"Study ofHeavy Metals in the Waters of the Unified Tuz-Khurmatu Project in Salah al-DinGovernorate

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Abstract:

The presentstudy was conducted in the laboratories of the Department of Life Sciences ,College of Education for Girls, Tikrit University, with the aim of identifyingsome of the qualitative characteristics of the water at the unifiedTuz-Khurmatu Pumping Station located in Salah al-Din Governorate. The studyaimed to demonstrate the suitability of the water at the selected station, andto observe monthly and locational changes over the six-month period of thestudy, which started in August 2022 and ended at the end of October 2023. Thestudy included measurements of some physical properties, such as heavy metalsin the water, and covered cadmium, lead, nickel, and cobalt. The resultssomewhat recorded non-compliant findings with Iraqi standards for both cadmiumand lead, as the current study results showed contamination with cadmium andlead elements since their values were outside the Iraqi specifications.

Keywords: Heavymetals, drinking water, pollutants"

Introduction:

Water is thelifeblood and one of the most crucial components of life, as all livingorganisms cannot survive without it. Water constitutes a part of plantstructure and various tissues in human and animal bodies. No absorption ,digestion, or metabolic processes can take place without a watery medium [1] .[With civilization's advancement in various aspects of life, there's a need forstations dedicated to purifying, filtering, and ensuring water quality ,preserving its natural physical and chemical properties free of pollutants, andproviding excellent quality, high-grade water [2].

Water is aunique chemical compound composed of two hydrogen atoms and one oxygen atom. Itis the only substance available in three physical states—solid, liquid, andgaseous. These physical properties of water grant it significant importance forlife. A water scarcity crisis is considered more dangerous than an energycrisis [3]. Seas and oceans are the primary water reservoirs, containing about %97.2 of the total water body as saline water. Freshwater represents only about %2.8 of the total water in the universe, of which approximately 75% is frozenas ice in the poles and some cold regions, making up about 2.2% of the world'stotal freshwater. Thus, only about 0.8% of the Earth's total water is availableas liquid freshwater for human use [4].

Rivers are themost critical sources of freshwater for humans. Political, economic, and socialdevelopment has largely depended on the distribution and availability offreshwater in river systems. River systems can be considered the Earth'sarteries, providing life, water, and a wealth of living creatures [5].

Pure water doesnot exist in nature. Even river water, the purest form of natural water , contains some gases and soil found in the air [6]. Thus, pollution can be definedas changes in the physical, chemical, and biological attributes of the waterand air environment [7].

Water pollutionis the degradation of environmental system water quality due to humaninterventions, rendering water unsuitable for life and industrial uses [4] .[Hence, the current study was carried out due to the increased pollution ratesin the water of the unified Tuz-Khurmatu station due to waste and seweragedumped into the waters, negatively affecting the concentration of physical ,chemical, and biological components [8].

Heavy metals arealso called trace elements due to their scarcity in living tissues. The rapidand increasing development in industry, along with the urgent need for heavymetals, has led to the release of these pollutants into the biosphere and theirpollution of underground bodies, whether liquid or surface elements. Thisconstitutes a genuine environmental problem that not only threatens theenvironment or water system but also human health through the consumption of contaminateddrinking water. Heavy metals differ from organic pollutants because they do notdecompose through biological processes, so it is supposed to develop suitablemethods or processes to remove these elements while considering not to removeother compounds present in the water [9].

The currentstudy aims to examine the physical characteristics of the water at the unifiedTuz-Khurmatu pumping station in Salah al-Din Governorate.

Study:Methodology

Study Area Description:

This study wasconducted at the Tuz Khurmatu Unified Water Station in the Tuz Khurmatudistrict of Salah al-Din Province, which was established in 1986 with aproduction capacity of 4000 m3/hour and is located at the coordinates)N34.5029.E44.3753). The study focused on heavy metals and their effects. Thechoice of study location in this region was due to the general importance ofdrinking water and specifically to the area of study, considering its impact onthe economic, social, and health life of the region.

Study Station:

The drinkingwater project is located in Tuz Khurmatu, Salah al-Din province, approximately 186 km away from Baghdad city. The water source for this project is the LesserZab River. Water is pumped from the source, pushed towards the project, andthen treated through sedimentation, filtration, and disinfection processesusing sand and chlorine. This project supplies parts of the Tuz Khurmatudistrict and the water is used for drinking and various other applications.

