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Qualitative Assessment of Water Resources for Watering Livestock and Poultry: A Case Study of The Waters of Duhok Valley, Kurdistan Region of IRAQ

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ABSTRACT

The current study was conducted to assess the water quality of Valley Duhok as a water source for drinking livestock and poultry in the region. Seventy-two water samples were collected from six sites in the valley to conduct physicochemical and biological tests, and the sub-index model (WQI) was applied to assess water quality.The results of the water quality index indicated that the water of Duhok Dam Lake (site N1) was of good quality for drinking livestock and poultry, while the rest of the sites on the valley were in the category of water very poor for drinking animals, with WQI values ranging from (204-286). This deterioration in water quality is a result of the relative increase in the three parameters of most of the studied properties, especially dissolved oxygen, organic load, and phosphate ions, to reach the values for the quality rating (Qi) and Sub-Index (Sbi)to (500 and 56.8), (1026 and 117) and (958 and 87.1) consecutively.

Keywords: Livestock watering, Poultry watering, Groundwater quality, Sub-index model, WQI.

INTRODUCTION

Water is one of the necessities of life because of its vital role in the activities of living organisms that we must preserve from pollution and wastage, due to the increase in human activities such as the disposal of agricultural waste containing fertilizers, (organic and industrial), and the disposal of civil wastewater in addition to animal waste, etc., so many areas in the world have become, especially the arid and semi-arid regions suffer from a decrease in the quantities of safe and pure water[1]. Although the amount of freshwater is relatively sufficient for human and animal consumption, due to its uneven distribution on the surface of the globe, in addition to the excesses by dumping wastewater without treatment to water resources, which led to an increase in the demand for clean and healthy water[2-4]. Water constitutes between 50 to 80% of the animals weight according to age and fatty layers, as it contributes to all the metabolic processes that occur inside the body of animals, as well as constitutes a large proportion of the secretions of saliva, milk, etc., and relatively cold water plays an important role in relieving Body temperature in the summer season by the evaporation of water through the respiratory system and the surface of the skin, thus increasing the activities of animals in grazing and forage[5].

In general, the studies related to assessing the quality of drinking water for livestock and poultry are very few and rare in Iraq, but there are some studies related to this field, including[6], study to assess the quality of water resources in the Nimrud district, southeast of Mosul city, for watering livestock and poultry using weighted mathematical models. The results of WQI values indicated that 70% of the water samples were of poor-quality water due to the high levels of salts, which amounted to (5069) uS. cm^{-1}, and the concentration of sodium, chloride and sulfate ions, which amounted to (664, 498 and 1688) ppm consecutively.

A study was also conducted to assess the suitability of water from wells in some areas on the left side of Mosul city for livestock watering using the sub-index model by[7], which indicated that the water quality is from the category of poor water to unsuitable for livestock and poultry watering, due to the high levels of salinity and the number of fecal coliform bacteria.

Moreover[8], conducted an assessment study of the water of 20 wells in the district of Al Hamdaniya for watering livestock and poultry, the results of the water quality index indicated that the values fluctuated between (33 to 282), where 45% of the wells were classified from the unfit category for watering animals, 25% from the category of poor quality water and the rest from the category of good quality water, they attributed the deterioration in most of the studied water to the high electrical conductivity values, which amounted to 4032, and the concentrations of calcium, magnesium, sodium, chlorides and sulfates, which reached (529, 487, 391, 362 and 2227) ppm sequentially.

Accordingly, for the purpose of preserving livestock, the study came to assess the water quality of Duhok valley for watering livestock and poultry using the sub-index model, as it is one of the very rare studies in Iraq.

MATERIALS AND METHODS

Duhok valley is one of the natural valleys in Duhok city to transfer rainwater and wastewater to the city drained to it transfer it through its long stream to the Mosul Dam lake, which is located on the Tigris River, north of the city of Mosul.

