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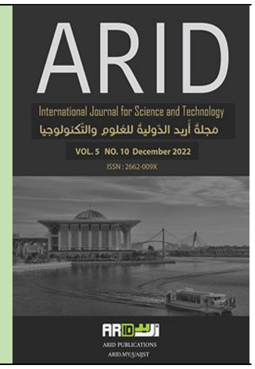

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The Effect of Sunlight Exposure on Physicochemical Properties of Plastic Bottled Water at Al-Mogran Station in Khartoum State, Sudan

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تأثير التعرض لأشعة الشمس على الخصائص الفيزيائية الكيميائية للمياه المعبأة في قارورة بلاستيكية في محطة المقرن بالخرطوم السودان

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ABSTRACT

In this work, Inductively Coupled Plasma Emission Spectroscopy Technique (ICPE) has been used to study the physicochemical properties of plastic bottled water before and after sun light exposure. One sample has been taken from Al-Mogran Station in Khartoum State, Sudan at the end of the fall season in 2019.This sample has been exposed to sunlight in plastic bottled for 50 days. Before exposure to sunlight, many macro and micro minerals such as (Calcium, Potassium, Magnesium, Sodium, Sulfur, Copper, Iron, Iodine, Rubidium, Silicon, Boron, Lithium, Manganese, and Zinc) were detected with different concentrations at (97,3.0,140,22,930,15,170, 15,730,220,0.87,0.05,0.75, and 0.95 ug/L) respectively. Some toxic and radioactive elements such as (Aluminum, Barium, Erbium, Titanium, and Strontium) were appeared with various concentrations at (63, 0.21, 12, 6.2, and 0.32 ug/L) consecutively. These results may return to the location of sample, vital activities, and the floods that transport the dirt to the Nile River in the fall season. After sunlight exposure, concentrations of macro and micro minerals above were changed to (100,1.6,100,15,730,11,43,12,700 ,95,0.49 ,0.05,0.35, and 0.26 ug/L) respectively. One new micro minerals which called (Vanadium) was found with concentration at $(0.22 \mu g/L)$. The concentrations of toxic and radioactive elements above were modified to (29, 0.14, 4.6, 2.5, and 0.35 ug/L) successively, and five new toxic elements like (Arsenic, Bismuth, Antimony, Holmium, and Platinum) were existed with concentrations at (21+, 4.8, 5.9, 1.5, and 23 ug/L) respectively, and these results might relate to the interaction between water and plastic. The results before and after exposure to sunlight were found at range within background values except for (Titanium, Arsenic, and Bismuth).

Keywords: Inductively Coupled Plasma Emission Spectroscopy, Concentration, Sunlight, Drinking Water, Plastic Bottled.

