

Assessment of Physicochemical Properties of Water in Bawashaswar Dam,  
Kurdistan Region, Iraq

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**Abstract**

This research has been carried out to determine the quality and use of water of Bawashaswar Dam based on the physical and chemical parameters. Twelve water samples were taken from different locations within the dam's reservoir; then, analyzed for physical and chemical parameters such as pH, electrical conductivity (EC), total hardness (TH), chloride ( $\text{Cl}^-$ ), sulphate ( $\text{SO}_4^{2-}$ ), bicarbonate ( $\text{HCO}_3^-$ ), nitrites ( $\text{NO}_3^-$ ), total dissolved solids (TDS), magnesium ( $\text{Mg}^{2+}$ ), calcium ( $\text{Ca}^{2+}$ ), sodium ( $\text{Na}^+$ ), and potassium ( $\text{K}^+$ ). The concentrations of these constituents were measured and interpreted with some water quality indices such as sodium adsorption ratio (SAR), residual sodium carbonate (RSC), magnesium hazard (MH%), and Kelly's ratio (KR). Compared with irrigation water standards and water quality for fisheries life, the characteristics of water in the reservoir revealed that the most measured parameters were acceptable. However, high values of turbidity, TDS and RSC in some sites basis on drinking water standards revealed that water in the dam needs proper treatment before distribution for public consumption.

**Key words:** Bawashaswar Dam, physical and chemical properties, water quality indices

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تقييم الخصائص الفيزيائية والكيميائية لمياه سد باوه شاسوار في اقليم كردستان

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الخلاصة

يهدف البحث إلى تحديد مؤشر جودة المياه لبحيرة سد باوه شاسوار في مدينة كفري اعتماداً على الخصائص الفيزيائية والكيميائية. حيث تم أخذ العينات من اثني عشرة مواقعاً مختلفاً من البحيرة. وقد تم إجراء التحاليل الفيزيائية والكيميائية لمياه البحيرة مثل النترات، العكارة، الاوكسجين الذائب، الناقلية الكهربائية، درجة الحموضة، مجموع المواد الصلبة الذائبة، إضافة الى بعض الأيونات السالبة والموجبة. تم تمثيل النتائج ومقارنتها مع القيم المسموحة لمياه الشرب والزراعة وتربية الاسماك وفق المواصفات القياسية لمنظمة الصحة العالمية. أظهرت النتائج أن معظم مؤشرات نوعية المياه كانت ضمن الحدود المقبولة، إلا ان النتائج اظهرت قيماً عالية من العكورة، مجموع المواد الصلبة الذائبة، وكاربونات الصوديوم المتبقية. وبناءً على نتائج المؤشرات تبين أن المياه لا يمكن استخدامها للشرب مباشرة بل تحتاج إلى عمليات المعالجة المناسبة قبل التوزيع للاستهلاك العام.

**الكلمات المفتاحية:** سد باوة شاسوار، الخصائص الفيزيائية والكيميائية، مؤشر جودة المياه.

Introduction

Surface water is available in dams, rivers, and ponds are used for different purposes such as irrigation, drinking, and fisheries life. Fresh water nowadays has become a global issue because the increased population worldwide and pollution [1]. Usually, water quality decreased as a result of the human activities increased. Also, using excessive amounts of fertilizers and pesticides in agricultural lands have great impacts on surface water resources [2]. Water quality of the dam has been assessed through testing some parameters such as ( $\text{Na}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{HCO}_3^-$  and  $\text{Cl}^-$ ). Moreover, the quality indices such as: Sodium Adsorption Ratio SAR, Soluble Sodium percentage SSP, Residual Sodium Carbonate RSC, and Kelly's Index have been calculated. The aim of this research is to determine the suitability of Bawashaswar water harvesting dam for drinking, irrigation and fisheries life basis of the quality indices and WHO standards.

