

**Sudan University of Science and Technology**

**College of graduate studies**

**Identification of Heavy Metals in Some Water  
Sources in Khartoum State using Laser Induced  
Breakdown Spectroscopy**

التعرف علي العناصر الثقيلة الموجودة في بعض مصادر المياه  
بولاية الخرطوم باستخدام مطيافية الانهيار الكهربائي المستحث  
بالليزر

**A thesis submitted for the fulfillment of the requirements for the  
degree of Doctor of Philosophy in Laser Applications in physics**

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## بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

نُورُ السَّمَاءِ وَالْأَرْضِ مِثْلُ نُورِهِ كَمِشْكَاةٍ فِيهَا مِصْبَاحٌ الْمِصْبَاحُ فِي  
زُجَاجَةٍ الزُّجَاجَةُ كَأَنَّهَا كَوْوِيٌّ كَبِيٌّ وَقَدْ مِنْ شَجَرَةٍ مُبَارَكَةٍ زَيْتُونَةٍ لَا  
شَرْقِيَّةٍ وَلَا غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ لَمْ تَمْسَسْهُ نَارٌ نُورٌ عَلَى نُورٍ  
يَدِي اللَّهُ لِنُورِهِ مَنْ يَشَاءُ وَيَضْرِبُ اللَّهُ الْأَمْثَالَ لِلنَّاسِ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيمٌ {

### صدق الله العظيم

(الاية 35 سورة النور)

# **Dedication**

**To my father**

**To my mother**

**To my husband**

**To my son**

**To my brothers& sisters**

**To my friends**

**To my colleagues**

**To soul of my friend Anne**

**To all**

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## Abstract

In this work, Laser Induced Breakdown Spectroscopy (LIBS) was used to investigate, and identify, the heavy metals in samples of water collected from different places in Khartoum state during the period from 2013 to 2015. Eight water samples were used as study samples.

The breakdown of the samples was induced by focusing a pulsed Nd:YAG laser at 532 nm, 2Hz Rpetition Rate, pulse duration of 10 ns, with different pulse energies: 60, 80, 100, and 120 mJ, respectively. The emission spectra of the samples plasma were collected via optical fiber and recorded by Ocean Optics 4000- spectrometer. The recorded spectra of the samples were analyzed using NIST data.

The analysis of the spectra showed considerable amounts of neutral atoms like (Ni, As, Ru, Th, Zr, Tb, Eu, Li, I, Cu, Xe, K, He, Ne, Cs, Hg, Cr, Tl, Cl, Na, Fe, Na, Ra and Ca)elements in addition to the ions: ( $\text{Ni}^{+1}$ ,  $\text{As}^{+1}$ ,  $\text{Th}^{+1}$ ,  $\text{Th}^{+2}$ ,  $\text{Zr}^{+1}$ ,  $\text{Cs}^{+1}$ ,  $\text{Cs}^{+2}$ ,  $\text{Cr}^{+1}$ ,  $\text{Cr}^{+2}$ ,  $\text{Tl}^{+1}$ ,  $\text{Tl}^{+2}$ ,  $\text{Fe}^{+1}$  and  $\text{Fe}^{+2}$ ).

The heavy metals like:(Cr, Hg, and Tl) were appeared in the eight samples with nearly amounts, they are toxic metals harmful to human and environment. Also metals like: (Na, I, Cu and K) were appeared with different amounts in many samples.

It can be concluded that LIBS technique proved to be, fast and accurate technique for the detection of heavy metals and can be used for the determination of its concentrations.

A portable LIBS system for online analysis indifferent sites can be recommended for improvement of the environment.

## المستخلص

في هذه الدراسة تم استخدام تقانة الإنهيار الكهربائي المستحث الليزر (LIBS) للكشف والتعرف على العناصر الثقيلة في ثمانية عينات مختلفة من مصادر المياه التي جمعت من بعض الأماكن في ولاية الخرطوم خلال الفترة من 2013 الى 2015.

تم تشييع هذه العينات بواسطة ليزر النيوديميوم - ياق النبضي ذي الطول الموجي 532 نانو متر بطاقات نبضة 100,80,60, 120 ملي جول وبزمن نبضة قدره 10 نانو ثانية وتردد 2 هيرتز وتكرار التشييع 20 مرة لكل عينة .

تم تسجيل أطيف الإنبعث للعينات بواسطة جهاز المطياف نوع (Spectrometer - Ocean,4000 )

وباستخدام قاعدة بيانات التحليل الطيفي للعناصر (Atomic Spectra Database line). تم تسجيل النتائج وتحليلها للتعرف على العناصر الموجودة في العينات.

تم التعرف على العناصر التالية:

(Ni, As, Ru, Th, Zr, Tb, Eu, Li, I, Cu, Xe, K, He, Ne, Cs, Hg, Cr, Tl, Cl, Na, Fe, Na, Ra and Ca)

بالإضافة لظهور ايونات بعض هذه العناصر مثل:  $Ni^{+1}$ ,  $As^{+1}$ ,  $Th^{+1}$ ,  $Th^{+2}$ ,  $Zr^{+1}$ ,  $Cs^{+1}$ ,  $Cs^{+2}$ ,  $Cr^{+1}$ ,  $Cr^{+2}$ ,  $Tl^{+1}$ ,  $Tl^{+2}$ ,  $Fe^{+1}$  and  $Fe^{+2}$ .

وجد أن عناصر الكروم, الزئبق والثاليوم تتواجد بكميات مختلفة في بعض العينات وكانت هذه الكميات متساوية تقريبا وهي عناصر ذات سمية عالية لها تأثير سلبي على صحة الانسان والبيئة.

بالإضافة لظهور بعض العناصر غير الثقيلة كالليوم والصوديوم والنحاس والبوتاسيوم بكميات مختلفة في بعض العينات.

من النتائج المتحصلة يستنتج أن طريقة الأنبعاث المستحث بالليزر (LIBS) تعتبر طريقة كفوة و سريعة ودقيقة للكشف عن العناصر الثقيلة وحساب كمياتها في العينات السائلة.

في نهاية البحث تمت التوصية بتصميم نظام متكامل محمول ميدانيا لإستخدام تقانة الانبعاث المستحث بالليزر (LIBS) للكشف عن العناصر الثقيلة في مواقع مختلفة من البيئة.

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