الملخص

في هذا العمل، استخدمت تقنية التحليل الطيفي لانبعاثات البلازما المقترنة بالحث لدراسة الخصائص الفيزيائية الكيميائية لعينة مياه المعبأة في قارورة بلاستيكية قبل وبعد التعرض لأشعة الشمس الطبيعية. عينة واحدة تم أخذها من مياه محطة المقرن في ولاية الخرطوم بالسودان في نهاية فصل الخريف 2019. هذه العينة تم تعريضها لأشعة الشمس (50 يوما). قبل التعريض لأشعة الشمس، عدد من عناصر الماكرو والميكرو مثل (الكالسيوم، البوتاسيوم، المغنسيوم، الصوديوم، الكبريت، النحاس، الحديد، اليود، الريبديوم، السليكون، البورون، الليثيوم، المنجنيز، والزنك) اكتشفت عند التراكيز (97، 3.0، 140، 22، 930، 15، 170، 15، 730، 220، 0.87، 0.05، 0.75، و0.95 ميكروغرام لكل لتر) على التوالي. بعض العناصر السامة والمشعة مثل (الألمنيوم، الباريوم، الاريبيوم، التيتانيوم، الاسترنشيوم) ظهرت عند التراكيز (63، 0.21، 12، 6.2، و0.32 ميكروغرام لكل لتر) على التعاقب. هذه النتائج قد تعود إلى موقع العينة، الأنشطة الحيوية، والسيول التي تنقل الأوساخ إلى نهر النيل في فصل الخريف. بعد التعريض لأشعة الشمس، تراكيز عناصر الماكرو والميكرو أعلاه قد تغيرت إلى (100، 1.6، 100، 15، 730، 11، 43، 12، 700، 95، 0.49، 0.05، 0.35، و0.26 ميكروغرام لكل لتر) على التسلسل. عنصر واحد جديد ميكرو يسمى (الفانديوم) اكتشف عند التركيز (0.22 ميكروغرام لكل لتر). تراكيز العناصر السامة والمشعة أعلاه قد تغيرت إلى (29، 0.14، 4.6، 2.5, و0.35 ميكروغرام لكل لتر) على التتالي. وخمسة عناصر سامة جديدة مثل (الزرنيخ، البزيموث، الأنتيمون، الهومليوم، والبلاتينيوم) وجدت عند التراكيز (21+، 4.8، 5.9، 1.5، و23 ميكروغرام لكل لتر) على التعاقب، وهذه النتائج تعود إلى التفاعل بين الماء والبلاستيك. النتائج قبل وبعد التعرض لأشعة الشمس وجدت في المدى ضمن القيم المرجعية باستثناء (التيتانيوم، الزرنيخ، والبزيموث).

كلمات مفتاحية: تقنية التحليل الطيفي لانبعاثات البلازما المقترنة بالحث، تركيز، ضوء الشمس، مياه الشرب، القوارير البلاستيكية.

1. Introduction:

Water plays many important roles in our bodies, and it travels throughout our body carrying nutrients, oxygen, and wastes to and from your cells and organs. Also, it keeps your body cool as part of your body's temperature regulating system, and it aids in digestion and absorption of food, as well as in the removal of wastes from your body. [1-2]

The water molecules have a special structure because they have attractive properties like ubiquitous, odorless, tasteless, and transparent. [3] In fact, water molecule has many various physicochemical parameters such as chemical oxygen demand, biochemical oxygen demand, dissolved oxygen, color, chloride, temperature, sulphate, pH, hardness, and turbidity [4-5]. Water molecule contains some elements classifications like macro, micro, toxic, and radioactive [6]. The macro and micro minerals can be found in the water molecular for example, Calcium , Potassium, Magnesium, Sodium, Sulfur, Copper, Iron, Iodine , Rubidium, Silicon, and Lithium.[4-6] Also, radioactive and toxic elements can be calculated in drinking water molecule for instance, Aluminum, Cadmium, Lead, Arsenic, Mercury, Silver, Uranium, Titanium, Thorium, Thallium , Holmium, Erbium, and Strontium. [7-10] These elements are very harmful for human health because they may be cause many dangerous diseases like cancer, kidney failure, hemolytic anemia, integumentary, nervous, respiratory, cardiovascular, hematopoietic, immune, endocrine, hepatic, renal, diarrhea, stomach pains, bone fracture, and reproductive failure. [11-14]

On the other hand, Polyethylene material (PE) has the simple structure of polymer which was synthesized by polymerization (CH_2=CH_2), and this material contains some very toxic and radioactive elements which are dangerous for human health when it placed directly under the normal sunlight. [15-17]

The Inductively Coupled Plasma Emission Spectroscopy Technique (ICPE) has been used for the detection of macro, micro, toxic, and radioactive metals, and calculate the concentrations of them in various environmental samples like soil, powders, and drinking water. The principle of this technique is to get elements to emit special wavelength light that can be measured, this technology of the ICPE method was used in the early 1960 century with the intention of the improving upon crystal growing technique, this spectroscopy technique has been used in conjunction with the other procedures for quantitative analysis. Also, the excitation source of this technique can be happen at a very high temperature at the range (7000-8000K). An ICPE typically involves some components like sample introduction system, ICPE torch, high frequency generator, transfer optics and spectrometer, and computer interface. [18-21]

The current paper aimed to detect and calculate the concentrations of macro, micro, toxic, and radioactive metals minerals before and after exposure to the selected sample to the normal sunlight which was taken from Al-Mogran Station in the Blue Nile River at Khartoum State, Sudan at the end of the fall season 2019.

