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Water Quality Assessment by Measuring Physio-chemical Properties and Heavy Metals Contents at Water Stations in Basra City, Iraq

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ABSTRACT

Aims There is a relationship between environmental pollutants, particularly heavy metals, the risk of water pollution, and diseases in numerous areas. This study aimed to assess the water quality by measuring physio-chemical properties and heavy metals contents at two water stations in Basra city, Iraq.

Materials & Methods The water samples were collected from two main water stations of Al-Baradi'yah and Al-Jubaila. The pH values, turbidity, and TDS of the water samples were measured, and the heavy metals analysis of Cd, Cr, and Cu was done by the direct extraction/ air acetylene flame method using a flame atomic absorption spectrometer. The results of the parameters were compared with the safe limits of WHO.

Findings The turbidity and total TDS for both stations showed a significant difference, whereas the pH values were not, referring to the raw and tap water at both stations being acidic (pH<7). A significant difference was observed between the level of Cr and Cd in the raw and tap water samples within the acceptable levels of WHO. A significant difference was observed in the Cu levels in Al-Bharatiya (p<0.05). Whereas, no significant difference was observed between the chromium level in the water samples of the Al-Jubaila station (p>0.05). The amount of the Pb was shown a slight increase from the acceptable levels in the tap water at Al-Baradi'yah station and the raw and tap water at the Al-Jubaila site.

Conclusion A part of the chemical parameters is within the WHO acceptable limits, except water turbidity and Pb levels.

Keywords Heavy Metals; Toxicity; Water Quality; Iraq

CITATION LINKS

[1] Analysis of physiochemical parameters ... [2] Peoples perception about ... [3] Factors affecting water ... [4] Evaluation of drinking water ... [5] Physico-chemical parameters ... [6] Quality of drinking water ... [7] Toxicity, mechanism and ... [8] The importance of copper ... [9] Heavy metal toxicity ... [10] Lead ... [11] The cellular effect of ... [12] Lead toxicity update ... [13] Lead poisoning-part 1... [14] Human health effects ... [15] Water resources in ... [16] Standard methods for ... [17] Water quality index ... [18] Quality assessment of ... [19] Examining the dynamics ... [20] Impact of raw water ... [21] A study on the ... [22] Total arsenic and speciation ... [23] Health risk assessments of ... [24] Ecological quality assessment ... [25] Study of radon concentration ... [26] Health risk assessment ... [27] Guidelines for drinking-water ... [28] Appropriate household ... [29] Industrial metal pollution ... [30] Geochemical thermodynamics ... [31] Contaminated childhood ... [32] Preliminary study of lead-contaminated ...

Introduction

Pure drinking water has been recognized as an essential right of human beings. It plays a vital role in human health and welfare [1]. Harmful effects on living organisms can occur due to any change in physical, chemical, or biological properties of water quality (pollution) [2]. Plants, fish, birds, humans, and other animals, are all affected by water pollution [2].
Water pollution can be defined as an alteration in the components of the watercourse due to human activities, which produce less appropriate drinking water for domestic uses [3]. Geological conditions and industrial, agricultural, and water treatment plant activities may be considered potential sources of water contamination [1].
Characteristics of drinking water, including physical, biological, and chemical properties have great importance on human health [4]. It is necessary to investigate water's different physicochemical parameters before its usage for drinking, domestic, agricultural, or industrial purposes [5].
Numerous physical parameters such as pH, total solids, total dissolved solids, and total suspensions should be assessed to test water quality and purity [6]. Water turbidity is an indicator of water pollution due to the deterioration of organic matter and the improper disposal of domestic and industrial solid wastes and wastewater [6].
To obtain water with good quality and high purity, it is necessary to check out its heavy metal and organic contents, which is residues of pesticides [5]. Different biochemical and physiological functions in living organisms depend on the presence of metals in trace amounts; nevertheless, they convert to harmful ones following their excess acceptable limits [7].
Toxicity by heavy metals can reduce energy levels and impair the normal function of essential organs such as the brain, lungs, kidney, liver, blood components, and other substantial organs with subsequent organ damage [7]. Cadmium targets the kidney to be accumulated in the proximal tubular cells in excessive concentrations [7]. Long-term exposure to cadmium in trace amounts leads to its gradual accumulation inside the kidney and causes lung and bone disorders [4].
Copper has a central role as a fundamental trace element in the biochemistry of all living organisms, and it has an impact on enzymes activity as a cofactor or ingredient of various metalloenzymes such as superoxide dismutase, ceruloplasmin, lysyl oxidase, cytochrome oxidase, and tyrosinase [8]. Therefore, physiological activities, including neurotransmission, biosynthesis of tissue, free-radical defense, and cellular respiration, depend on copper availability [8].
Lead, the bluish-gray highly toxic metal, exists naturally in trace levels in the earth's superficial layer [9]. Widespread utilization of lead has resulted in widespread environmental pollution and diseases in numerous areas of the world [9]. Intoxication by lead was classified as a classic disease that targets the central nervous system and gastrointestinal tract of children and adults [10].
Tap water is considered one of the sources of lead poisoning [11]. It has been observed in children's dysfunctions, including hyperactivity, anorexia, decreased play activity, low intelligence quotient, and poor school performance when exposed to high lead levels [12]. Initially, the distribution of lead in the body depends on the blood flow into different tissues [12].
Skeletal bones are the deposition place of more than 95% of lead as an insoluble phosphate [13]. Lead exposure at a high level might result in abortion in pregnant women and can damage the organs of sperm generation in men [14]. Lead chronic exposure can cause mental retardation birth defects, psychosis, autism, allergies, dyslexia, weight loss, hyperactivity, paralysis, muscular weakness, brain damage, and kidney damage and can result in death [14].
Basra city is located in the far south-eastern region of Iraq, and it is characterized by a dry–desert climate according to the climate classification Koppen [15]. The primary source of water in Basra is the Shatt al-Arab and its freshwater canals [15]. Two of the main water stations in the city center of Basra (Al-Baradi'yah and Al-Jubaila) were chosen for water sampling since these stations have well-established projects for water treatment. These stations depend on the Shatt al-Arab to draw raw water for purification before pumping it to the residents of Basra.
This study aimed to assess the water quality by measuring physio-chemical properties and heavy metals contents at two water stations in Basra city, Iraq.