Sample Collection:

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Samplecollection began in the morning starting from the raw water stage to theeffluent stage, twice a month, at the beginning of each month starting fromAugust 2022 until the end of January 2023. After pumping a certain amount ofsample water for ten minutes to eliminate any stagnant contaminated water, thebottles were filled directly with the sample water, leaving the least possibleair gap to preserve the physical and chemical properties of the sample waterduring transportation. Polyethylene bottles with a capacity of 2.25 liters wereused for conducting the physical and chemical tests, with careful washing ofthe bottles with the sample water three times before taking them..

Measurement of Some Heavy Elements in:Water

Theconcentrations of trace element ions dissolved in the water were measuredaccording to Method [10]. One liter of the sample water was filtered throughMillipore Filter paper type 0.45M, after which concentrated nitric acid (1:3 (was added and the sample was evaporated slowly until a light-colored solutionwas obtained. The volume was made up to 100 ml with distilled water, and thenthe dissolved metals (Lead Pb, Nickel Ni, Cobalt Co, Cadmium Cd) were measuredusing the Thermo Atomic Absorption Spectrometer AA-20.

•Statistical Analysis:

Statisticalanalysis was conducted using the Special Program for Statistical System (SPSS)version 23

Pearson:Correlation Coefficient

This test was used to find the degree of relationshipbetween the studied variables based on the correlation coefficient betweenthese variables at a significance level and $P \leq 0.01$ $P \leq 0.05$.

Analysis of)Variance test (ANOVA:(

This test indicates the existence or absence ofsignificant differences in the studied variables according to the variables) spatial differences between the station locations and temporal differencesbetween the months and seasons). This analysis does not show which categoricalvariables are responsible for these differences in the studied variables at asignificance level $P \leq 0.05$.

Results:

(Cadmium Cd^{+2}):

The results ofthe current study, as shown in schedule(1), indicate that the highest value forcadmium was 0.0641 mg/liter during the month of January, while the lowest valuefor cadmium was 0.001 mg/liter during the month of November.

Samples Average	January	December	November	October	September	August	/months Samples
0.0185 b	0.0641	0.019	0.002	0.01	0.006	0.01	Raw Sample
0.0251 a	0.0272	0.017	0.011	0.0211	0.031	0.043	Sedimented
0.0125c	0.01	0.015	0.012	0.01	0.01	0.018	Treated
0.0214 a	0.0214	0.013	0.016	0.02	0.023	0.035	Preservation tank
0.0119 c	0.0181	0.011	0.011	0.018	0.003	0.01	Station 1
0.0114 c	0.0151	0.02	0.001	0.01	0.008	0.014	Station 2
0.0108 b	0.01	0.009	0.01	0.01	0.011	0.015	Station 3
0.0107 c	0.01	0.006	0.01	0.01	0.013	0.015	Station 4
0.0134c	0.0133	0.01	0.01	0.019	0.01	0.018	Station 5
0.0177b	0.01	0.005	0.013	0.016	0.019	0.043	Station 6
	0.0199 b	0.0125c	0.0096 d	0.0144c	0.0134 c	0.0221a	Average months

schedule 1illustrates the monthly and locational variations of cadmium (Cd) levels , expressed in micrograms per liter (µg/L), in the water over the duration of thestudy.

(+Lead 2Pb):

The resultsdepicted inschedule 2 show that the highest concentration of lead peaked at 3.034 µg/L during December, while the lowest lead value reached 0.002 µg/L inthe month of November.

Samples Average	January	December	November	October	September	August	months/Samples
0.5274 a	0.0566	3.012	0.03	0.046	0.01	0.01	Raw Sample
0.2257 d	0.0333	1.06	0.09	0.098	0.031	0.042	Sedimented
0.3493 c	0.0136	2.04	0.002	0.01	0.018	0.012	Treated
0.0424 b	0.0216	0.003	0.08	0.088	0.025	0.037	Preservation tank
0.3735bc	0.026	2.04	0.066	0.07	0.02	0.019	Station 1
0.3928 b	0.01	2.225	0.05	0.051	0.011	0.01	Station 2
0.3737bc	0.01	2.101	0.048	0.056	0.01	0.017	Station 3
0.5467 a	0.0269	3.088	0.056	0.06	0.022	0.027	Station 4
0.5353 a	0.0216	3.034	0.065	0.068	0.013	0.01	Station 5
0.4080 b	0.01	2.271	0.07	0.073	0.01	0.014	Station 6
	0.0230 c	2.0874 a	0.0557 b	0.0620 b	0.0170 d	0.0198 d	Average months

schedule 2illustrates the monthly and locational variations of lead (Pb) levels , expressed in micrograms per liter (µg/L), in the water over the duration of thestudy.

