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WATER QUALITY INDEX OF TOURIST RESORTS AT CITY OF ZAKHO IN KURDISTAN REGION OF IRAQ

PAYMAN A. ABDULJABAR

Department of Environmental Science, Faculty of Science, University of Zakho, University Main Campus, Zakho International Road, Duhok, Kurdistan Region-Iraq.

SAMARA S. FARAJ

Department of Environmental Science, Faculty of Science, University of Zakho, University Main Campus, Zakho International Road, Duhok, Kurdistan Region-Iraq.

RAMI N. SALEEM

Department of Environmental Science, Faculty of Science, University of Zakho, University Main Campus, Zakho International Road, Duhok, Kurdistan Region-Iraq. Corresponding Email: rami.saleem@uoz.edu.krd

Abstract

A crucial component and effective instrument for examining the general characteristics of water quality is the Water Quality Index (WQI). Among the most significant tourist destinations in the northern part of Iraq and Kurdistan are the resort areas surrounding Zakho city. In December 2021, water samples were taken from a number of tourist locations, including Dashttagh, Sharanish Waterfall, and Bahair Cave. For the samples that were obtained, this investigation comprised chemical, biological, and physical tests. According to the World Health Organization drinking water quality standards, we conducted this research to determine whether this water is suitable for use by people, animals, and agriculture. The results of the tests revealed that water samples taken from Sharanish Waterfall had the best water quality when compared to other sources. both Bahair Cave, and Dashttagh samples.

Keywords: Chemical and Biological Properties, Drinking water, Water Quality Index, Zakho Resorts.

1. INTRODUCTION

Iraq's water supply has seen significant alterations with regional and temporal variance. Undoubtedly, the rise in population and the expansion of economic activity are factors in the rising need for water for usage in a variety of ways. Iraq's water resources, particularly in the last two decades, have experienced significant stress in terms of water quantity due to a variety of factors, including the construction of dams on the Tigris and Euphrates in neighboring nations, the effects of global climate change, the regional sharp decline in yearly precipitation rates and the inefficient use of water inside Iraq [1, 2, 3]. The number and quality of supplies coming from various sources do affect water quality. Consequently, it is essential to create a thorough preparation for the allocation of water among various applications and the management of water resources to maintain the amount or concentration of contaminants in the water. It is not unexpected that studying water quality is crucial to be done in order to maintain our awareness and comprehension of our environment given the aforementioned causes. One of the most essential demands of any civilization throughout history has been access to clean drinking water. In addition to other physical, chemical, and biological qualities, the sources of drinking water have their own criteria for things like flavor and color. The water quality index is a metric that captures these qualities. It is frequently employed to assess the water sample. There are universal

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standards for drinking water quality, accessibility for human use, and impact on ecological systems that have been established by numerous agencies and organizations, including WHO and CDC. Drinking water quality depends on the water's chemical composition, which is impacted by both natural and human processes. If those precautions went beyond the permitted thresholds established by those agencies, the water might be fatal. These organizations establish the acceptable norms and limits for chemical pollutants that might be found in drinking water. The resorts in the Kurdistan area, particularly those around the city of Zakho, have recently experienced fast growth and have established themselves as popular travel destinations for local tourists. On the other hand, there has been a severe water shortage in Iraq for a variety of causes. Tests and measurements were performed on water samples from three well-known resorts to assess their water quality for the two reasons mentioned above. In addition to determining whether the water available in such areas may be used as a source of drinking water, these studies focused on the amount of various pollutants to assess their influence on the traveling visitors. A baseline for comparing the success and failure of management techniques to improve water quality is also provided by WQI measurements [4]. Since Horton [5] first suggested using WQIs, other alternative methods for calculating WQIs have been created. A panel of 142 water quality experts provided their professional judgment in the development of the WQI. They chose nine variables: total solids, dissolved oxygen, fecal coliform, pH, biochemical oxygen demand, and total phosphate, nitrate, and turbidity. Then, based on the data range, a quality value (Q value) from 0 to more than 300 was assigned for each parameter. Each Q value was multiplied by a weighting factor based on the significance of the characteristic; the WQI, which categorizes water as excellent, good, poor, extremely poor, and inappropriate, was produced by adding the weighted Q values. During a workshop held in Sulaimaniyah, Iraq, in July 2008, organizations and institutions in Iraq gave close attention to the topic of seeding and introduced water quality indices to the Iraqi scientists. In light of the requirements of national planning and resource management, this project may be regarded as one of the aspects of the key ecological investigation tools in this regard [6]. It applied several models of (WQI) and Indices of Biological Integrity (IBI) on data collected by Nature Iraq and others.

