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Research Article

Detecting the Contaminants in Water Wells Using Spectroscopy Techniques Via Optical Properties

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Abstract

Water resources are closely linked to human productivity and life. Owing to the deteriorating water resources environment, accurate and rapid determination of the main water quality parameters has become a current research hotspot. Ultraviolet-visible (UV-Vis) spectroscopy offers an effective tool for qualitative analysis and quantitative detection of contaminants in a water environment. This review aimed to investigate and detect groundwater contamination via optical properties in west Berbar (Younis area (A and B), Gadalla (E), Alhalfa wadalfaki Ali (D), and Atbara area (C). The optical properties (absorption coefficient, reflection, refractive index, and extinction coefficient) of the contaminated water were obtained. The samples were analyzed using UV, ICP, XRD, pH meter, and conductivity meter. The result showed that there is no heavy metal with ICP spectroscopy, even though there is silicon in all samples that confirms UV. All optical properties in the IR region, TDS, pH, and EC showed that they were higher than the WHO (2008) standard; the optical properties for all samples (E, B, A, C, and D) matched with the pH, TDS, EC, and sodium concentration. Finally, the future development of UV-Vis spectroscopy for the determination of water quality was discussed. Therefore, it recommends the government and other responsible authorities take appropriate corrective measures.

Keywords: Contaminants; Water Wells; Spectroscopy; Optical Properties; Sudan

Introduction

Since the 21st century, with the continuous improvement in human living standards, the problems of global climate change, rapid population growth, and environmental pollution have become increasingly serious. Human activities have exerted great pressure on the environment. Among the many environmental problems, addressing water pollution is an urgent need [1]. Water is an indispensable element of human production and life, and is also related to food security, environmental protection, and human health, among other aspects. With rapid social development and the increasing use of agricultural fertilizers, an increasing number of industrial pollutants are discharged into rivers and oceans, causing eutrophication. When the original ecosystem is destroyed, the oxygen content of water is reduced, and many fish and other species are killed, leading to challenges in terms of water resource conservation [2]. As the living standards of consumers have standardized upward, demand for higher quality and quantity of water has emerged relative to the past [3]. Neither pure water nor pure seawater ever occurs in nature. Natural waters, both fresh and saline, are a witch brew of dissolved and particulate matter. These solutes and particulates are both optically significant and highly variable in kind and concentration. Just as optics utilizes results from the biological, chemical, geological, and physical sub-disciplines of limnology and oceanography, so do those sub-disciplines incorporate optics. This synergism is seen in such areas as bio-optical oceanography, marine photochemistry, mixed-layer dynamics, laser bathymetry, and remote sensing of biological productivity [4]. Safe drinking water is a human birthright - as much a birthright as clean air. As a matter of fact, in most of the African and Asian countries, even in relatively advanced countries such as India; safe drinking water is not easily available. Of the 6 billion people on earth, more than one billion lack access to safe drinking water, and, about 2.5 billion do not have access to adequate sanitation services [5]. In addition to these shortcomings, various types of waterborne. Diseases kill on average more than 6 million children each year i.e. about 20,000 children a day [5]. Water covers 70 percent of the globe's surface, but most is saltwater. Freshwater covers only 3 percent of the earth's surface and much of it lies frozen in the Antarctic and Greenland polar ice. Freshwater that is available for human consumption comes from rivers, lakes, and subsurface aquifers. Today 31 countries representing 2.8 billion people, including China, India, Kenya, Ethiopia, Nigeria, and Peru confront chronic water problems. Within a generation, the world population will climb to an estimated 8 billion people. Yet, the amount of water will remain the same [6]. The challenge is as clear and compelling as pristine water cascading down a mountain stream: We must find new and equitable ways of saving, using, and recycling the water that we have [7]. Besides the shortage, drinking water may be contaminated by different contaminants which have an impact on the health and economic status of the consumers [8]. Contaminants such as bacteria, viruses, heavy metals, nitrates, and salt have found their way into water supplies due to inadequate treatment and disposal of waste (human and livestock), industrial discharges, and the overuse of limited water resources [9]. Even if no sources of anthropogenic contamination exist, natural sources also equally have the potential to contribute higher levels of metals and other chemicals that can harm human health [10]. In River Nile state, the dominant source of drinking water used to supply major urban and rural communities is from rivers and wells. There is no systematic inside the rural area because every house has a well Although there are no systematic and comprehensive water quality assessment programs in the rural area, there are increasing indications of water contamination problems in some parts of the area. The major causes of this contamination could be mining activities, soil erosion, domestic waste from urban and rural areas industrial wastes. So far, no sufficient study has been conducted on heavy metal contamination of drinking water of the Berber and Atbara. For this reason, due emphasis is given to the analysis of these contaminants. Heavy metals normally occurring in nature are not harmful to our environment because they are only present in very small amounts. However, if the levels of these metals and chemical composition are higher than the recommended limits, their roles change to a negative dimension and are related to the optical properties.

