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Detection of Technetium on Soil, Plant and Water in the Area around Khartoum Petroleum Refinery by using Laser Induced Breakdown Spectroscopy

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Abstract: *Laser Induced Breakdown Spectroscopy (LIBS) technique is applied to determine the concentrations of Technetium (Tc)in surface soil, Plant leaves (Ziziplhus spina – Sidr Plant) and jars water (ten samples for each) which collected from the area around Khartoum Petroleum Refinery. The results display that Technetium (Tc) was the most element present approximately in all samples. The average concentration of Tc in soil was 14.533ppm, 16.185ppm in plant and 16.266ppm in water sample. We found that Technetium (Tc) have same configuration in all samples.*

Keywords: *LIBS, Refinery, Ziziplhus spina and Technetium.*

1. Introduction

Environmental pollution in countries with rapid industrial development is one of the most challenging persistent causes of danger to human health [1] as well as generating significant direct and indirect adverse effects on (soil, plant and water) [2,3]. Refinery and Factors including air humidity, precipitation, and hot temperatures may exacerbate pollution damage to plants…ect [4] even further. Plants can absorb air pollutants through roots and bio accumulate in the leaves and bark of trees [5].

The laser-induced breakdown spectroscopy (LIBS) is an atomic emission spectroscopy technique utilizing high power laser pulses [6-9].(LIBS) Identify any material's elemental composition in real-time. Focusing the energy of a laser pulse on the sample surface produces plasma that gives information about the material composition [10]

When a pulsed high power laser beam is focused on the material (Solid, Liquid, Gas and aerosols), a short lived (micro second) high temperature (few eV) and density (10^{16}- 10^{19} cm^{-3}) plasma is produced and expands perpendicular to the target surface. Such laser produced plasmas, which contains a diversity of atomic and ionic species as well as free electron emit radiation over an extensive spectral range stretching from infrared to the X-ray region. Although different materials have different breakdown thresholds, the plasma is typically generated when the laser irradiance exceeds ~ 10^8 MW/cm^2 [11]. Spectral features such as emission lines, peak intensity, and integrated intensity determine the elemental concentration of the target or discriminate one material from another through their unique spectral signatures [12]This technique has the advantages of not needing sample preparation; likewise, it could analyze samples in any state of matter. Also, LIBS analysis is relatively fast since, with a laser shot (20 ns), it is possible to obtain the sample's emission spectrum [13]LIBS have many advantages over other conventional spectroscopic techniques such as laser ablation inductively coupled plasma (LA-ICP), X-ray fluorescence (XRF), atomic absorption spectroscopy (AAS) and spark-discharge optical emission spectroscopy (SD-OES). These advantages generally include the fact that sample preparation is either not necessary or minimal. Sample excitation/ionization in the LIBS is carried out by optical energy. It is an almost non-destructive technique that provides direct characterization of the solid sample [14]. The most important point about LIBS is that it has powerful capability in carrying out remote on line and in-situ analysis of the samples particularly situated in the hostile and harsh environments. However, it is lacking on the sensitivity front. Various techniques have been used to enhance the sensitivity of the LIBS. Some of them include expansion of plasma in the magnetic field, dual and multiple pulse excitation of plasma, spatial confinement of LIBS plasma as well as combination of LIBS with laser induced fluorescence technique [15].

The aim of this study Laser Induced Breakdown Spectroscopy (LIBS) has been used to identify of Technetiumon (Soil, Plant and Water)in Sudanese Refineries extracted from Khartoum Petroleum Refinery in Khartoum city capital of republic of Sudan.

IBS has proved to be a powerful technique for elemental analysis.

2.2 Experimental Setup Details

The experimental set up used for the analysis of (surface soil, Plant(Ziziplhus spina – Sidr Plant) and jars water)) is depicted schematically in Figure 1. The LIBS system consists of Ocean Optics LIBS 2000+ spectrometer, a sample holder, N_2 - Laser and OOILIBS software. The 337.8 nm radiations emitted at fundamental frequency from N_2- laser were applied for production of plasma spark at target surface. Laser beam was focused by a convex lens of focal length 30 mm onto the sample. The pulse energy utilized in these experiments was in the range of 100 mJ. The light from the plasma spark is collected by optical fiber with SMA connector. The USB 2000+ has four spectrometer modules to provide high resolution (FWHM 0.1 nm) with a gated CCD detector having 14,336 pixels for simultaneous recording of the spectrum in the 400 nm to 1150 nm wavelength region. The emission is collected at a 45º angle to the incident laser radiation. The spectrometer software reads the data from the detector and reconstructs the spectrum.

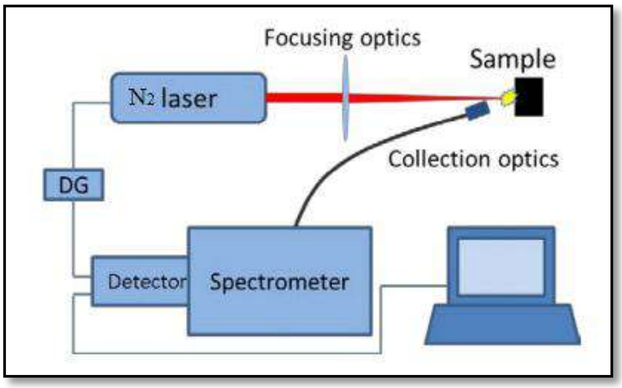

Figure 1 The experimental set up LIBS used for the analysis of (Soil, Plant and Water)

3. Results

A number of Thirteen samples (10 surface soil, 10 Plant(Ziziplhus spina – Sidr Plant) and 10 jars water) were collected from Khartoum Petroleum Refinery, Sudan to detection Technetium (Tc) element using Laser-Induced Breakdown Spectroscopy (LIBS) and to calculate the concentrations as shown in table (1).