Due to the massive expansion of the city with the increase in the population in recent years, this resulted in an increase in wastewater discharged to it without any treatment, which constitutes a breach and an environmental threat to the water resources. The spread of aquatic plants and reeds on the course of the valley, exposure to sunlight and other environmental factors may play a vital role in the occurrence of self-purification processes for the water of the valley, Table 1 and Fig. 1 show some characteristics of the study area.

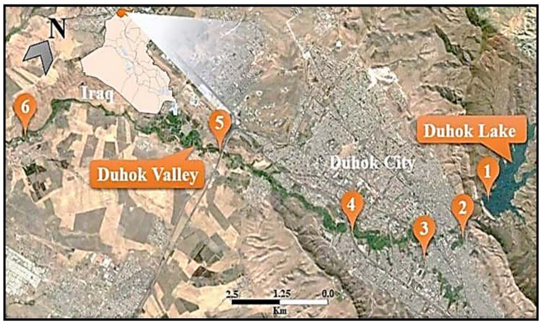

Fig. 1. Map showing the locations of collecting water samples from Duhok valley

Table 1: Characteristics of the studied sites for the waters of Duhok valley, northern Iraq.

Sites		Altitude (m)	Longitudes (E)	Latitudes (N)	Notes
N1	Duhok dam	607	40°00'09"	36°87'74"	The transparency of the valley's water decreased with foul odors in some periods
N2	Near D.P.C.*	551	43°00'23"	36°86'78"	
N3	Khashman Spring**	523	42°99'38"	36.85'39"	
N4	Shindokha Bridge	499	42°96'79"	36°85'19"	
N5	Aloka bridge	434	42°91'08"	36°84'05"	
N6	Bakhotmy	364	42°85'38"	36°80'86"	

*Near the Duhok Provincial Council., ** Near Duhok Stadium

Seventy-two water samples were collected during the study period (from February 2021 until January 2022) using clean polyethene bottles (liter capacity) for physical and chemical tests and capped bottles for samples of dissolved oxygen (DO) and biochemical oxygen demand (BOD_5). The samples were placed in a cooler box away from the light until reaching the laboratories of the faculties of science at the University of Zakho and the University of Duhok, according to the internationally used methods for collecting water samples[9]. The internationally approved standard methods for analyzing water samples[9-11], were also used to measure water temperature in the field (T), PH, electrical conductivity (EC_{25}), dissolved oxygen in water (DO), organic load (BOD_5), total hardness (T.H.), total alkalinity (T.A), sodium ions (Na^+), potassium (K^+), chloride(Cl^-), bicarbonate (HCO_3^-) sulfates ($SO_4^=$), phosphate (PO_4^{-3}) and nitrates (NO_3^-).The devices used for these measurments are a mercury thermometer, Philips pH meter model pw9421, EC-Meter model Mc-1Mark V, consecutively, As for (DO), (BOD_5), (T.H.), (T.A) was measured by titration method & equation, for (Na^+), (K^+) measured by Flame Atomic Absorption Spectrophotometer, (Cl^-) by *Mhor method*, (HCO_3^-) by equation, ($SO_4^=$) by Labtech Digital Turbidity meter, (PO_4^{-3}) Stannus chloride method, and (NO_3^-) by Ultra violet screening method.

The sub-index model was also applied to calculate the water quality index (WQI) as a composite indicator of water quality that gathers information for different water quality standards to find a single value of importance in evaluating the interactions between the studied parameters that can be quickly and easily understood for the general public and decision-makers[12-14]. Rather than confusing in the interpretation of all the measured parameters to determine the state of water quality, thus providing an easy and comprehensive method for determining water quality for different uses as well as using it to compare the state of different water bodies across space and time[15]. Sub-index model (Sbi) was applied on twelve parameters for the calculation of water quality index (WQI) based on the standard permitted limits for livestock and animal watering as shown in Table 2, according to the following steps[16,17]. In the first stage, the weight (Pwi) of each of the twelve parameters is determined according to its concentration and its effect on water quality 1 to 5, where the maximum weight of 5 was given to each of nitrate, electrical conductivity, dissolved oxygen and organic load for its importance and effects on public health. For livestock and poultry and their productivity, potassium ion was given 1 due to its low concentration in the studied water[18,19], as shown in Table 2.