1.1 The aim of the research

Knowing the extent of the water's impact on visitors, particularly during bathing or recreation in the summer travel season, and measuring the quality of resorts' water will help determine whether it is possible to build a water purification plant to make it drinkable. You will also be able to determine whether it is possible to use this water to create artificial lakes and small dams to create fishing opportunities.

2. MATERIALS AND METHODS:

Samples collection for water

The experiment's purpose was to collect several samples from three of the most popular resorts in the Zakho area and use those samples to conduct nine tests and measurements to assess the water quality in the intended areas. Sharanish Waterfall, Bahair Cave, and Dashttagh are the three areas that will be studied; they are located 40, 45, and 60 kilometers

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from Zakho city center, respectively. Each location had three water samples taken at a depth of 10 cm from the water's surface. The following maps show the study sites:

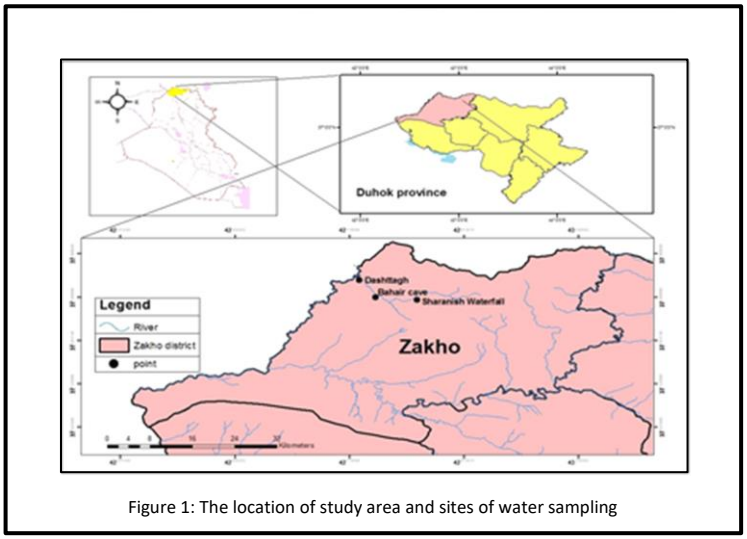

Figure 1: The location of study area and sites of water sampling

The following tests are performed after the process of data collection:

2.1 pH level Test

The hydrogen ion (H+) concentration in a sample is determined by the pH level (water sample in this case). When H+ concentrations are high, the water becomes more acidic, whereas when concentrations are low, the water becomes more alkaline. This means that determining the pH level provides information about the balance of acidity in water.

2.2 Total Dissolved Solids (TDS) test

Regardless of whether it is discovered as a molecular or ionic suspension, which reflects the amount of organic and non-organic compounds that is contained in the examined sample. TDS is frequently used to describe the appropriateness of drinking water.

2.3 Turbidity measure

These contaminants, which are often microscopic particles that cannot be seen with bare eyes, indicate the presence of dopants and solid pollutants in a water sample. As a common indicator of the water quality, turbidity can be assessed using a device AL250T-IR

2.4 Salinity measurement

Which refers to the quantity of salt (sodium chloride, calcium chloride, etc.) dissolved in water. Using potassium chromate (K_2CrO_4) as an oxidizing agent, silver nitrate ($AgNO_3$) is used in a titration to assess salinity**.**

2.5 CO_2 measure

It manifests itself in water as a dissolved gas. A carbon atom is covalently doubly linked to two oxygen atoms to form carbon dioxide. It is a trace gas that naturally exists in the

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atmosphere of the Earth. Through the use of sodium hydroxide titration, the presence of CO_2 was determined (NaOH).

2.6 Ammonia Measurement

One of the most significant pollutants in the aquatic environment is ammonia. Not only because it is extremely poisonous, but also because surface water systems frequently include it. Reverse titration using NaOH and H_2SO_4 sulfuric acid is used to quantify ammonia.

2.7 Total Hardness measure

The total amount of cations in the water, including calcium Ca2+, magnesium Mg2+, iron Fe2+, manganese Mn2+, and other cations, is what is known as water hardness. Total hardness was determined by titrating the sample with EDTA after bringing the pH level to 10 with a controlled ammonia solution.