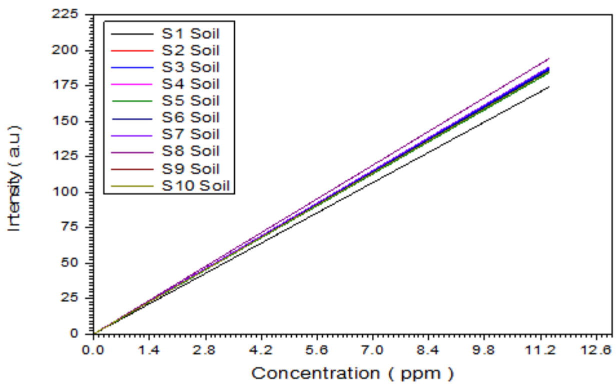

Fig (2) Calibration curve for Technetium (Tc)on Soil samples obtained by using analytic calibration function of (Tc) with known concentration

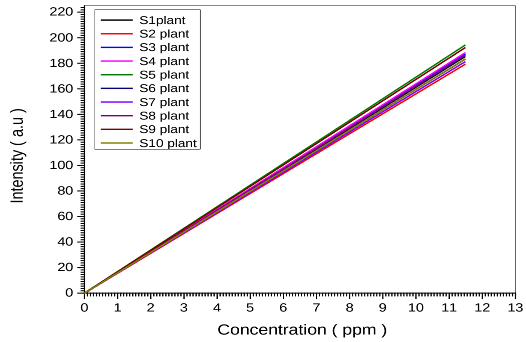

Fig (3) Calibration curve for Technetium (Tc)on plant samples obtained by using analytic calibration function of (Tc) with known concentration.

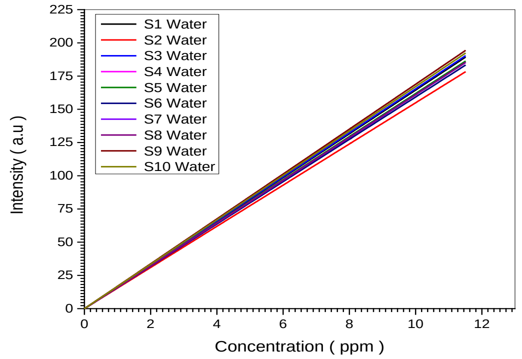

Fig (4) Calibration curve for Technetium (Tc)on water samples obtained by using analytic calibration function of (Tc) with known concentration.

Table (1) concentration and configuration of Technetium (Tc) on (soil, plant and water) samples

No	Concentration (ppm)			Configuration		
	Soil	Plant	Water	Soil	Plant	Water
1	000	16.13	16.45	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$
2	15.25	15.56	15.57	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$
3	16.29	16.29	16.53	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$
4	16.05	16.37	16.13	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$
5	16.05	16.85	16.21	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2}$→$4d^6(^5D)5p$ z $^4F^o_{9/2}$

6	16.21	15.97	15.97	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$
7	16.37	15.81	16.13	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$
8	16.85	16.21	16.13	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$
9	16.13	16.69	16.85	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$
10	16.13	15.97	16.69	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$	$4d^6(^5D)5s$ a $^4D_{7/2} \rightarrow 4d^6(^5D)5p$ z $^4F^o_{9/2}$

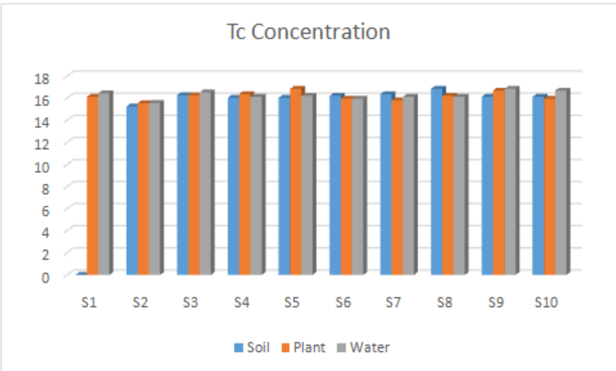

Fig (5) Compression Statistical Chart for Technetium (Tc) concentration on soil, plant and water samples.

4. Discussion

After survey the area around Khartoum Petroleum Refinery it was found that Technetium (Tc) is most elements appear in all samples. This element results from uranium decay which exist in petrol cruel [16]. The concentration of Technetium was calculated using Saha's equation depending on intensity of plasma that made LIBS system. Fig (2), fig (3) and fig (4) display calibration curve of Technetium (Tc) on soil, plant and water samples which obtained from calibration function. The average concentration of Technetium in soil was 14.533ppm, 16.185ppm in plant while 16.266ppm in water sample, it was observed that the concentration of Tc in water greater than and plant and soil, this refers to air pollution in this area which produced from refinery procedure in addition to Tc have high solubility in water. Table (1) show the concentration and configuration of Technetium (Tc)on (soil, plant and water) samples, we found that the signature was same in soil, plant and water for Technetium (Tc)element because Tc non ionized in all samples. The. Fig (5) display statistical compression for Technetium (Tc) concentration (soil, plant and water) in all survey area, it was noted that there a divergence in concentration of Tc in all samples expect soil in sample one and this me be due to air pollution.

4. Conclusions

LIBS system was used to detect most element present in 30 samples (10 surface soil, 10 leaves of (Ziziplhus spina – Sidr Plant) and 10 water) which collected from the area around Khartoum Petroleum Refinery. Technetium was existed approximately in most samples. The concentration of Technetium (Tc) in water greater than plant and soil.

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