2. Material and Methods:

This study was conducted for one sample that was taken from Al-Mogran Station in the Blue Nile River at Khartoum State, Sudan. The plastic bottle of I.5 Litter was cleaned thoroughly with distilled water, and it was washed with sample water to avoid any trace of pollution. After that, this sample was analyzed be ICPE Technique to detect and calculate the concentrations of the macro, micro, toxic, and radioactive elements before exposure this sample to sunlight. The plastic bottle was placed under the normal sunlight for a period time about 50 days, and the temperature average was recorded at $33^{\circ}C$. After this step, the selected sample was analyzed again using the same technique to find the difference in the results for the elements classifications which were mentioned above.

3. Results:

This experiment explained the physicochemical properties of plastic bottled water such as Detect and calculate the concentrations of the macro, micro, toxic, and radioactive minerals before and after sun light exposure as shown below:

3.1. The concentrations of macro and micro minerals before and after sunlight exposure:

The results in figure (1) and table (I) showed that the concentrations of the macro and micro minerals that can be appeared with various values before and after exposure the sample to sunlight as displayed at below:

Table (I): The ICPE results of major and trace elements before and after sunlight exposure:

Element	Classification of element	Concentration before sunlight	Concentration after sunlight	Standards in the background values [24-32]
Ca	Macro minerals	$97\mu g/L$	$100\mu g/L$	Permissible limits
K	Macro minerals	$3.0\mu g/L$	$1.6\mu g/L$	Permissible limits
Mg	Macro minerals	$140\mu g/L$	$100\mu g/L$	Permissible limits
Na	Macro minerals	$22\mu g/L$	$15\mu g/L$	Permissible limits
S	Macro minerals	$930\mu g/L$	$730\mu g/L$	Permissible limits
Cu	Micro minerals	$15\mu g/L$	$11\mu g/L$	Permissible limits
Fe	Micro minerals	$170\mu g/L$	$43\mu g/L$	Permissible limits
I	Micro minerals	$15\mu g/L$	$12\mu g/L$	Permissible limits
Rb	Micro minerals	$730\mu g/L$	$700\mu g/L$	Permissible limits
Si	Micro minerals	$220\mu g/L$	$95\mu g/L$	Permissible limits
B	Micro minerals	$0.87\mu g/L$	$0.49\mu g/L$	Permissible limits
Li	Micro minerals	$0.05\mu g/L$	$0.05\mu g/L$	Permissible limits
Mn	Micro minerals	$0.75\mu g/L$	$0.35\mu g/L$	Permissible limits
Zn	Micro minerals	$0.95\mu g/L$	$0.26\mu g/L$	Permissible limits
V	Micro minerals	$0.00\mu g/L$	$0.22\mu g/L$	Permissible limits

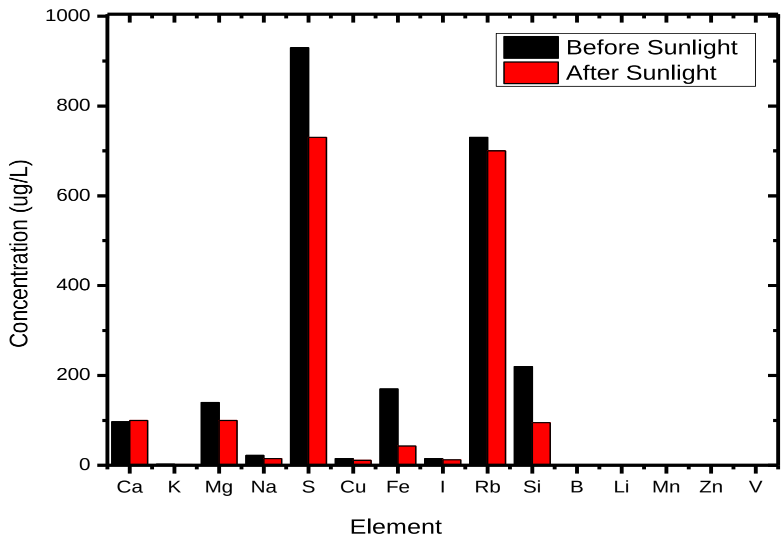

Figure (1): the ICPE results for major and trace elements before and after sunlight exposure