Methodology

This paper introduced the theoretical basis of determining various water quality parameters by UV-Vis spectroscopy and expounded the complete spectral data analysis process, including data preprocessing. In the work five samples (Water) four samples from west Berber in different places two samples from Yuonis, sample(A) close to the river (B)quite far sample (C) from Atbara (D) Alhalfa wad Alfaki Ali and (E)from gadalla to determine the heavy metal and chemical component related to optical properties. All samples were collected from the Tap dentally without any chlorine treatment but samples from Atbara after treatment Using UV: Ultra violate spectroscopy type UV Mini 1240 manufactured by Shimadzu company-Japan and coming with serial number A10934081718SM to determine the optical properties of the water well. X-ray diffractometer Shemadzo Maxima X XRD 7000 Corporation to determine the chemical composition. Inductively coupled plasma (ICP) to determine the concentration of heavy metal 3510 PH meter manufactured by JENAY 4510 conductivity meter manufactured by JENAY to determine TDS, and EC.

Results

All substances investigated can be detected with intensities comparable to those of other lab devices or commercial sensor probes. The data was collected from the sample after analysis with UV, XRD, and ICP. Sample (A) from Younis (Near the river), Sample (B) from Younis (far from the river), Sample (c) from Atbara (Almatar Zone), Sample (D) from Alhalfa Wadalfai Ali, Sample (E) from Gadalla. The physical parameters, including conductivity, TDS, hardness, pH, and turbidity, of the drinking water samples are given (Table 2). Electrical conductivity (EC), which is a measure of water ability to conduct an electric current, is related to the number of dissolved minerals in the water, but it does not give an indication of which element is present. A higher value of EC is a good indicator of the presence of contaminants such as sodium, potassium, chloride, or sulphate. Analysis of the results shows that all the samples from Gadalla, Yonis (near to the river and far to the river), Alfalfa (wadalfaki Ali), and Atbara (Almatar Zone) have an EC value. Greater than the WHO (2008) (Table 1), maximum admissible limit, while the range of EC of the samples was from 643 to 2364 µS/cm, with a minimum (643) from Atbara (Almatar Zone) and a maximum (2364) from Gadalla drinking water samples. Very high values of EC with mean values of 2364, 1357, and 1262 µS/cm were recorded for samples collected from Gadalla, Alhalfa (WadalfakiAli), and Younis (far to River), respectively. According to WHO (2008), there is no health-based limit for TDS in drinking water, as TDS occurs in drinking water at concentrations well below which toxic effects may occur, but the palatability of water with a TDS level of less than 500 mg/L is generally considered to be good. Drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/L. TDS greater than 1200 mg/L may be objectionable to consumers and could have impacts for those who need to limit their daily salt intake, e.g. severely hypertensive, diabetic, and renal dialysis patients. All samples analyzed were found to contain TDS values greater than 500 mg/L. The pH of the samples was between 7.1 (Alhafa wadafaki Ali) and 7.8 (Atbara Almatar Zone, which is near the river and far from the river) and 8.0 for Gadalla's pH, which lies in the alkaline range. There is no guideline value by WHO for pH, but all of the samples analysed were within the US EPA admissible limit (6.5 - 8.5). Turbidity is a measure of the cloudiness of water. It has no health effects. However, turbidity can interfere with disinfection and provide a medium for microbial growth. Two samples have a turbidity value greater than 5 NTU (nephelometric turbidity units), which is the WHO (2008) maximum desirable limit in drinking water, and these were mainly from Atbara (Almatar Zone), Gadalla, A turbidity value as high as 11.7 NTU was observed in a sample from Gadalla and the lowest, 1.27 from Younis (near the river). Check the absorbance of five water molecules, which are measured at room temperature as a function of wavelength in the spectral range from 940 nm to 1040 nm. However, the maximum absorbance observed at wavelength (1030 nm) for sample (E)) then decreases for other samples. The absorbance edge of the five water occurs at wavelength (1030 nm) corresponding to photon energy (1.204 eV) (Figure 1). The optical transmittance of the five water as a function wavelength the transmittance spectra decrease from the wavelength 939 nm to wavelength 960 nm, and the mean transmittance of the five water is 0.89 (a.u.) for sample E at wavelength 960 nm. The value of transmittance for all samples decreases than the sample (D) sample. The reflectance of five water molecules, which are measured at room temperature as a function of wavelength in the spectral range from 970 nm to 1040 nm. And in figure 1, it shows the reflectance spectra, and it has a maximum value at wavelength (1030 nm) for the (E) sample, and it decreases in the wavelength region (960 nm). Also, the value of (α) for the (E) sample is greater than other samples. The increase in absorbance coefficient may be due to the increase in grain size and decrease in the number of defects.