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### Study area

Bawashaswar earth fill dam was constructed in Kifri district in 2011 and located in the Southeast of Sulaimaniyah province in Kurdistan Region, Iraq. The dam has embankment length of 240 m and a height of 22 m. The reservoir of the dam has a capacity of  $(6.5 \times 10^6 \text{ m}^3)$  and is used for irrigation and flood control. The study area is located between (N:  $34^\circ 43' 12''$ ), (E:  $44^\circ 58' 27''$ ), with elevation of 250 m above sea level. It is located in Kifri district, about 2 km to the northeast of the city and collects water from two main valleys which are (Baker shal and Omer bel). Both valleys receive water from the surrounding mountains.

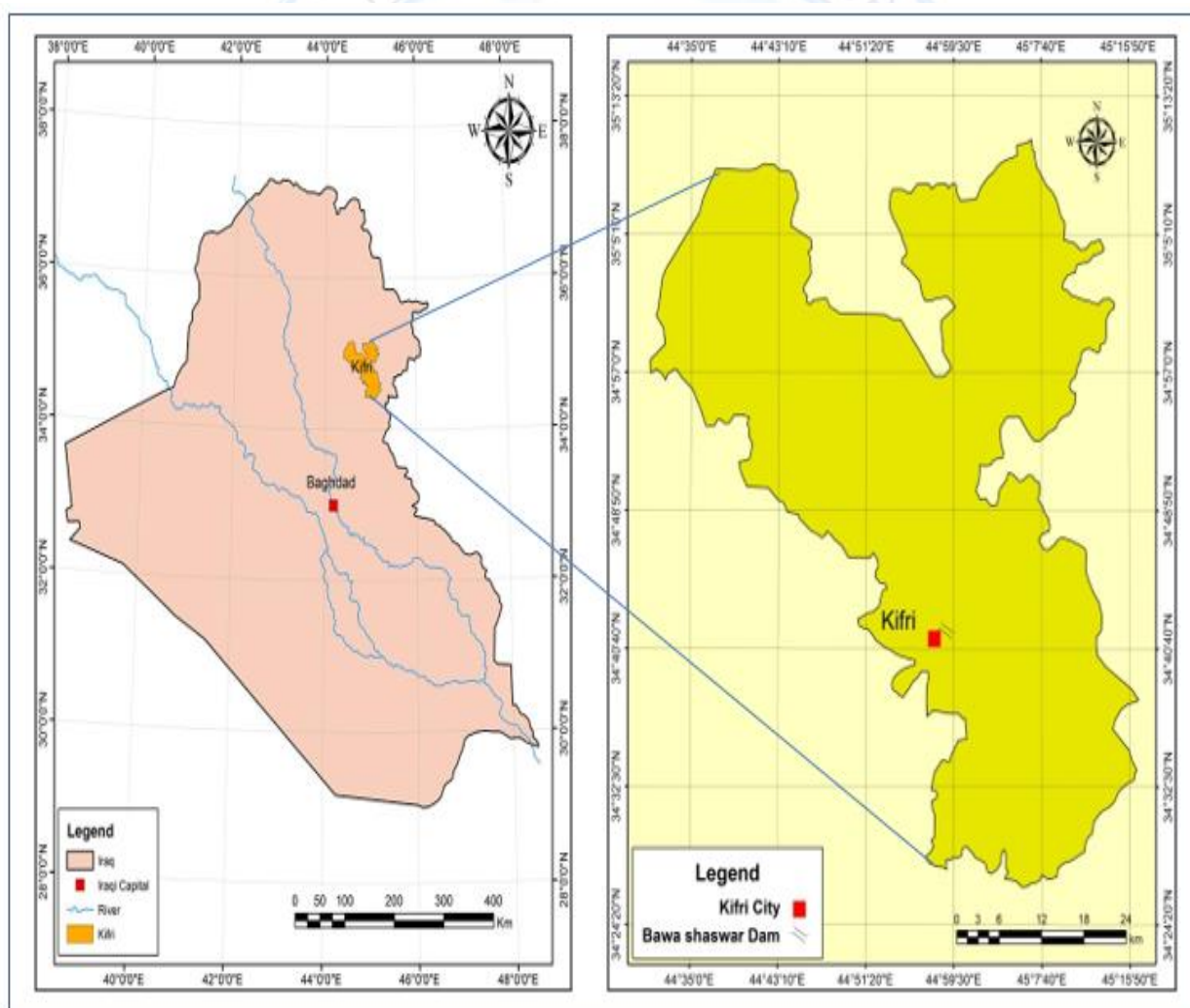


Figure 1: Location of Bawashaswar Dam (ArcGIS10.2.2)

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### Materials and Methods

#### **Water Sample Collection:**

The sampling campaign was begun in 5<sup>th</sup> of June 2017. Water samples were collected from twelve locations using plastic bottles; then, were labeled with respect to the points of collections. The collected samples were transferred to the laboratory in a cooled water container after measuring pH, EC, TDS, Temperature, and DO.

These water quality parameters were analyzed: total hardness (TH), chloride ( $\text{Cl}^-$ ), nitrite ( $\text{NO}_3^-$ ), sulphate ( $\text{SO}_4^{2-}$ ), bicarbonate ( $\text{HCO}_3^-$ ) calcium ( $\text{Ca}^{2+}$ ), sodium ( $\text{Na}^+$ ), magnesium ( $\text{Mg}^{2+}$ ), and potassium ( $\text{K}^+$ ).

#### **Analysis of Water Samples:**

After collection of the samples, few physical property parameters include pH, TDS, DO, EC, and turbidity, were measured directly at the site without physically removing the samples. Other chemical properties consist of essential elements (Ca, Mg, K, Na,) and total hardness were measured by means of inductively coupled plasma optical emission spectroscopy (ICPOES) (Spectro Arcos, Germany).