(Cobalt CO+2):

The currentstudy's results, as shown in schedule 3, indicate that the highest value ofcobalt reached 0.0367 µg/L in January, while the lowest value was 0.001 µg/L inNovember.

Samples Average	January	December	November	October	September	August	months/Samples
0.0215 a	0.0367	0.06	0.001	0.01	0.01	0.011	Raw Sample
0.0299 a	0.0132	0.055	0.031	0.037	0.018	0.025	Sedimented
0.0182 a	0.0179	0.043	0.01	0.01	0.012	0.016	Treated
0.0254 a	0.0211	0.034	0.025	0.029	0.02	0.023	Preservation tank
0.0170 a	0.0181	0.03	0.01	0.01	0.013	0.021	Station 1
0.0138 a	0.01	0.041	0.01	0.01	0.002	0.01	Station 2
0.0153 a	0.0199	0.032	0.01	0.01	0.01	0.01	Station 3
0.0138 a	0.0207	0.029	0.002	0.01	0.011	0.01	Station 4
0.0160 a	0.0187	0.03	0.003	0.01	0.014	0.02	Station 5
0.0233 a	0.01	0.027	0.036	0.044	0.01	0.013	Station 6
	0.0186 b	0.0381 a	0.0138 d	0.0180 b	0.0120 d	0.0159 c	Average months

schedule 3displays the monthly and locational changes of cobalt (Co) concentration , expressed in micrograms per liter (µg/L), in the water over the course of thestudy.

(Nickel 2+Ni):

The currentstudy's results, as indicated in schedule 4, present the nickel concentrationsduring the months of study for the analyzed water samples. It was found thatthe nickel concentrations varied over the course of the study, reaching a peakof 0.0249 µg/L in January, while the lowest level of nickel was observed to be 0.001µg/L in November.

Samples Average	January	December	November	October	September	August	months/Samples
0.0132 b	0.0249	0.021	0.001	0.01	0.009	0.013	Raw Sample
0.0170 a	0.0181	0.02	0.016	0.019	0.013	0.016	Sedimented
0.0133 b	0.0159	0.016	0.011	0.013	0.01	0.014	Treated
0.0131 b	0.0128	0.019	0.01	0.013	0.011	0.013	Preservation tank
0.0077 c	0.0114	0.003	0.002	0.01	0.01	0.01	Station 1
0.0108 c	0.01	0.02	0.009	0.013	0.003	0.01	Station 2
0.0120 b	0.01	0.011	0.014	0.016	0.008	0.013	Station 3
0.0098 c	0.016	0.006	0.001	0.01	0.012	0.014	Station 4
0.0139 b	0.0106	0.021	0.014	0.011	0.013	0.014	Station 5
0.0188 a	0.01	0.018	0.017	0.018	0.04	0.01	Station 6
	0.0140 b	0.0155 a	0.0095 d	0.0133bc	0.0129 c	0.0127 c	Average months

schedule 4displays the monthly and locational changes of nickel (Ni) concentration , expressed in micrograms per liter (µg/L), in the water over the course of thestudy.

Discussion :

Cadmium is atoxic element that naturally occurs in water and has no known essentialbiological function. Generally, cadmium is found in the environment at lowlevels. However, human activity has significantly increased these levels [11].The high concentrations of cadmium in some water samples can be attributed tothe geology of the studied area and the industrial waste from fertilizers ,dyes, and other untreated materials, leading to high accumulations of cadmiumin the soil. Consequently, these concentrations infiltrate into river watersduring rainfall. The low concentrations of cadmium could be due to rainwaterdiluting the concentrations in chemical fertilizers to such an extent that itreaches the water at low concentrations [12].