2.8 Body Oxygen Demands BOD

This is the quantity of oxygen that microbes use to break down organic stuff**.**

2.9 Atomic Absorbance

which uses an atomic spectrum analyzer to calculate the contents of (lead Pb, iron Fe, copper Cu, calcium Ca, magnesium Mg, phosphate PO_4, and nitrate NO_3) in water samples.

3. RESULTS AND DISCUSSION:

The aforementioned tests and measurements are completed, and the results are displayed in table 1. The figures in the table show the average results of the chemical and biological analyses performed on water samples taken from the three key locations. The WHO standard safety limits are displayed in the first column.

Table 1
Outcomes of the perform experiments

Parameters	Value standard (WHO)	Sharanish Waterfall mg/L	Bahair Cave mg/L	Dashtatagh Resort mg/L
Pb	0.05	0.91	1.103	0.981
Fe	0.3	0	0	0
Cu	0.05	0.02	0.05	0.03
Ca	75	26.56	36.04	29.46
Mg	50	2.845	2.755	2.74
PO4	0.04	0.03	0.068	0.053
NO3	50	37.2	74.4	55.8
PH	6.5-8.5	8.6	8.5	8.7
turbidity	5	4.5	2.6	2
TDS	500	275	304	211
Alkalinity	100	33	28	20
Cl-	250	24	4	4
Salinity	0.04	0.00021	0.0004	0.00018
Total hardness	100	46	56	60
Ammonia	0.2	0.011	0.012	0.01
CO2	3	0.399	0.798	0.499
SO4	250	5.56	9.88	2.88
DO	7.2	9.8	9.5	9.9
BOD	5	2.5	2.5	1.9

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Lead (Pb) levels. Lead is a poisonous metal that occurs naturally in the crust of the earth. When it enters the body of a person, it is dispersed to various organs including the brain, kidneys, liver, and bones. Lead is stored by the body in the teeth and bones, where it over time builds up. During pregnancy, lead that has been accumulated in the bones might leak into the blood, endangering the unborn child. Because their bodies absorb lead more readily if they are undernourished and lack other minerals like calcium, malnourished children are more likely to get lead poisoning [7]. Due to this, the lead content of the water was determined, and the results are displayed in table 1.

The World Health Organization's experts' lowest suggested level of iron concentration, (0 mg/L), was present in all three samples, but this does not endanger human health. One of the essential nutrients for the human body is iron, which is crucial for producing red blood cells and delivering oxygen to every region of the body [8]. By comparing the copper concentrations in the three samples, it was discovered that the Bahair Cave sample had a higher copper concentration than the Sharanish Waterfall and Dashttagh Resort samples. This can be explained by the fact that Bahair Cave contains a lot of green, brown, red, and blue-green algae, which are high in proteins, salts like sodium, chlorine, copper, and molybdenum, as well as vitamins A, B1, B2, C, and E, as well as folic acid, but it is still considered to be within the permitted limits and has no impact. The environment contains copper in a variety of states and combinations. The form in which copper is present has an impact on its solubility. The form of copper in food differs from that in water. Typically, copper is either adsorbed to insoluble particles or complexed with inorganic ligands [9]. Insignificant amounts of copper are found in drinking water [10][11]. Several human activities, particularly those involving land and mining operations, emit copper into the environment [10] [12]. In addition, sewage treatment facilities, soil weathering, industrial waste discharged into water, and antifouling coatings all contribute to the release of copper into water [13].

While the magnesium concentration was considerably greater in the Sharanish Waterfall sample than the Dashttagh resort and the Bahair Cave sample, both calcium and magnesium concentrations were within the World Health Organization's range of acceptable values. Although excessively high levels of calcium and magnesium can have certain detrimental health effects, these minerals are necessary for human health and have numerous positive impacts. For instance, vascular (cerebral) bleeding risk is increased by low calcium levels, while high amounts encourage vascular aging (arteriosclerosis). Low calcium levels in people with arthritis lead to inflammatory kinds of joint disease, whereas excessive calcium levels lead to degenerative (osteoarthritic) joint damage. Insomnia will result from a diet low in the minerals calcium and magnesium [10] [14]. Although groundwater serves as a major source of both of these elements, it is frequently overlooked in this regard.