The ICPOES conditions used were: Spray chamber is Scott spray; Nebulizer: crossflow; RF power/W: 1400; pump speed: 30 RPM; Coolant flow (L/min): 13; Auxiliary flow (L/min): 0.9; nebulizer gas flow (L/min): 0.8; Preflush (s): 30; Measure time (s): 28; replicate measurement: 3; multi-elements stock solutions containing 1000 mg/L were obtained from Bernd Kraft (Bernd Kraft GmbH, Duisburg, Germany); serial diluted solutions were prepared as 0.1, 0.5, 2 mg/L in 0.5% nitric acid as diluent.

The major anions of the water samples were quantified by using ion selective electrodes (ISE) with different electrode for each specific parameters comprise sulphate, chloride, nitrate electrodes. The concentrations of bicarbonate ion were measured by acid base titration with standardized hydrochloric acid using double indicator methods [3-4].

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### Water quality indices analysis:

The evaluation of suitability of water quality for different purposes was conducted by using some indices such as Sodium Absorption Ratio (SAR), Soluble Sodium Percentage (SSP), Residual Sodium Carbonate (RSC), and Kelly's Index (KI).

### Results and discussion

The obtained results are presented in the table (1). Because of the importance of drinking, agriculture, and fisheries life sectors, water quality indices assessment has been carried out that the water is acceptable for different purposes.

#### **pH and DO**

pH is a representative of acidic or alkaline of water and it is an important parameter regarding water quality. pH value can sensitively indicate variations in water quality and is affected by dissolved substances [5].

The maximum and minimum values of pH were observed (7.8-8.28) indicating that all water samples are slightly alkaline and found within WHO limits for all purposes.

The reason of (slight alkaline) of water in Bawashaswar dam is calcium carbonate, which comes from limestone rocks that widely exist in Kifri. Over all, there is a little variation in pH in the reservoir, and there is no sample with pH less than (6.5).