Table 2: Desirable standard limits, weight and relative weight of the parameter used in calculating the WQI for watering livestock and poultry

Parameter	St. limit (Sti)	Weight(Pwi)	Relative Weight (RWi)
Tempt.C°	20 to 28	3	0.06818181818
pH	6.0- 8.0	4	0.09090909090
EC_{25}	1000	5	0.11363636363
DO	5.0	5	0.11363636363
BOD_5	5.0	5	0.11363636363
Na^+	300	3	0.06818181818
K^+	20	1	0.02272727272
HCO_3^-	1000	2	0.04545454545
PO_4^{-3}	2.15	4	0.09090909090
NO_3^-	44.0	5	0.11363636363
SO_4^{-2}	300	4	0.09090909090
Cl^-	100	3	0.06818181818
∑		44	0.99999999993

In the second stage the relative weight (Rwi) is calculated using the following equation[5,20,21]:

$$\text{Rwi} = \sum_{i=1}^{n} \frac{Pwi}{\sum Pwi} \quad (1)$$

The third stage is to find the values of quality rating rate (Qi) from the following equation:

$$\text{Qi} = \frac{Ci}{Sti} \times 100 \quad (2)$$

Ci: represents the value of the measured parameter.
Si: allowable standard limits.

As for the last stage, the values of Sub-index (Sbi) and Water Quality Index (WQI) are calculated as in the following equations:

$$\text{Sbi} = \text{Qi} \times \text{Rwi} \quad (3)$$
$$\text{WQI} = \sum \text{Sbi} \quad (4)$$

The calculated (WQI) values are classified into five classes Table 3 for livestock and poultry watering[5,16]. To know the effect of each parameter on the value of WQI to judge it, the effective weight (Epwi) for each parameter is calculated by dividing the sub-index Sbi by the value of WQI as in the following equation[22,23]:

$$Epwi = \left[\frac{Sbi}{WQI}\right] \times 100 \quad (5)$$

Table 3: Classification for water quality index categories and statements

Values Range	<50	51-100	101-200	201-300	>300
Categories	Excellent	Good	Poor	Very Poor	Unfit
Statement	I	II	II	IV	V

RESULTS AND DISCUSSION

The results shown table 4 indicate that the values of the water quality index (WQI) for the water of Duhok Dam Lake (site N1) amounted to (82.4), as it was classified under the category of good water quality (statement II), and this good quality is due to the measured values (Ci) of the studied parameters which not exceed the permissible limits (Sti) for livestock drinking except for the values of PO_4^{-3}, BOD_5 and pH in some period, which reached (10.0 and 6.7) ppm and (8.16) sequentially, as a result of the presence of sulfur springs around the dam lake as well as dumping civilian and agricultural wastewater for some villages into the dam lake.