The concentrations of cadmium in the studied watersamples did not align with Iraqi standards for river and water pollutionprotection (1976) and the standard specifications for Iraqi and internationaldrinking water (Central Agency for Standardization and Quality Control, 1996 ,(which is 0.005 µg/L. The results of the current study were higher than theresults of Khoidem's study (2012), where the cadmium concentration was 0.008µg/L. Statistical analysis results showed significant differences between thestudied stations at a significance level of 0.05 ≤ P, and significantdifferences between the months as well.

Lead (Pb) isknown for its cumulative nature in the human body, where it accumulates in thekidneys and joints, causing an increase in uric acid production, miscarriage , fetal deformation, as well as mental retardation in children and generalweakness, as it replaces calcium in bone tissue and reduces the formation ofhemoglobin pigment in the body [13]. The reason for the high lead values duringsome study months could be due to the fact that lead is produced from carexhausts as it is present in car fuel, and thus it is transferred to the riverthrough the air [14]

The decrease in lead levels might be attributed to thehigh concentrations of calcium ions, which subsequently reduces theconcentration of dissolved lead as it competes with calcium ions[15].Additionally, lead's ability to form and stabilize organic complexes and itsrapid absorption properties are notable. The lead levels during some months ofthe study were not within the Iraqi benchmarks for the system of protectingrivers and water from pollution (1967), as well as the Iraqi and internationalstandard specifications for drinking water (Central Organization forStandardization and Quality Control, 1996) which is 0.03 mg/L. The statisticalanalysis results showed significant differences between the stations at asignificant level of 0.05 ≤ P, in additionto significant differences duringcertain months of the study. The results of this study are comparable to theresults obtained by [16], where the average lead concentration ranged between 3.41-1.69 mg/L.

Cobalt is considered a heavy but essential element forsome living organisms and is a fundamental element for some types of bacteriaand algae. On the other hand, it is not necessary or of significant importancefor higher animals and plants[17]. Its presence at low concentrations is due tothe fact that sewage pollutants containing cobalt are discharged into the riverwater at very low rates. However, its presence at high concentrations may beattributed to the salts of elements and ions that seep from agricultural landsas a result of the impact of rainwater into river water or due to the leakageof industrial waste, especially industries in which cobalt is used, such aswall paints, dry paints, and heat-resistant ceramics. This consequentlyincreases the concentration of cobalt[18]. The statistical analysis resultsshowed no significant differences between the stations at a significant levelof 0.05 ≤ P, as well as no significant differences during the months of thestudy.

Numerous studieshave reported on heavy metal ratios, including nickel. In a study by AL-Heetyet al. (2021) of the Euphrates River, the average nickel concentration in thewater was recorded to be 0.038 mg/L. The results of the current study aresimilar to the results of [19] in their study of heavy metal assessment indrinking water from a water purification station in Baqubah, where nickelresults ranged between 0.20 - N.D mg/L. The results were higher than those of [20] in their study of some heavy elements in the Tigris River water north ofTikrit city, where it reached 0.07 - N.D mg/L.

The fluctuation of nickel concentration between differentstations is indicative of the various quantities added to the river fromhousehold, agricultural, and industrial waste. The decrease in itsconcentration at the stations can be attributed to the removal of this elementthrough adsorption onto suspended materials or sedimentation or consumption byaquatic life. The statistical analysis results showed significant differencesat a significant level of 0.05 ≤ P between the study stations and between themonths of the study .

The results alsoshowed a match in nickel concentrations throughout the study period with theIraqi benchmarks for the system of protecting rivers from pollution No. 25 ofthe year (1967) and the Iraqi and international drinking specifications ,[22][21] which are (0.1 – 0.02) mg/L.

Conclusion:

Theconcentrations of some heavy metals were within the permissible limitsaccording to the Iraqi specifications and the World Health Organization, withthe exception of lead and cadmium, which were higher than the standard values .Therefore, it is essential to raise public awareness about the adverse effectsof disposing light and heavy water waste through all media outlets, as well asto pursue and foster scientific collaboration with relevant entities to createan integrated environmental management system. It is also important to guidefarmers to reduce the use of chemical fertilizers and pesticides thatcontribute to river water pollution. Furthermore, research should beintensified on certain elements that have shown an increase in theirconcentrations, such as cadmium and others, to understand the causes leading tothe increased concentration of these elements.

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