Oxidative Stress among Syrian Workers Exposed to TVOCs in Primitive Oil Refining Station

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Abstract: _Background_: _The Syrian oil industry suffered heavily from the ongoing civil war. As the fuel supply dropped, thousands of makeshift oil refineries sprung up across the region in order to deal with the demand. Exposure of workers to pollutants such as hydrocarbons at the air-workplace may lead to various health problems. The present study was carried out to evaluate the effects of total volatile organic compounds (TVOCs) exposure on oxidative stress levels of the primitive oil workers. _Subjects & Methods_: A cross-sectional study was conducted among 80 male participants consisting of 40 primitive oil workers occupationally exposed to TVOCs in Idlep City- Syria, and 40 male control. All workers were subjected to a structured questionnaire included questions about (Personal and socio-demographic data-Occupational history) and laboratory investigations to measure oxidative stress markers (total oxidative stress (TOS) and total antioxidants status (TAS)). As well as, the measure of TVOCs in the air of work environment. _Results_: The average levels of TVOCs in the air work place were (3907 PPM). The mean levels of TOS in the present study were found to be highly significantly increased while the levels of TAS were highly significantly decreased in exposed workers as compared to the control group (P < 0.0001). There was a positive association between duration of exposure and TOS levels, while there was a negative association between TOS and TAS in exposed workers (0.0001) respectively. _Conclusion_: The investigated workers are exposed to highly dangerous levels of TVOCs in their workplace and they work under far worse conditions. The workers occupationally exposed to these pollutants for prolonged periods leads to an increase in their oxidative stress as evidenced by elevated TOS levels and overwhelmed antioxidant TAS and consequences, resulting in a broad spectrum of diseases._

Keywords: Syrian oil industry, makeshift oil refineries, oxidative stress, TOS, TAS, TVOCs

1. Introduction

In late 2011, as the peaceful popular uprisings in Syria slowly turned into an armed conflict with the Syrian government, many civilians started to flee the clashes, Among those fleeing were many engineers and professionals from the country's oil industry, while others joined armed groups. As a result, the output of Syria's oil industry slowed down significantly. Both the internal displacement of Syrians and the attacks on oil infrastructure led to the growth of artisanal oil refineries. At these makeshift systems, crude oil is processed into a useable material for sales on the local market or smuggled to buyers in government-controlled areas and Turkey. Refining oil has become a major alternative economy in Syria, with tens of thousands of refineries across the region. These craft refineries are often operated by civilians, not rarely by children who work in dangerous situations and are exposed to toxic materials. Apart from serious health concerns, small-scale oil refineries leave a large local environmental footprint as they produce hazardous waste products that cause local pollution and can contribute to contamination of local surface and groundwater supplies, potentially contributing to long-term environmental health risks for communities.

The petroleum industry uses and generates many mixtures of chemicals in the upstream processing of petroleum resources. Petroleum and chemicals used in oil and gas exploration and production are inhaled and ingested by domestic, wild and human animals. Contamination of surface and groundwater can occur [1].

Petroleum is a complex mixture of gaseous (sweet gas or sour gas of hydrogen sulfide, ethane, methane, propane), liquid (crude and refined oils) or solid (bitumen, asphalt) hydrocarbons. Exposure to petroleum mixtures may be caused by ingestion , inhalation, or ocular or dermal touch, and may cause adverse effects mainly in the gastrointestinal (GI), respiratory and nervous system[2]. Refined petroleum products (e.g., petrol, kerosene, diesel, petroleum naphtha, and distillates) can contain multiple toxic substances, including heavy metals, oxidizing agent-emulsifiers, anti-wear agents, and toxins[3].

The health effects of exposure to petroleum products vary based on the substance's concentration and duration of exposure. Breathing petroleum vapors can cause effects on the nervous system (such as headache, nausea and dizziness) and trouble of the breathing. High exposure can cause both coma and death[4].Liquid petroleum products that come into skin contact can cause irritation and some may be absorbed through the skin. Chronic petroleum exposure can affect the nervous system, blood and kidneys. Gasoline contains small quantities of the known human carcinogen, benzene. Animals who were exposed to high levels of certain petroleum products have developed tumors in the liver and kidney[5][6][7].