Table 4: Values for Quality Rating, Sub-Index and (WQI) of Duhok valley

Sites Parameters	N_1		N_2		N_3		N_4		N_5		N_6	
	Q_1	Sb_1	Q_2	Sb_2	Q_3	Sb_3	Q_4	Sb_4	Q_5	Sb_5	Q_6	Sb_6
T.C	91.7	6.25	85	5.79	104	7.09	97.6	6.68	95.6	6.52	88.0	5.99
pH	104	9.45	111	10.1	105	9.55	98.0	9.91	99.3	9.03	102	9.27
EC_{25}	72.7	8.26	92	10.5	88	9.96	87.7	9.97	89.4	10.2	102	11.6
DO	67.6	7.68	89	10.1	500	56.8	500	56.8	119	13.5	110	12.5
BOD_5	81.0	9.20	996	113	952	108	1026	117	956	109	904	103
Na^+	16.9	1.15	11	0.76	14	0.95	19.3	1.32	16.4	1.12	17.9	1.22
K^+	36.5	0.83	34	0.77	65	1.48	82.0	1.86	64.5	1.47	51.5	1.17
HCO_3^-	28.1	1.28	28	1.27	44	1.99	42.0	1.91	47.9	2.18	41.5	1.89
PO_4^{-3}	348	31.6	439	39.9	828	75.3	958	87.1	572	52.0	940	85.5
NO_3^-	6.90	0.70	7.0	0.80	29	3.26	13.4	1.52	8.86	1.00	9.32	1.06
SO_4^{-2}	49.7	4.52	6.4	5.85	49	4.45	68.3	6.21	30.3	2.75	39.0	3.55
Cl^-	22.2	1.51	67	5.11	102	6.95	93.0	6.34	88.0	5.99	74.0	5.05
WQI	Value	82.4	204		286		307		215		242	
	Status	Good	Very Poor		Very Poor		Unfit		Very Poor		Very Poor	

As for the rest of the studied sites of Duhok valley (N2-N6), the results shown in Table 4 indicate a deterioration in water quality, the values of the water quality index (WQI) ranged between (204 to 307), where it was classified from the categories of Very poorto Unfitwater quality for drinking livestock. This deterioration in quality is mainly due to the high values of quality rating (Qi) for most of the studied properties, especially biochemical oxygen demand (BOD_5), phosphate ions (PO_4^{-3}),dissolved oxygen (DO), electrical conductivity (EC_{25}) and pH, which amounted to (1026, 958, 500, 102 and 111), which was reflected in an increase of Sub-Index (Sbi) values to reach (117, 87.1, 56.8, 11.6 and 10.1) consecutively. This is confirmed by the values of the properties affecting water quality (Epwi) shown in the Table 5, especially the biochemical oxygen demand (BOD_5), phosphate ions, dissolved oxygen, electrical conductivity and pH, which It reached (57.1, 35.3, 19.9, 5.30 and 5.10) consecutively.

Table 5: Effective characteristics values (Epwi) in water quality index (WQI)

Sites Parameters	N_1	N_2	N_3	N_4	N_5	N_6
TC	7.80	2.90	2.48	2.18	3.03	2.48
pH	10.0	5.10	3.34	3.24	4.20	3.83
EC_{25}	8.26	5.30	3.48	3.25	4.74	4.79
DO	9.32	5.10	19.9	19.9	6.28	5.17
BOD_5	11.2	57.1	37.8	38.1	50.7	42.6
Na^+	1.40	0.38	0.33	0.43	0.52	0.50
K^+	1.01	0.39	0.52	0.61	0.68	0.48
HCO_3^{-1}	1.55	0.64	0.70	0.62	1.01	0.78
PO_4^{-3}	38.4	20,2	26.3	28.4	24.2	35.3
NO_3^{-1}	0.80	0.40	1.14	0.50	0.47	0.44
SO_4^{-2}	5.49	2.87	1.56	2.02	1.28	1.47
Cl^{-1}	1.83	2.51	2.43	2.07	2.79	2.09

It is also noted from Table 4, that the water quality of the valley was in the worst condition at the fourth site (N_4) as a result of the huge amount of wastewater drained to it from the center of Duhok city, and this confirms the high concentrations of most of the studied characteristics shown in the same Table 6, where the concentration of dissolved oxygen in the water decreases to reach (0.0) ppm in most periods, especially in the summer. This will lead to the creation of anaerobic conditions and thus the activation of anaerobic bacteria, which leads to a change in the paths of biological reactions and the products of the analysis of organic materials to form methane (CH_4), hydrogen sulfide (H_2S) and amines, etc., leading to a decrease in water transparency and emission unpleasant odors, which confirms this, is the high levels of organic load, reaching the highest value of the biochemical oxygen demand (BOD_5) at the site (N_4) to (66.0) ppm.