Materials & Methods

This descriptive cross-sectional research was conducted for one year (2021) in two main water stations (Al-Baradi'yah and Al-Jubaila) in the center of Basra city, Iraq. The samples of raw and tap water were collected through the mentioned stations with the assistance of the Basra water directorate staff. The water samples were collected in clean plastic bottles and then labeled and numbered according to their locations and sources (Table 1). The samples were kept at 4°C to avoid the effects of temperature and light.

The collected water samples were analyzed to determine pH, turbidity, and total dissolved solids. The pH values of water samples were measured using a portable digital pH meter (8686 AZ Water Quality Testing pH Meter; GEXEX Laboratories; USA). After turning on the meter and submerging its probe in the water samples to be held for a moment, the values of each sample were recorded after stabilization.

To measure water turbidity, standard procedures were followed using a turbidity meter. The meter holder was used to pour water samples to keep them inside for a few minutes. The result of each sample was noted following completing the reading stability.

Regarding the total dissolved solids characteristics, the collected water samples were measured using one apparatus. The probe was calibrated using a standard solution. The total dissolved solids values were recorded following submerging of the probe in the water samples and the disappearance of the stability indicator. Following each measurement, the probe was rinsed with deionized water to avoid cross-contamination among different samples.

The standard digestion method was followed by transferring 50 ml of each water sample into clean beakers. Then, 10 ml of concentrated HNO3 was added to each water sample to be shaken well [16]. Then, the hot plate was used to boil and evaporate the water samples to the lowest possible volume to be cooled at room temperature.

For dilution, 25 ml of distilled water was then added to each water sample. The diluted samples were then shifted to 50ml clean plastic containers to be foiled and kept at 4°C until the analysis of the mentioned heavy metals [16].

The heavy metals analysis of Cd, Cr, and Cu, was done by following the direct extraction/air acetylene flame method using Flame Atomic Absorption Spectrometer (FAAS, AA7000, Shimadzu, Japan), available at Marine Science Centre of Basra University [16]. Before heavy metals analysis for each water sample, the standard solution for each tested element was prepared according to its concentration and utilized for system calibration. Automatically, the obtained heavy metal concentrations were recorded using a computer connected to the FAAS system.

The findings were analyzed using paired t-test through SPSS 25 software.

Table 1) Collected water samples locations and their sources

No.	Location	Source
1	Al-Baradiyah station	Raw water
2	Al-Baradiyah station	Tap water
3	Al-Jubaila station	Raw water
4	Al-Jubaila station	Tap water

Findings

There was no significant difference between the pH level in raw and tap water samples in Al-Baradiyah ($p>0.05$) and Al-Jubaila stations ($p>0.05$). The pH level showed acidic water in the stations (pH<7).