Dissolved oxygen represents the amount of oxygen dissolved in the water. DO value with more than (5 ppm) is very important for fisheries life and production [6]. It is observed that the amount of dissolved oxygen is between (7.38-8.3) mg/l and the average of DO in the reservoir is (7.7) mg/l. Therefore, the level of DO in the reservoir is satisfied for most stages and activities in the life cycle of fish.

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**Table (1): Results of water quality analysis of Bawashaswar Reservoir**

Sample	pH	EC	Turbidity	Total Hardness	TDS	DO	NO3	Ca	Mg	K	Na	Cl	SO4	HCO3
1	7.8	1095.3	2.83	7.13	770	7.62	2.62	25.21	10.58	2.77	41.67	165	155	169.6
								1.26	0.88	0.07	1.82	4.66	3.23	2.61
2	8.17	982.9	2.96	6.66	688	8.02	2.97	25.93	10.81	2.38	39.64	172	159	178.1
								1.30	0.90	0.06	1.73	4.86	3.31	2.74
3	8.23	994.3	3.45	7.13	700	8	3.37	26.14	10.92	2.4	39.72	366	159	176.9
								1.31	0.91	0.06	1.73	10.34	3.31	2.72
4	8.04	1020	3.3	8.73	715	7.61	2.97	28.89	10.76	2.43	39.1	297	147	207.4
								1.45	0.90	0.06	1.70	8.39	3.06	3.19
5	8.26	991.3	4.9	6.22	684	7.38	2.73	26.82	11.09	2.41	39.62	251	138	197.6
								1.34	0.93	0.06	1.73	7.09	2.88	3.04
6	8.23	1001.5	3.89	6.66	671	7.51	2.73	26.05	11.27	2.48	40.01	262	126	185.4
								1.30	0.94	0.06	1.74	7.40	2.63	2.85
7	8.23	985.7	5.53	7.63	690	7.65	2.12	27.82	11.21	2.41	40.69	241	158	178.1
								1.39	0.94	0.06	1.77	6.81	3.29	2.74
8	8.27	1017.9	4.6	7.63	682	7.5	1.87	27.4	11.2	2.44	40.24	222	165	207.4
								1.37	0.93	0.06	1.75	6.27	3.44	3.19
9	8.25	540	2.95	7.63	378	8.3	1.46	26.99	11.19	2.45	40.31	222	155	201.3
								1.35	0.93	0.06	1.76	6.27	3.23	3.09
10	8.26	985.5	3.88	7.13	680	7.68	1.65	27.47	11.47	2.45	39.95	204	159	195.2
								1.38	0.96	0.06	1.74	5.76	3.31	3.001
11	8.25	968.7	5.56	7.63	680	7.71	1.58	58	11.32	2.43	39.69	223	153	183
								2.90	0.94	0.06	2	6.30	3.19	2.81
12	8.28	971	5.8	7.13	670	7.43	1.65	26.32	11.19	2.49	40.28	231	123	244
								1.3	0.93	0.06	1.76	6.53	2.6	3.75
Minimum (mg/l)	7.8	540	2.83	6.22	378	7.38	1.46	25.21	10.58	2.38	39.1	165	123	169.58
Maximum (mg/l)	8.28	1095.3	5.8	8.73	770	8.3	3.37	58	11.47	2.77	41.67	366	165	244
Average	8.19	962.84	4.13	7.27	667.33	7.7	2.31	29.42	11.08	2.46	40.07	238	149.75	193.67
WHO	6.5-8.5	400-800	1.5	<100	500		45	75	125	150	100	250	250	-

### Electric conductivity and TDS

It represents the ability to conduct electrical current, ions which are carrying positive and negative charges [7]. It is also regarded as an effective indicator to classify water into good, medium, and bad categories. The EC of all water samples are varied between (540-1095.3) dS/m. Comparing to the acceptable values of conductivity, all samples exceed the safe limit except sample (9). High value of EC in the sample (9) indicates the presence of high amount of dissolved inorganic substances in ionized form at that location. The permissible value for (EC) is (600 dS/m) according to (WHO 2011) standards [8].