The Bahair Cave sample has a modest rise in PO_4 levels when compared to other samples, however this does not present a threat to the environment or to people. The ground is the natural source of the chemical compound phosphate. As any imbalance in the percentage of phosphate in water causes the so-called premature aging, a maximum percentage of phosphate in water has been set at 0.04 mg/L. The Bahair Cave sample

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has a modest rise in PO4 levels when compared to other samples, however this does not present a threat to the environment or to people. The ground is the natural source of the chemical compound phosphate. As any imbalance in the percentage of phosphate in water causes the so-called premature aging, a maximum percentage of phosphate in water has been set at 0.04 mg/L. If the phosphate concentration in the water is raised, aquatic plants and algae start to develop more quickly than usual. The huge size of plants and plankton that block sunlight from others causes many plants and algae that age prematurely to die and sunlight to not reach lower levels of water [15]. The huge size of plants and plankton that block sunlight from others causes many plants and algae that age prematurely to die and sunlight to not reach lower levels of water [15]. As a result, these plants absorb oxygen at a very rapid rate, which causes the water to become oxygen-deficient and cause some aquatic life to perish. According to a Harvard study, phosphate levels above a certain threshold hasten the development of aging symptoms in people [16].

There has been a noticeable increase in NO_3 concentration in the Bahair Cave sample, which can be linked to the geological features of the cave, which include cracks and passageways and may be the cause of the leaking of pollutants into the water. Contributes to the nitrate-based fixation of atmospheric nitrogen. According to the German Center for Cancer Research, animal studies have shown a connection between nitrosamines and stomach cancer as the body produces nitrosamines as a result of nitrates' interaction with protein. However, no connection between nitrosamines and human cancer has been discovered to far [17].

Additionally, the pH values of the three water samples are within the WHO standards' upper limit (8.6, 8.5, and 8.7 for the Sharanish Waterfall, Bahair Cave, and Dashttagh Resort, respectively), indicating that the water possesses alkaline characteristics. Examining the CO_2 and Chloride ions Cl-, which are substantially lower than WHO criteria, further supports this. The fact that there is a correlation between the pH values in the sample and the percentage of dissolved carbon dioxide in the water shows that the acidity of the water has started to increase recently as a result of climate change. Where human-produced carbon dioxide from the atmosphere is absorbed by water, harming aquatic life in the process [18]. However, the three models' low carbon dioxide concentrations can be supported. We see a modest rise in pH levels. BOD is computed by figuring out how much oxygen is required for microbes to oxidize organic compounds in the water. A technique suggested by Trivedy et al. was used to measure it [19]. Additionally, chemical oxygen demand was measured as the amount of oxygen used during the oxidation of oxidizable organic matter by a powerful oxidizing agent [19]. The biological oxygen demand is a crucial criterion for assessing any waste water's quality and applicability to aquatic life. The quantity of BOD growth reflects an increase in the proportion of organic pollutants in the water. BOD is the amount of oxygen needed by microorganisms to break down organic waste in waste water. The amount of oxygen necessary for bacteria to convert degradable organic matter into simpler molecules in any particular body of water is known as biological oxygen demand [20]. Accordingly, a high level of BOD is greatly influenced by the presence rate of microorganisms and oxidizable organic matter, which measures the quantity of oxygen needed to break down oxidizable organic matter.

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Therefore, high BOD contents in water are a sign of severely contaminated waters. Our results concur with those of [21][22], who found that BOD is within WHO permitted limits.