It can also note from Table 6, the relatively high electrical conductivity values that reached (1045) uS. cm^{-1} at site (N_2), this rise in values may be due to the disposal of wastewater from Duhok city to the valleys rich in salt, in addition to the interactions that occur in which it dissolves salts in the bottom sediments, converting them to dissolved forms. In general, 12% of the studied samples have exceeded the limits recommended for drinking livestock and poultry[24,25].

The high levels of salinity in the drinking water of livestock and poultry cause increased salivation, diarrhea, vomiting, ataxia and confusion when walking[5,26]. Although ruminants have a wide range of tolerance to salinity, but high concentrations reduce the animal's drinking of water, which affects its health. As for poultry, the high salinity will be reflected in a decrease in its intake of food and water, which leads to a decrease in its productivity rates (weight and number of eggs). This effect increases at high temperatures in the summer, also during pregnancy and lactation, causing health problems in the animal digestive system[3,27,28].

Table 6: Results of the lower and upper limits, average and standard deviation of the waters of Duhok valley (ppm)

Param. Sites		TC°	pH	EC_{25}	DO	BOD	Na^+	K^+	HCO_3^-	PO_4^{-3}	NO_3^-	SO_4^{-2}	Cl^-
N1	Min	18.4	7.67	671	5.60	1.85	32.0	6.0	195	5.40	1.0	124	53.9
	Max	25	8.16	794	10.4	6.70	63.0	9.0	449	10.0	5.6	198	77.9
	Mean	22	7.79	727	7.40	4.05	50.6	7.3	281	7.49	2.9	149	66.5
	± Sd	2.68	0.14	43.6	1.38	1.53	8.32	1.2	72.3	1.79	1.5	20.4	6.43
N2	Min	19.0	7.32	812	4.0	37.6	21.0	5.0	210	6.20	1.3	89.0	66.9
	Max	22.0	7.88	1045	7.20	59.2	39.0	9.0	347	12.4	5.4	273	85.9
	Mean	20.3	7.64	918	5.6	49.8	33.4	6.8	281	9.43	3.1	193	74.8
	± Sd	0.92	0.18	60.5	0.92	6,92	5.90	1.3	37.5	2.01	1.4	58.2	6.05
N3	Min	19.1	7.24	795	0.00	36.1	41.0	12.0	400	15.0	6.6	101	75.9
	Max	28.6	7.61	1016	6.20	60	56.0	15.0	492	20.0	12.0	190	120
	Mean	24.9	7.38	877	1.00	47.6	41.8	13.0	439	17.8	9.1	147	102
	± Sd	3.05	0.09	71.6	2.24	7.65	5.32	1.00	26.1	1.69	1.7	26.1	14.9
N4	Min	19.0	7.21	825	0.00	29.0	44.0	15.0	345	15.9	3.1	169	75.9
	Max	28.0	7.86	981	6.10	66.0	69.0	18.0	478	25.0	8.5	240	130
	Mean	24.4	7.32	877	1.00	51.3	57.8	16.4	420	20.6	5.9	205	92.9
	± Sd	2.32	0.17	47.8	1.85	10.3	9.37	1.20	41.2	2.96	1.7	21.2	14.2
N5	Min	22.0	7.25	856	1.20	28.7	35.0	12.0	400	9.70	1.2	79.0	75.9
	Max	25.0	7.58	943	7.20	63.7	58.0	14.0	600	15.2	6.5	107	108
	Mean	23.9	7.45	894	4.20	47.8	49.2	12.9	479	12.3	3.9	90.8	87.9
	± Sd	0.92	0.11	23.5	1.85	10.2	7.71	0.86	63.6	1.76	1.6	8.68	12.5
N6	Min	18.4	7.18	899	1.60	27.0	36.0	9.0	388	17.0	1.2	98.0	61.9
	Max	28.0	7.85	1135	11.2	54.2	61.0	11.0	542	24.0	6.8	126	83.9
	Mean	22.0	7.66	1016	5.50	45.2	53.8	10.3	414	20.2	4.1	117	73.5
	± Sd	3.25	0.17	98.1	2,93	8.08	6.72	0.74	94.8	2.19	1.6	10.2	6.83