Country	EC (µS/cm)	TDS (mg/L)	pH	Turbidity (NTU)
USEPA, 2008	NM	500	6.5 - 8.5	0.5- 1
EU, 1998	2500	NM	6.5 - 9.5	NM
WHO, 2008	250	NGL	NGL	NGLa
Iranian, 1997	NM	500	6.5 - 8.5	25
Australian, 1996	NM	500c	6.5 - 8.5	5.0
Indian, 2005	NG	1500	6.5 - 9.2	10
New Zealand, 2008	NM	1000	7.0 - 8.5	2.5

Table 1: *Drinking water contaminants and maximum admissible limits are set by different national and international organizations.*

Parameters	A	B	C	D	E	Unit
Turbidity	1.27	2.61	5.7	2.74	11.7	NTU
PH	7.8	7.8	7.8	7.1	8.0	
TDS	508	757	385	814	1418	Mg/L
EC	846	1262	643	1357	2364	µs/cm
T. Hardness	234	374	200	638	234	Mg/l

Table 2: Level of some physical parameters for drinking water samples from Berber and Atbara.

Sample Concentration mg/l					Elements	Standard Maximum admissible limit
<0.01	<0.01	<0.01	<0.01	<0.01	Pb	0.5
<0.01	<0.01	<0.01	<0.01	<0.01	Ni	0.1
<0.00	<0.00	<0.00	<0.00	<0.00	Cr	0.5
0.02	0.02	0.02	0.02	0.02	Cu	3
<0.00	<0.00	<0.00	<0.00	<0.00	Zn	5
<0.00	<0.00	<0.00	<0.00	<0.00	Hg	0.001
<0.02	<0.02	<0.02	<0.02	<0.02	As	0.01
<0.02	<0.02	<0.02	<0.02	<0.02	U	0.03
0.00	0.00	0.00	0.00	0.00	Cd	0.2
<0.00	<0.00	<0.00	<0.00	<0.00	Mn	0.05
<0.02	<0.02	<0.02	<0.02	<0.02	Au	
<0.00	<0.00	<0.00	<0.00	<0.00	Sn	
<0.04	<0.04	<0.04	<0.04	<0.04	Ti	
<0.00	<0.00	<0.00	<0.00	0.00	Tl	
<0.00	<0.00	<0.00	<0.00	0.00	v	
<0.00	<0.00	<0.00	0.03	0.00	Fe	0.2
<0.03	<0.03	<0.03	<0.03	<0.03	Se	0.01
0.00	0.00	0.00	0.00	0.00	Ba	1.0
<0.02	<0.02	<0.02	<0.02	<0.01	Al	0.2
<0.00	<0.00	<0.00	<0.00	<0.00	Co	0.1