Exposure to petroleum products lead to cause oxidative stress, resulting in the formation of Reactive Oxygen Species (ROS) and eventually leads to neuronal and cellular damage[8]. In the human body, ROS are formed in the cytosol, mitochondria, lysosomes, peroxisomes and plasma membranes under both physiological and pathological conditions; and their levels can be increased by different stressful situations such as occupational stress. Stressful

conditions lead to the formation of excessive free radicals and cause oxidative stress [9].Which in turn, binding with the unsaturated fatty acids of the phospholipids of cell membranes, resulting in lipidperoxidation damage [10]. Oxidative stresses occur when the production of free radicals exceeds the defensive response of the antioxidant system[11]. Which led to liver and other organ disorder [12].

Antioxidants such as ascorbate, glutathione (GSH), α-tocopherol and uric acid present in epithelial lining fluid (ELF) may protect the airways from oxidant injury induced by exposure to air pollutants [13]. Antioxidants prevent the oxidation of lipids, proteins and carbohydrates by scavenging oxidant pollutants from the air ways. But insufficient levels of antioxidants, or inhibition of the antioxidant enzymes, cause oxidative stress and may damage or kill cells. Till date analysis of the effect of exposure to TVOCs in Syrian workers during civil war is not documented. This study was conducted to determine the level of TVOCs at air work place and oxidative stress by measuring TOS and TAS among primitive oil Refinery workers in Idlep-Syrian.

2. Participants and methods

The study consists of forty male primitive oil refinery workers. They had worked in four division for less than 2 consecutive years and were designated as the exposed group and therefore exposed directly or indirectly to TVOCs at the work place. Forty non-exposed male workers, who had never worked in oil refinery or related work, were matched with the exposed workers for age, socioeconomic status and special habits, and were designated as the control group. An interview questionnaire was administered that was especially designed to cover present and past occupational histories as well as questions on manifestations suggestive of exposure to TVOCs intoxications for both exposed and control groups. Exclusion criteria being male workers or control, subjects with medication and nutrient supplements, known cases of cardiac disorders, hepatitis, dyslipidemias, pulmonary disorders and metabolic errors and family history of above mentioned illness.

3. Ethical Approval

The University of Idlep Ethics Committee have approved the present study (No.1/MSc /2018) and all participants provided written informed consent.

Primitive refining stage
The refining process involves refine crude oil using a very simple technique. They distil the oil in homemade kilns above an open flame, let the fumes cool down in a water quench and collect the distilled fuel in buckets figure (1).
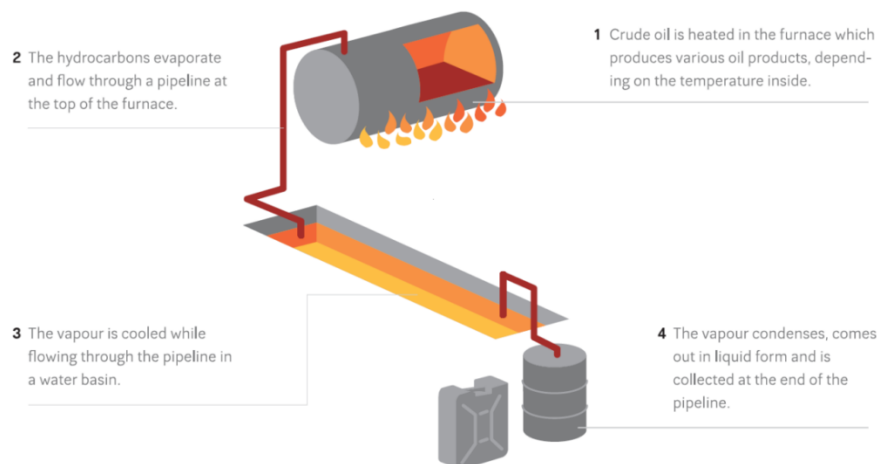

Figure 1: Stages of oil refinery in primitive oil industry

Air sampling
Experimental measurements focused on determination of TVOC levels were performed in primitive oil refinery at Maart Naassan- Idlep- Syria - in June 2018. TVOC concentrations were measured with photoionization detector with UV lamp—ppbRAE 3000 (RAE Systems, Inc., San Jose, CA, USA). Data from measuring devices were recorded in a minute interval.