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TDS is formed as a result of water ability to dissolve salts and minerals; then, these minerals produce undesirable taste in water [9]. The (WHO 2009) and Iraqi standards value for TDS is (500 ppm). Results show that value of conductivity and concentration of (TDS) changes along the reservoir.

The TDS concentrations in Bawashaswar Reservoir ranged between (378- 770) mg/l, and the average of the entire reservoir is (667.3) mg/l. Overall, the concentrations of TDS in Bawashaswar Reservoir, exceeds the range that is acceptable by WHO. High levels of TDS are caused by the presence of organic sources such as leaves, silt, plankton, fertilizers and pesticides used on agricultural lands around the reservoir [10].

### **Turbidity**

It defines as the quantity of suspended material in water or solution which interferes with light penetration, high turbidity leads to make DO stratification in water bodies Thus, the water body loss its ability to support aquatic life [10].

The values of turbidity in the reservoir are ranged between (2.83- 5.56 NTU), with the average value of (4.14 NTU). It can be considered a safe limit. Most of the samples do not exceed the turbidity limits (5 NTU).

### **Calcium, Magnesium and TH**

In general, water body gains hardness because of presence of calcium and magnesium, and these elements enter water body as a result of leaching limestone, magnesita, dolomite, and others [11]. TH defines the concentration of the metallic cations in a solution.

The concentrations of calcium were between (25.21-58) mg/l. All the samples were under acceptable and permissible limit. The concentrations of magnesium were between (10.58- 11.47) mg/l. The water samples were within the permissible limits [8]. The permissible value for total hardness is (500) mg/l according to the WHO.

### **Sodium and potassium**

The samples analysis showed that the concentration of sodium varies between (39.1- 41.67) mg/l. These were observed to be within permissible limit. For drinking water, the acceptable

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limit for Na is about (200) mg/l [8]. On the other hand, potassium concentrations vary between (2.38-2.77) mg/l. Therefore, all samples had potassium concentration within the acceptable limit.

### **Chloride**

Excess concentration of chloride may cause salty taste to water [8]. The values of chloride were between (165-366) mg/l. These values found to be within permissible limit (250) mg/l.

### **Sulphate**

It is naturally exist in surface waters as sulphate ions ( $\text{SO}_4^{2-}$ ). Sulphate ions are formed from the leaching of Sulphur compounds, sulphate or sulphide minerals such as gypsum and pyrite [12]. Water sample analysis observed sulphate to (123) mg/ l as a minimum value, and (165) mg/l as a maximum value. So, these samples were within permissible limit (200) mg/l.

### **Nitrate**

Human, animal wastes, using fertilizers and industrial effluent considered as the main sources of  $\text{NO}_3^-$  in water bodies [13]. The concentration of nitrate in the water samples were between (1.46-3.37) mg/l. This indicates that all samples were found to be well within the prescribed limits of (45) mg/l.

### **Carbonate and Bicarbonate**

They are existed in water because of some carbonate minerals present in water such as limestone, magnesite, and dolomite. This may influence pH values of water [14]. The concentrations of bicarbonate were between (169.58-244) mg/l. So, all samples were found to be within permissible limits [8].

### **Results of water quality indices**

The results of water quality indices are shown in the table (2).

### **Kelly's Index (KI):**

The alkaline hazard is represented by the concentration of Na, Ca & Mg in water samples. Less than (1) of KI value indicates good water quality for irrigation and vice versa [15].



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Values of KI in the studied area were varied from (0.45-0.85). So, based on the KI all of water samples are acceptable for irrigation.