Table 2) Physiochemical characteristics and the heavy metals concentrations (mean±SD) of the water samples

Parameter	Al-Barbadian	Al-Jubaila	WHO standards
pH			
RW	5.60±0.03	6.10±0.03	6.5-8.5
TW	6.00±0.07	6.10±0.08	
Turbidity (NTU)			
RW	16.8±2.2	35.50±0.27	5
TW	19.7±1.5	15.00±0.99	
TDS (mg/L)			
RW	283.6±19.8	303.2±6.4	1000
TW	326.5±0.3	308.7±0.2	
Cd (mg/L)			
RW	0.001±0.001	0.001±0.001	0.003
TW	0.002±0.001	0.002±0.001	
Cr (mg/L)			
RW	0.002±0.001	0.013±0.001	0.05
TW	0.022±0.007	0.023±0.011	
Cu (mg/L)			
RW	0.003±0.001	0.006±0.001	2
TW	0.008±0.002	0.013±0.008	
Pb (mg/L)			
RW	0.002±0.001	0.027±0.009	0.01
TW	0.037±0.013	0.038±0.018	

RW= Raw Water; TW= Tap Water

A significant difference was observed between the water turbidity in the raw and the tap water samples in Al-Baradiyah ($p=0.003$) and Al-Jubaila stations ($p=0.002$). The possible reason for the tap water turbidity elevation at Al-Baradiyah station (mean=19.7) is the poor purification system. The raw water turbidity at Al-Jubaila station (mean=35.5) is very high compared to its value at Al-Baradiyah station. This might be because the Al-Jubaila site draws the raw water from the deep surface of the Shatt al-Arab to be affected by the tap water turbidity.

In addition, there was a significant difference between the level of dissolved solids outcomes between the raw and tap waters in the Al-Baradiyah station ($p=0.026$) and Al-Jubaila station ($p=0.04$), which were within the safe limits of WHO (<1000mg/L).

In terms of heavy metals, a significant difference was observed between the level of copper and cadmium in the raw and tap water samples in the Al-Baradiyah station (p=0.001) and Al-Jubaila station (p=0.001), which level of copper and cadmium were within WHO acceptable levels less than 0.003 mg/L and 2 mg/L, respectively.

A significant difference was observed in the chromium levels of the samples in Al-Baradiyah (p=0.047), whereas no significant difference was observed between the chromium level in the raw and tap water samples in Al-Jubaila station (p=0.08). The mean of the chromium level in the studied stations was within the world health organization's acceptable levels.

There was a significant difference between the lead content in the raw and tap water samples in Al-Baradiyah (p=0.001) and Al-Jubaila stations (p=0.003). The lead content of the raw (0.027 mg/L), and the tap water samples (0.038 mg/L) in Al-Jubaila station, and tap water sample in Al-Baradiyah was higher than the allowable limits of WHO (0.01 mg/L).

Discussion

In this study, the water quality of two stations of Al-Jubaila and Al-Baradiyah in Basra, Iraq, was studied to evaluate the extent of water pollution.

The mean pH values varied from 6.11 to 8.37, which indicated that the water was slightly acidic to alkaline. The findings of this study revealed slight acidity of drinking water, although the ideal pH for human consumption is stated to be 7.4 [17]. World Health Organization suggested a controlled pH of the water to reduce the contamination of drinking water. Several factors, including rock and soil composition and the presence of organic materials or other chemicals, affected the pH level of water. Napacho and Manyele [18] found that pH values in shallow tubewells varied between 6.7 and 8.3 due to dissolved minerals in the soil and rocks. They explained higher alkalinity by the presence of two common minerals, calcium and magnesium, affecting the hardness of the water. Water with low pH values shows the acidic condition of the water. Saadilong *et al.* [19] found that the relationship between water pH and other water quality parameters is different in different water systems and can be influenced by the presence of other parameters.

Effective reduction of turbidity is one of the primary goals, especially for drinking water due to the negative effects on consumer acceptance. The results of this study showed turbidity elevation at the tap and row water samples in Al-Baradiyah and Al-Jubaila sites, respectively. Turbidity might interfere with filtration by clogging the filter prematurely. It can interfere with chemical disinfection by creating oxidant demand, UV irradiation by blocking light transmission, and reduce the efficacy of both by protecting microbes in aggregates or internal to other particles. Turbidity also has negative impacts on consumer acceptance of water. Turbidity is not a direct measure of microbial contamination, whereas microbes are often associated with particles in water. So, the purification of turbidity removes some microbes while reducing the levels of organic matter and other particles. Gauthier *et al.* [20] stated the increasing concentration of suspended particles in treated water during turbid events resulted in higher bacterial aerobic spore concentration for raw, treated, and distributed water. So, they emphasize the need to carefully monitor raw and treated water quality for utilities using “high-quality” water resources with limited treatment barriers, especially when such water resources are affected by even slight turbidity variations.