3.2. The concentrations of toxic and radioactive elements before and after sunlight exposure:

The results in figure (2) and table (II) confirmed that the concentrations of the toxic and radioactive elements can be found with different values before and after exposure the sample to sunlight as showed at below:

Table (II): The ICPE results of toxic and radioactive elements before and after sunlight exposure:

Element	Classification of element	Concentration before sunlight	Concentration after sunlight	Standards in the background values [24-32]
Al	Toxic	$63 \mu g / L$	$29 \mu g / L$	Permissible limits
Ba	Toxic	$0.21 \mu g / L$	$0.14 \mu g / L$	Permissible limits
As	Toxic	$0.00 \mu g / L$	$12 + \mu g / L$	More than permissible limits
Bi	Toxic	$0.00 \mu g / L$	$4.8 \mu g / L$	More than permissible limits
Sb	Toxic	$0.00 \mu g / L$	$5.9 \mu g / L$	permissible limits
Er	Toxic	$12 \mu g / L$	$4.6 \mu g / L$	permissible limits
Ho	Toxic	$0.00 \mu g / L$	$1.5 \mu g / L$	Permissible limits
Pt	Toxic	$0.00 \mu g / L$	$23 \mu g / L$	Permissible limits
Ti	Radioactive	$6.2 \mu g / L$	$2.5 \mu g / L$	More than permissible limits
Sr	Radioactive	$0.32 \mu g / L$	$0.35 \mu g / L$	Permissible limits

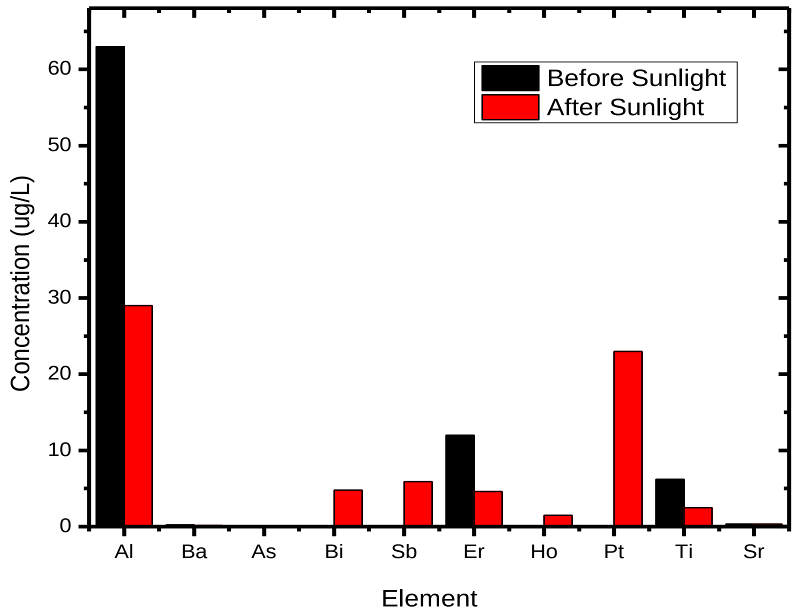

Figure (2): the ICPE results for major and trace elements before and after exposure to sunlight

4. Discussion:

This part includes more discussions for the results of the selected sample before and after exposure:

4.1. The Concentrations of Macro and Micro Elements Before and After Sunlight Exposure:

The results in table (I) and figure (1) before exposure the sample to sunlight confirmed that the macro elements like (Ca, K, Mg, Na, and S) were appeared with different concentrations at (97,3.0,140,22, and 930 $\mu g / L$) respectively. Also, the micro minerals such as (Cu, Fe, I, Rb, Si, B, Mn, and Zn) were showed with divers concentrations at (15, 170, 15, 730, 220, 0.87, 0.75, and 0.95 $\mu g / L$) selectively, and these results may be related to the geological structure of the selected sample location. [21]

After exposure to sunlight, the content of (Ca) was increased slightly to ($100 \mu g/L$), and the values of other macro elements for example (K, Mg , Na , and S) were decreased to (1.6, 100, 15, and 730 $\mu g/L$) respectively. In addition, the concentrations of macro minerals such as (Cu, Fe, I, Rb, Si, B, Mn, Zn) were decreased sharply to (11, 43, 12, 700, 95, 0.49. 0.35, and 0.26 $\mu g/L$) consecutively. Furthermore, the concentration of Lithium was constant during this case due to the molecules of this chemical element was never affected with interaction between water and plastic. Also, Vanadium atoms were appeared as new atoms after exposure this sample to the normal sunlight with concertation at $0.22 \mu g/L$.These results might return to the interaction between to water and plastic which was manufactured from polyethylene material, and the immigration of atoms during this chemical process during exposure this sample to sunlight. [22-23]

The results of the macro and micro minerals before and after exposing to the normal sunlight were found within the globally allowed limits. [24-29]

4.2 The Concentrations of Toxic and Radioactive Elements Before and After Sunlight Exposure:

The obtained results in figure (2) and table (II) before exposure to sunlight proved that the toxic elements for instance (Al, Ba, and Er) were found with several concentrations at (63, 0.21, and $\mu g/L$) respectively, and the radioactive elements like (Ti and Sr) were displayed with various concentrations at (6.2 and 0.32 $\mu g/L$) respectively. These results due to the location of this sample, vital activities and the floods that transport dirt to the Nile River in the fall season in Sudan. [21] After exposure to sunlight, some new toxic metals like (As, Bi, Sb, Ho, And Pt) were appeared with various concentrations at (12+, 4.8, 5.9,1.5, and 23 $\mu g/L$) respectively, and the concentrations of toxic metals above were changed to (29,0.14, 4.6 $\mu g/L$) successively ,due to the interaction between water and plastic. [24] In addition, the concentration of titanium was decreased to $(2.5\mu g / L)$, and the concentration of strontium was increased to $(35\mu g / L)$. These results may be related to the interaction between water and plastic, and the immigration of atoms during this chemical process. [23] The results of the toxic and radioactive elements before and after exposure sunlight were found within the globally allowed limits expect for (As, Bi, and Ti). [24-32]

5. Conclusion:

It was found that the effect in the physicochemical properties of plastic bottled water like concentrations of macro, micro, toxic, and radioactive minerals in the selected sample which was taken from Al-Mogran Station in the Blue Nile River at Khartoum State, Sudan. The concentrations of them were increased or decreased during this experimental work, and some new elements were appeared, and others disappeared after exposure the same sample to the normal sunlight for period time for (50 days). The results explained that there is an interaction between water molecules which were manufactured from polyethylene material, and the choosing for the exposure period to the sunlight was based on a numbers of literature review, therefore there is no effect for the validity period on the bottles.

6. Abbreviations:

Al: Aluminum.
Sb: Antimony.
As: Arsenic.
Ba: Barium.
Bi: Bismuth.
B: Boron.
Ca: Calcium.
Cu: Copper.
Er: Erbium.
Ho: Holmium.

ICPE: Inductively Coupled Plasma Emission Spectroscopy Technique.
I: Iodine.
Fe: Iron.
Li: Lithium.
Mg: Magnesium.
Mg: Manganese.
PE: Polyethylene.
Pt: Platinum.
K: Potassium.
Rb: Rubidium.
Si: Silicon.
Na: Sodium.
Sr: Strontium.
S: Sulfur.
Ti: Titanium.
V: Vanadium.
Zn: Zinc:

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