### **Residual Sodium Carbonate (RSC)**

Excess concentrations of carbonate lead to make combination with calcium and magnesium; then, form some solid materials which settle out of the water [16]. Thus, influence the water acceptability for irrigation. Water with high RSC has high pH makes the lands that irrigated with these types of water infertile gradually [17].

Values of (RSC) less than (1.25) meq/l considered as safe for irrigation. Values between (1.25-2.5) meq/l are of marginal quality. However, values more than (2.5) meq/l are unsuitable for irrigation [18]. Regarding the study area, the RSC values are in the range of (-1.04 - 1.50) meq/l. Therefore, most of the water samples are suitable for irrigation regarding RSC except only one sample which has a value of (1.5) meq/l.

### **Soluble Sodium Percentage (SSP)**

The minimum SSP value has been observed is (31) as presented in the table (2). However, maximum value has been recorded (45.84). Therefore, all the samples are within the permissible level for irrigation [16].

### **Sodium Adsorption Ratio (SAR)**

The values of SAR were ranged between (0.94-1.39). Water with SAR value less than (10) is considered as good for irrigation. The results show that all the sites studied are good for irrigation [16]. When (Na) ration increase compared to (Ca and Mg) resulting in soil dispersion [19]. Ca and Mg ions are important since they tend to counter the effects of sodium. Moreover, high SAR values make sodium to be attached to soil particles; thus, leads to breakdown in the soil physical structure.

### **Sodium Percentages (SP)**

It also called (Sodium Hazard), which is considered as an important water quality factor especially for irrigation [20]. Water with high values of sodium leads to produce undesirable impact that is because (Na) will react with soil to decrease its permeability and thus

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negatively affects the growth of plant [21]. In order to get rid of sodium accumulations and breaking down in the physical properties of soil, the values of (SP) should be less than 60% in irrigation water. The values of (SP) in Bawashaswar water samples are ranging from (4.41-4.63); according to the Wilcox work [22], this indicates that water in the study area is falling under excellent category.

### **Magnesium Hazard Ratio (MH)**

The value of magnesium hazard (MH) ratio in water is very significant factor for irrigation purpose [23]. When the values of magnesium are equal or higher than (50); ultimately, the effects will be adverse on the production. The results in Table (2) shown that Bawashaswar water samples have (MH) values greater ranged (24.55-41.90) and falling under excellent category.

**Table 2:** Results water quality indices in the samples

Sample	SAR	Na%	MH%	KR	RSC	SSP
1	1.39	4.63	41.16	0.85	0.46	45.84
2	1.31	4.46	41.00	0.78	0.54	43.97
3	1.30	4.48	41.05	0.78	0.50	43.80
4	1.24	4.41	38.30	0.73	0.84	42.08
5	1.28	4.48	40.80	0.76	0.77	43.21
6	1.31	4.53	41.90	0.78	0.61	43.71
7	1.30	4.58	40.18	0.76	0.41	43.22
8	1.29	4.54	40.53	0.76	0.88	43.18
9	1.30	4.55	40.87	0.77	0.81	43.45
10	1.28	4.54	41.04	0.75	0.67	42.73
11	0.94	4.48	24.55	0.45	-1.04	31.00
12	1.31	4.55	41.48	0.78	1.50	43.80
Minimum	0.94	4.41	24.55	0.45	-1.04	31.00
Maximum	1.39	4.63	41.90	0.85	1.50	45.84

### **Conclusion**

The study of water quality of Bawashaswar Reservoir has poor water quality with some parameters. Therefore, the quality of water in Bawashaswar Reservoir is not suitable for drinking directly (without treatment), but it can be used for other purposes such as agriculture and fisheries life. The indices such as MH, KI, RSC, SSP and SAR were within the permissible limits for irrigation. Monitoring monthly and seasonally is required including

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samples in the upstream and downstream of the dam which is very important to help farmers for using acceptable water quality; this will help proper management of water. Finally, increasing the number of parameters of water quality for tests is very important because it gives us more accurate and reliable results.

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