Blood sampling and biochemical methods
5 ml of blood was collected into a clean tube from each participant at 12:00-2:00 p.m. before the lunch break on the last day of the working week. Blood samples were left to clot for 20 min at 37°C and then centrifuged at 3000 rpm for

15 min. The sera were separated and stored at –20°C until measurement.

Measurement of TAS and TOS levels:
TAS reveals the total antioxidant capacity of the body against powerful free radicals, whereas TOS gives total oxidant amount in the body. They were determined with a commercial kit (Rel Assay Diagnostics, Turkey) spectrophotometrically by a Biosystem BT 350as per manufacturer's recommendations in serum samples. Results were given as (mmol trolox Eqv/l) for TAS. While, the results are given as the equivalent of H_2O_2 (μmol H_2O_2 Eqv/l) for TOS.

Statistical analysis

All statistical analyses were conducted using a statistical software package "SPSS 21.0 for Microsoft Windows, SPSS Inc., Chicago, Illinois, USA) and considered statistically significant at a two-sided P< 0.05. Numerical data were expressed as mean ± SD. Comparisons of quantitative data between two groups were done using the Student's t test for data with normal distribution. The correlation was evaluated by Pearson and spearman correlation coefficient.

4. Results

The demographic and other data of the exposed and controls are shown table (1). The mean age and BMI of the participants in the exposure and control groups was 37.95 ± 7.54 and 39.62 ± 6.81 years, also the mean of BMI 26.93 ± 3.62 and 28.31± 3.78 respectively. The mean difference in age between the two groups was nonsignificant (P=0.300). The average years of employment were 6 ± 2 months. No statistically significant difference was found between exposed and control participants in terms of smoking habits. When the protective measures were investigated, none of the exposed workers were using protective equipment at all during work.

Table 1: Demographic characteristics of controls and workers exposed to TVOCs under investigation

Parameter	Control N=40	Exposed N=40	p-value
Age (M± SD) years	39.62 ± 6.81	37.95±7.54	0.300
BMI (M± SD) Kg/m^2	28.31± 3.78	26.93 ± 3.62	0.101
Duration of employment (months)	-	6 ± 2	-
Using personal protective yes	-	0	-
no	-	40	

Identification of TVOCs in the air at the work place

Analysis of TVOCs in the air of the work place in different part of primitive oil refinery figure (2) confirmed that the workers were exposed to high levels of TVOCs ranged from 2200- 13000 PPM. The concentrations of TVOCs detected were above the permissible exposure limit…..
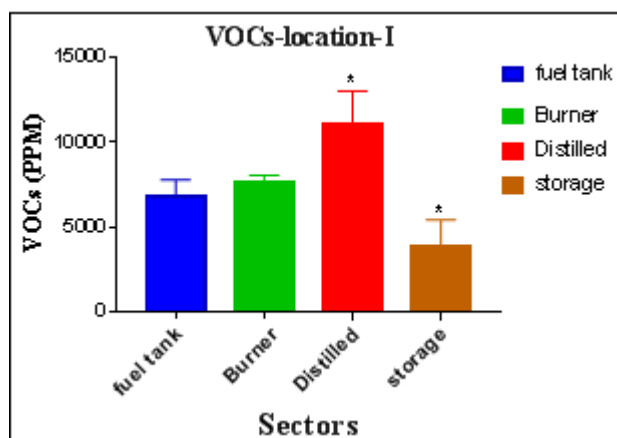