***Table 3:** Concentration of heavy metals in drinking water.*

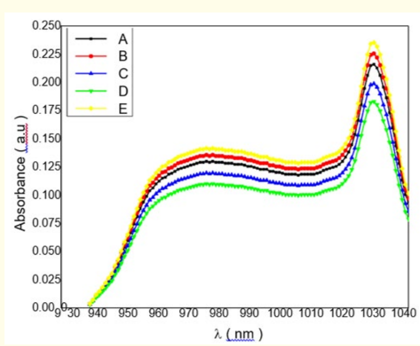

***Figure 1:** Relationship between absorbance's and wavelength of samples.*

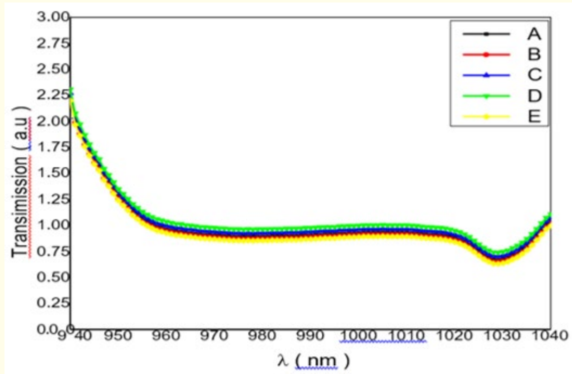

Figure 2: *Relationship between transmission and wavelength of samples.*

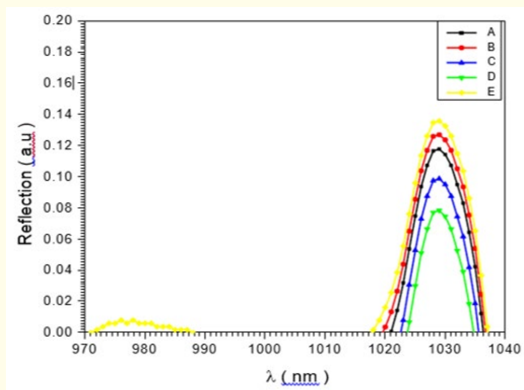

Figure 3: *Relationship between reflection and wavelength of samples.*

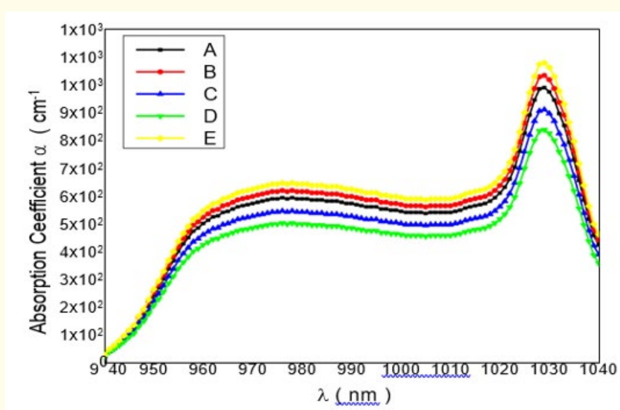

Figure 4: *The relationship between absorbance's Coefficient and wavelength of five water samples.*

Discussion and Conclusion

For all samples, the absorbance at wavelength 1030 nm is the maximum for samples far from the Nile as long as the line of wavelength 960-1020 al sample has constant absorbance. The absorbance coefficients for samples E = 1081.055, D = 838.59, C = 911.79, B = 1035.31, and A = 994.13 cm^{-1}. The refractive index, E = 1.684, D = 1.35, C = 1.46, B = 1.63, and A = 1.57, increases with salinity. As long as the wavelength is 960-1020, the transmission is constant. A sample at wavelength 970-1020 does not reflect, which means it's opaque except sample (E) has little reflectance at 970-990. All physical properties happened at wavelength 1030 at maximum size in infrared because all samples contain silica, which has a covalent bond and causes an organic bond. All samples are good for drinking but are not suitable for washing because they have high contamination of TDS. Electrical conductivity, hardness, and PH are in the alkaline range; the highest physical properties increase with the concentration of sodium and decrease with it according to the distance from the river. All samples have a concentration of heavy metal less than the limit, which means they are good for dining and cooking. High turbidity may indicate the presence of disease-causing organisms. These organisms include bacteria, viruses, and parasites that can cause symptoms such as nausea, cramps, diarrhoea, and associated headaches [11].

Future Recommendations

Distillation may reduce concentrations of sodium and potassium. Sodium may lead to hypertension. Treatment of salt caused the hardness of water by nanotechnology. recommends the government and other responsible authorities introduce relevant drinking water treatment techniques that can reduce the current levels of TDS, Prevent any kind of waste disposal into rivers, canals, or any reservoirs that supply domestic drinking water, educate the people to have better drinking water storage practices, and support further study to be conducted on other physical, chemical, and biological parameters of significant health concern and identification of potential sources of the contaminants, including calcium, sodium, and potassium.

Consent

The patient's written consent has been collected.

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Conflict of Interest

The authors have declared that no competing interests exist.

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