Utilizing calcium (Ca+2), magnesium (Mg+2), sodium (Na+), and chloride (Cl), TDS (total dissolved solids) was determined [23]. Total dissolved solids (TDS), a measure of mineral and organic component contamination of water, decreased with distance from the WHO value norm, according to table 1. TDS is a metric used to determine how many organic and inorganic compounds are present in a particular amount of water. TDS isn't often thought of, though, as a major pollutant; it is used as indicator of the presence of a wide range of chemical pollutants [24]. Titrating the water sample against HCl as indicated in determined the alkalinity of the water sample [19]. Acidity can be neutralized by dissolved inorganic and organic material, which is where alkalinity primarily derives from. Data registered in Table 1 shows that alkalinity in Sharanish sample is nearly three times greater than average and much higher than Bahair Cave and Dashttagh Resort [25][26]. The wastewater hardness was assessed by titrating it with a regular EDTA solution [21]. Total hardness is caused by calcium and magnesium combining with chloride and sulfate to generate dissolved ions in water. Table 1 demonstrates that this sort of water has much less calcium, chloride, and sulfate than the WHO-recommended norm. Current findings support the [25][26]. The amount of water transparency caused by suspended particulates is referred to as turbidity. The cloudiness. This result supports the findings of [24][26]. The sulphate level in Sharanish, Bahair Cave, and Dashttagh Resort is within the usual range of SO_4 in accordance with WHO criteria, as indicated in table 1. Chlorine has a detrimental effect on the environment, poses a threat to aquatic life, and interferes with the reproduction and growth of aquatic creatures [24]. The main halogen that damages the ozone layer and upsets the balance of the ecosystem is chlorine. In addition to acidifying fresh water, too much chlorine in the water will induce salinization, the solubilization of hazardous heavy metals, disruption of the microbial population, particularly nitrifying and denitrifying bacteria, and other effects. As seen in table 1, the chlorine concentrations in the three locations are below the average value, meaning that they won't have any negative consequences over time. Our findings conflict with [25][26]. However, compared to the current study, [27] observed lower amounts of chloride ion. The three samples' dissolved oxygen (DO) concentrations are similar to but somewhat higher than the norm. However, a number of factors, including water dynamics, hard objects and obstructions in the water's path, the quantity of aquatic plants present, water temperature, ice cover, and depth, all have an impact on dissolved oxygen levels. Very cold water has higher quantities of dissolved oxygen than very warm water [28]. However, the level of the water body may drop if an ice cover limits its surface. Algal growth and water temperature both influence the concentration of dissolved oxygen (e.g., chlorophyll). On the other hand, dissolved oxygen affects the quantities of specific chemical components as well as the forms and toxicity of specific metals (such as dissolved metals) (e.g., sulphide and ammonia). Although there are several factors that influence DO levels in the water, temperature variations are the most frequent. Due to their inverse relationship, temperature and dissolved oxygen have an impact on one another; as water temperature rises, DO levels fall [29]. Regarding salinity, which is the total amount of dissolved salts in water, such as sodium chloride (NaCl), calcium chloride

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($CaCl_2$), etc., it is quite low compared to the standard values established by the WHO. This can be explained by the fact that the springs from which this water is drawn have a lower salinity level. Moreover, the plants and animals that live in water affect salinity. Additionally, there is a negative correlation between salinity and dissolved oxygen, meaning that as salinity rises, water's capacity to retain oxygen declines [30]. Water Quality Index (WQI) was calculated from the outcomes collected. WQI was found using its standard equation (equation 1) and compared to the standard WQI [31].

$$WQI = \sum_{i=1}^{i=n} w_i \times q_i / \sum w_i \quad (1)$$

Where wi is and qi represent According to the calculation made, WQI for the three locations were as shown in Table 2. Table 3, on the other hand, shows the WQI standards for water quality evaluation. Comparing the two tables returns the decision about whether the water is suitable as drinking water or not.

Whereas:

w_i: the relative weight of each adjective.

q_i: A measure of the degree of quality for each adjective.

Table2
Water Quality Index for the three targeted locations

Sample	WQI
Sharanish Waterfall	394
Bahair Cave	507
Dashttagh Resort	441

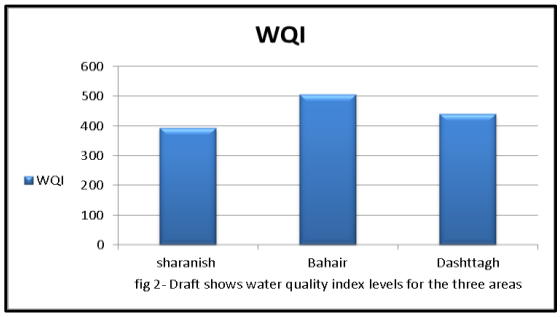

fig 2- Draft shows water quality index levels for the three areas

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Table 3
Water quality classification based on WQI value, [32]

Range	<50	50-100	100-200	200-300	>300
Quality	Excellent	Good	Poor	Very poor	Unsuitable

4. CONCLUSION

The WQI values are high, more than 300, indicating they are of an unstable type, according to a comparison of the data obtained in Table 2 with the criteria stated in Table 3. The studied samples could not be utilized for drinking since the Bahair sample had the highest value, the Dashttagh sample came in second, and the Sharanish waterfall sample had the lowest value. To make the target water suitable for human consumption, it must undergo chemical operations such as purification, filtration, heavy metal calibration, and others. However, the targeted water bodies can be used for irrigation in addition to being used for livestock or fisheries projects because they are surrounded by some of the most fertile lands that have been transformed over time into active agricultural areas, in addition to being used as sources of drinking water. The WQI values, however, are secure and do not endanger visitors while they are having fun, which is a benefit for drawing in more visitors.

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