Figure 2: TVOCs level in different sectors of Syrian primitive oil refinery

The mean levels of TOS in the present study were found to be highly significantly increased in exposed workers as compared to control group (P<0.0001), while the mean levels of TAS was found to be highly significantly decreased in exposed workers as compared to control group (P<0.0001) figure (2).
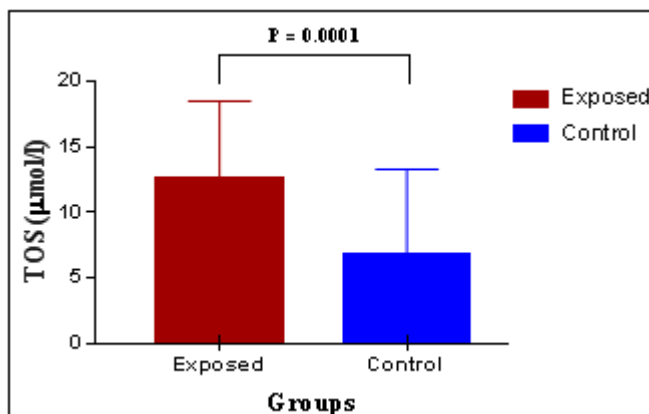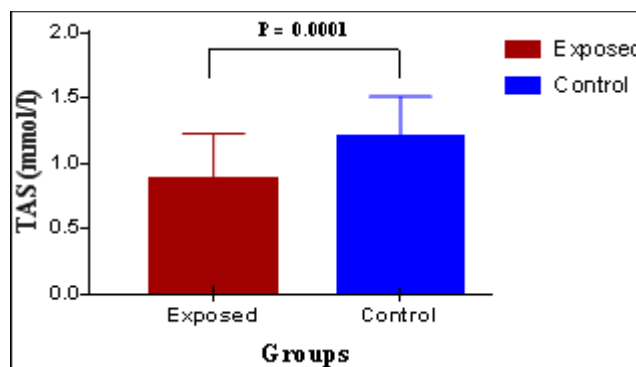

Figure 2: Levels of TAS and TOS in different studied group

The present work showed significant positive correlation between duration of employment and TOS in exposed workers. Whereas there was significant negative correlation between duration of employment ($P < 0.0001$) separately. Finally, the correlation of TAS with TOS was significantly negative ($P < 0.0001$) in exposed workers table (2).

Table 2: The association between oxidative stress markers and duration of employment

Parameter	TAS mmol/l		TOS µmol/l	
Duration of employment	r= - 0.659	P < 0.0001	r= 0.927	P < 0.0001
TAS mmol/l			r= - 0.609	P < 0.0001

5. Discussion

To our knowledge, the present study was the first in Syria during the civil war to examine the level of TVOCs in air makeshift oil refinery and its association with oxidative stress markers (TAS and TOS as indicators of oxidative stress). This study was conducted in artisanal oil refineries. In the present cross-sectional study, the association between age, BMI, markers of oxidative stress were assessed. The concentrations of TVOCs detected were above the permissible exposure limit.

In the recent past, attempts have been made regarding the evaluation of health impact and toxicological implications of inhalational exposure to petrol fumes [8]. The biomarkers evaluated in this work may provide early signals of damage

in subjects occupationally exposed to TVOCs. Petroleum products remain necessary environmental hazards. Their uses cannot be overemphasized; however, exposure to their hydrocarbon constituents poses significant threats to health. Exposure of experimental animals to various petroleum hydrocarbons triggered oxidative stress. Oxidative stress is a threat to well-being. The antioxidant enzymes SOD, CAT, and glutathione peroxidase (GPx) serve as a primary line of defense in destroying the free radicals[14]produced by oxidative stress. Numerous studies have linked excess generation of ROS with cellular damage. Oxidative stress caused by the unbalance between the generations of ROS and the rate of their consumption by antioxidants. Generally, ROS is generated in two different ways [15]. Benzene and its organic derivatives exposure have been associated with increases in the overall formation of free radicals which led to increasing TOS and decreases TAS in exposed workers, as we found in the present work.

Taken together, the refining oil has become a major alternative economy in Syria, with tens-of-thousands refineries all over the country. These artisanal refineries are mostly run by civilians, not rarely children that work in hazardous circumstances, and are exposed to toxic materials that trigger of systemic oxidative stress. Though there are insufficient data in the scientific literature that document the effect of petroleum hydrocarbons by inhalation of various petroleum products on oxidative damage, findings from the present study reveal that inhalation of petroleum hydrocarbons is a risk factor in organ pathologies.

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