The main ingredients of water TDS are the cat ions such as potassium, calcium, and magnesium and the anions such as carbonate bicarbonate, chloride sulfate, nitrate, etc. The level of TDS in the studied stations was within the standard limit by WHO (<1000mg/L). TDS in drinking water originates from resources such as sewage, urban run-offs, natural sources, chemicals in the water treatment process, industrial wastewater, or chemical fertilizers used in the garden. Water is a universal solvent and can dissolve these particles quickly. Although elevated levels of TDS in drinking water are not a health hazard, it does lend the water a bitter, salty, or brackish taste. Calcium and magnesium, two minerals commonly found in TDS, can also cause water hardness. Among the contents of TDS, dissolved calcium and magnesium in the water are called “Hardness”. Some mentioned ions are essential, whereas some ions are toxic to human health. For example, Islam *et al.* [21] found the alarming low TDS in drinking water. So, water purification to control the standard limits of TDS, especially for drinking water, is essential.

In this study, the level of heavy metals in water samples in the two sites was within the acceptable limits by WHO. Several studies have evaluated the level of toxic metals in drinking water and reported that the concentrations of these metals are below permissible limits [22, 23]. However, emphasizing comparisons with standards is not enough to quantitatively assess the health risk of toxic element exposure via the consumption of drinking water. Based on the human health risk assessment models, exposure to toxic elements could increase the incidence of adverse effects on human health [24]. Heavy metals and arsenic contamination in drinking water are serious threats to human life because of their toxicity, persistence in the environment, and bio-accumulative nature [25]. The heavy metals contaminate the groundwater and surface water through natural processes and anthropogenic activities [26]. According to the World Health Organization (WHO) report in 2015, 71% of the global population uses safely managed drinking water sources [27]. This includes piped treated water that is located on the premises and protected dug wells [28]. However, safely managed water sources can still be polluted by toxic elements because of the poor domestic treatment system, use of chemical materials in the water treatment system, pipeline corrosion, leaching of elements from pipes of water distribution, and use of improper storage containers, etc. [29]. Most developing countries are faced with this challenge, especially due to their limited economic capacities to use advanced technologies for heavy metal removal [23].

The findings of this study showed the higher lead content of the raw (0.027 mg/L) and the tap water samples (0.038 mg/L) in Al-Jubail station and tap water sample in Al-Baradiyah than the allowable limits of WHO (0.01mg/L). Contact with lead is associated with several adverse health outcomes [30]. Studies have also conclusively shown that minority and low-income communities have the highest levels of lead exposure compared to their more affluent counterparts [31]. The causal link between lead exposure and severe cognitive health effects has been well established, as have other outcomes such as memory loss, abdominal pain, kidney damage, high blood pressure, and weakness [32]. There is a critical need to better characterize the concentration of lead. Fawkes and Sanson [32] stated that detectable traces of lead in drinking water frequently arise from lead pipes, faucets, and fixtures. So they recommend monitoring existing pipe networks for water managers because changing the water chemistry can impact the exposure risks.

Lead-contaminated drinking water, even at low levels, is harmful to human health. Great strides toward the elimination of lead in drinking water and educate the consumers to be sensitive to the quality of the used water are essential. To avoid the phenomenon of water pollution with other pollutants, such as toxic elements and to inhibit elevation of the described parameters, should be raised public awareness on proper use and precautions to preserve water quality through inhibition from contaminations by physical, chemical, or biological pollutants. High-efficient filtration systems should be available at water stations to remove water impurities using a physical barrier, chemical, and/or biological method. It is necessary to remove potential sources of water pollution and provide state-certified testing laboratories with different instruments and chemicals for water quality analysis.

In the next studies, it is suggested to increase the pathological analysis such as histological technique and also to increase the water stations to include the cities near Basra. In addition, it is suggested to study the relationship between bisphenol and water pollution.

Conclusion

The level of lead, turbidity, and pH are versus the allowable limits of WHO standards at both water stations in Basra city, Iraq. The rest of these parameters related to heavy metals exhibited an interesting reduction of Cu at both water stations and Cd at Al-Jubaila one against the acceptable levels of the indicated organization standards. Regarding the effect of the mentioned factors in drinking water on human health, it suggests more control over water purification.

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