduced feed consumption, as well as the interaction of sulfates with copper and molybdenum when present in water or food consumed, resulting in increased brain disorder (Sigler and Kleehammer, 2009). Fortunately, their concentrations did not exceed the permissible limits, despite their relatively high levels in some water samples due to the geological formations of the area.

As for nitrate ions, high concentrations have a negative effect on animals, especially pregnant, where they cause abortion and sudden death of newborns. Fortunately, they did not exceed the limits allowed for drinking; the highest rate (11.06) mgL^{-1} .

3.3. Bacterial Properties

It is considered one of the most important qualitative characteristics of water to determine the degree of contamination of groundwater by aerobic and anaerobic bacteria (Kablan et al, 2018). The results indicated in the Table 4 that the average number of bacteria ranged between $(3.0-0.47) \times 10^3$ cells. mL^{-1} . In general, all studied samples exceed the permissible limits for watering livestock and poultry (Socha et al, 2003). The presence of faecal coliform bacteria in the water is evidence of faecal contamination and the probability of the presence of waterborne pathogens to livestock and poultry, which is more effective on small animals and calves than in adult animals (Grant, 1996). Fecal coliform bacteria ranged from (56–0.0) cells. 100 ml^{-1} , this confirms the contamination of well water as a result of the leakage of wastewater to it by fissures and gaps that may occur in the geological layers (Al-Saffawi and Al-Sardar, 2018).

Table 5: Quality rate (Qi), Sub-Index (Sli) and Water Quality Index (WQI) values of groundwater studied for livestock and poultry watering

Wells Parame.	1		2		3		4		5	
	Qi	Sli	Qi	Sli	Qi	Sli	Qi	Sli	Qi	Sli
T. °C	87.5	6.56	92.9	6.97	68.3	5.13	88.8	6.66	94.6	7.09
pH	94.8	9.48	95.2	9.52	94.9	9.49	99.2	9.92	95.2	9.52
EC ₂₅	132	13.2	155	15.5	88.3	8.83	69.1	6.91	144	14.4
Alk.	27.6	1.38	33.3	1.67	31.8	1.59	38.4	1.92	43.7	2.19
Ca	35.5	1.78	46.3	2.32	13.6	0.68	8.22	0.41	26.3	1.32
Mg	27.8	1.39	33.4	1.67	15.6	0.78	35.2	1.76	47.4	2.37
Na	5.07	0.48	7.83	0.59	1.70	0.13	2.77	0.21	10.4	0.78
SO ₄	40.4	4.04	5.12	5.11	24.0	2.40	23.8	2.38	50.6	5.06
Cl	32.3	0.81	48.3	1.21	15.7	0.39	22.3	0.56	53.7	1.34
NO ₃	8.72	1.09	8.80	1.10	1.13	0.14	1.07	0.13	1.13	0.14
TPC*	2000	250	114	91.0	3000	375	2000	250	910	114
FC**	560	70.0	140	17.5	410	51.3	330	41.3	148	19.0
WQI	360		177		456		322		178	
Wat. class	Unfit		Poor		Unfit		Unfit		Poor	

Table 5: Continue

Wells Parame.	6		7		8		9		10		11	
	Qi	Sli	Qi	Sli	Qi	Sli	Qi	Sli	Qi	Sli	Qi	Sli
T, °C	94.2	7.06	92.9	6.97	101	7.59	90.0	6.75	86.7	6.50	91.3	6.85
pH	94.4	9.44	98.1	9.81	96.4	9.64	97.6	9.76	100	10.0	99.6	9.96
EC ₂₅	145	14.5	116	11.6	133	13.3	169	16.9	117	11.7	82.6	8.26
Alk.	34.2	1.13	27.2	1.36	45.2	2.26	37.2	1.86	36.7	1.84	28.4	1.42
Ca	22.5	1.13	11.2	0.56	13.2	0.66	17.2	0.86	16.0	0.80	6.81	0.34
Mg	41.8	2.09	36.4	1.82	43.2	2.16	62.8	3.14	47.8	2.39	16.3	0.82
Na	16.4	1.23	6.67	0.50	16.3	1.22	20.0	1.50	6.33	0.48	3.00	0.23
SO ₄	56.2	5.62	26.7	0.67	42.3	1.06	70.8	7.08	36.8	2.68	16.8	1.68
Cl	34.0	0.85	38.8	3.88	40.2	4.02	56.0	1.40	29.0	0.73	13.3	0.33
NO ₃	3.61	0.45	6.69	0.84	2.56	0.32	2.35	0.29	2.56	0.32	2.15	0.27
TPC*	470	58.8	1000	125	830	104	1000	125	2000	250	3000	375
FC**	46.0	5.75	0.00	0.00	150	18.8	170	21.3	46.0	5.75	196	24.5
WQI	109		163		167		196		294		430	
Wat class	Poor		Poor		Poor		Poor		Very Poor		Unfit	

3.4. Assessment of water quality for drinking:

The results shown in Table 5 indicate that WQI values ranged from (430-109), the highest values of the studied water samples in well number 11 and the lowest values in the well samples number 6. When comparing the results of the water quality index in the Table 3 for the classification of water quality, we find that 55% of the groundwater in the study area was poor water quality (wells: 2, 5, 6, 7, 8, 9) and 36% of water samples are not suitable for drinking livestock Poultry (wells 11, 3, 1) and 9% of them are very poor quality

This deterioration in the quality of wells water are due to the high concentrations of some studied characteristics over the permissible upper limits of animal drinking water such as electrical conductivity EC₂₅, T. Alkalinity and Sulfate ions as well as Bacterial contamination, which played a major role in the deterioration of water quality; The significant increase in the water quality coefficient values for wells (1, 3, 11), is mainly due to the high numbers of TPC and F. coliform bacteria throughout the study period, It is noted from Table 5 that there is a clear increase in the Qi values as well as the high values of the sub-index (Sli) for the above criteria,

It is emphasized that the main factor for the deterioration of the studied water quality is electrical conductivity and bacterial contamination because the values of the rate of quality (qi) and its sub-index (Sli) are very high compared to other parameters and therefore high values of the water quality index (WQI) ie the deterioration of water quality.

4. CONCLUSIONS AND RECOMMENDATIONS

Main findings of the current study are listed as follows:

1. The results of the study indicated the deterioration of the groundwater quality for watering livestock and poultry, as the water quality between poor to unfit.

2. High values of electrical conductivity and the total number of bacteria and fecal coliform bacteria are well above the permissible limits for animal consumption.

Therefore, it recommends to spread awareness among citizens especially educators of livestock and poultry about the need for the use of clean water for watering to protect them from diseases and increase production as well as exposing this type of water to solar radiation with special basins to kill bacteria and improve water quality.

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Conflict of Interest: Authors declare that there is no conflict of interest.

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