As for the relative increase of phosphate ions, which amounted to (25.0) ppm at a site (N_4), it is due to domestic wastewater containing detergents rich in phosphate compounds, and agricultural residues containing fertilization. In addition, the low concentration of dissolved oxygen in the water contributed to the transformations of precipitated forms of phosphate to dissolved forms. As for the fluctuation in concentration, it may be attributed to adsorption processes on the surfaces of particles and bottom sediments, and the precipitation processes in the form of calcium phosphate that occur due to interactions with calcium ions as in the following equation[2,26].

$$3Ca^{+2} + 2PO_4^{-3} \rightarrow Ca_3(PO_4)_2 \quad (1)$$

On the other hand, it is noted that the concentration of bicarbonate ions (HCO_3^-) increased with the watercourse in the valley, reaching (600) ppm at the site (N_5). This rise is due to the interactions which occur in water containing carbon dioxide and carboxylic acids resulting from the processes of bacterial decomposition of organic materials, leading to reactions with insoluble $CaCO_3$ to form soluble bicarbonate in water, as in the following equations[29].

$$CO_2 + H_2O \rightarrow H_2CO_3 \quad (2)$$

$$H_2CO_3 + CaCO_3\downarrow \rightarrow Ca(HCO_3)_2 \quad (3)$$

$$CaMg(CO_3)_2 + 2H_2CO_3 \rightarrow Ca(HCO_3)_2 + Mg(HCO_3)_2 \quad (4)$$

While no concentration of carbonate ions was observed during the study period, and this confirms that the pH values do not exceed (pH < 8.16), for the same reason, the range of fluctuations values decreased to range between (7.18 to 7.88). This is due to the high concentration of bicarbonate ions and the total alkalinity of the water, which gives it the ability to neutralize the acidity (ANC), which limits the extreme fluctuation in the PH values. Without this ability, the fluctuation in values would be large, thus, further deteriorating water quality. Generally, the values are within the permissible limits for watering livestock and poultry[5].

As for the rest of the studied characteristics, they were within the permissible limits for watering animals, despite their relative height in some periods, for example the temperature of the valley water rises close to the upper limits allowed in some periods to reach 28C°at the sites(N_3, N_4 and N_6) in the summer. Livestock and poultry need to drink relatively cold water less than 18C° to cool the body temperature and exercise its activity in eating feed. As for sulfate ions, it reached (273) ppm at the site (N_2), its high concentration, especially when magnesium is the accompanying cation, which has negative health effects on the animals.

CONCLUSION

1. The relatively high levels of most of the studied parameters, especially the biochemical oxygen demand, phosphate ions, electrical conductivity with a low concentration of oxygen in the water, create anaerobic conditions and the formation of harmful products to the aquatic ecosystem and livestock and poultry.
2. The quality of the studied water ranged from very poor to Unfit category for watering livestock and poultry, as a result of exceeding some of the studied parameters for the permissible limits, which led to an increase in the values of the quality ratting (Qi), which was negatively reflected on the values of the sub-index (Sbi) and the water quality index (WQI), except the water of Duhok Dam lake (N1), which was of the category of good quality water for watering animals.

Therefore, the study recommends preventing the use of the water of Duhok valley for watering livestock and poultry to maintain the health and safety of animals, and the use of safe and healthy water to increase the production of meat, milk, and eggs.

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Conflicts of Interest

The author declares no any conflict of interest.

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