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Research Article

DETERMINATION OF POLLUTANTS CONCENTRATIONS PRODUCED BY PETROLEUM STATIONS, KHARTOUM STATE, SUDAN

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ABSTRACT

Considerable attention has been subjected towards the hazards of Petroleum Stations activities and their expected impacts on health and environment. This study involved 15 fuel stations in Khartoum State, Sudan. Three cities were selected for the study, including Greater Khartoum, Khartoum North, and Omdurman. The study aims to assess the pollutants concentrations that could be produced by these selected fuel stations activities on the surrounding environment regarding air, soil, and underground water. The study adopted a scientific method including environmental measurements of sound levels, Air quality Monitoring (CO SO_2, NO_2, TVOC's, and PM_{10}), Soil and Car Washing Waste Water analysis. The results revealed that the ambient air averages for NO_2, and TVOC's, parameters were exceeding both National (SSMO) and FEPA recommended limits; while SO_2 was not detected. Regarding Soils and Car washing waste water, the results showed the contamination by both Pb and Cd (Lead and Cadmium), and their averages were above the recommended permissible limits as per the National (SSMO) standards.

INTRODUCTION

Occupational health and safety of the workers and environment at petroleum stations is still a serious issue, which has classified diesel engine exhaust as carcinogenic to humans (Burton, *et al*., 2016). Car refueling procedure is a major source of exposure to benzene for the working attendants, while also for the people living in the close vicinity of an urban gasoline station. The main interest of studies on benzene is focused on its continuous and prolonged exposure to relatively low levels, both in occupational and environmental settings (Fenga, *et al*., 2016).

Preventive measures were adopted during the last few years, such as a reduction in the quantity of benzene in gasoline, the installation of systems to extract solvent vapors on gasoline pumps. Human health is significantly affected due to rapid urbanization and industrialization that has caused various pollution problems. Gas service station workers, who worked near volatile organic compounds (TVOCs) sources, such as gasoline vapor emissions, and motor vehicle exhausts, may be exposed to highly elevated TVOCs levels (Gaur, *et al*., 2016; Ministry of Health. Khatroum State, 2010).

Despite of the importance of petrol as a source of energy in Sudan for developing of different activities, there are some problems and consequences of petrol stations activities and processes from health and environmental perspectives. It also impacts on human health for the workers and the neighboring residence because of air pollution due to the vapors of petrol components, such as Volatile Organic Compounds (VOCs) Cd & Pb (Cadmium & Lead). On the contrary, petroleum stations activities can threat the health and safety of people, who are providing the services, in case of non-compliance to the health and safety policy and regulations (Chartier, 2014; Duarte-Davidson, *et al*., 2001). All these activities contribute to air, soil, and underground water pollution;

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therefore, this study was conducted to provide more information regarding the persistent issue because some pollutants concentrations may exceed the national permissible limits. The study aims to assess the pollutants concentrations generated by some selected fuel stations in Khartoum State, Sudan.

Study Objectives

The main objectives of this study are as follows;

• To provide valuable information about issues related to increase in the concentration of pollutants.

• To assess the generation of pollutants' concentration by fuel stations in Khartoum State.

MATERIALS AND METHODS

Khartoum City is the National Capital of Sudan. Greater Khartoum consists of three cities, including Omdurman city followed by Khartoum North city, and Khartoum city. Khartoum State is one of the states, characterized by the presence of most of the petroleum stations in the country. The study opted a cross-sectional design and stratified random sampling technique to assess the pollutants that could be generated by fuel station services and their adverse effects on the environment (air, soil and underground water). The samples were collected from three different Nile river terraces. The areas, where study was conducted, descend towards the Nile river.

The contamination of water, air, and soil with pollutants was studied, using two major parameters. Firstly, the concentration of pollutants was compared with mean concentrations in most parts of world, and secondly enrichment factor of all the environments was considered. 15 fuel stations were selected randomly (5 stations per city) to assess the following parameters:

1. Sound levels,
2. Ambient air monitoring including the parameters (CO, SO_2, NO_2, TVOC, PM_{10}),
3. Soil samples,
4. Car washing waste water samples.

RESULTS AND DISCUSSION

Noise Level Monitoring and Ambient Air Quality Monitoring

Audiometric Test was conducted via CEM DT-8820 Digital Multifunction Environment Meter to measure the noise levels at the selected fuel stations. All results were below the permissible recommended standards as per (SSMO and Ministry of Health, Khartoum State, 2010) of (85 dB). Ambient Air Quality Monitoring was carried out at the selected fuel station via Modular Area Monitor Instrument.

Average Concentrations of (CO)

Carbon Monoxide (CO) is a colorless and odorless gas that is formed, when carbon in fuel is not burned completely. CO can cause harmful effects by reducing oxygen delivery to body's organs (like the heart and brain) and tissues. People, who breathe high levels of CO, can develop vision problems, reduce ability to work or learn, reduce manual dexterity, and difficulty performing complex tasks. At extremely high levels, CO is poisonous and can cause death. The average concentrations range between (6.27 - 11.29) mg/m^3 (Table 1). According to the National Institute for Occupational Safety and Health of USA (NIOSH), the recommended exposure limit for 8 hours for CO is (29 mg/m^3). As shown in the results, all the maximum readings are within the allowable limit. These results are also within the allowed limits of the local standards "Sudanese Standards and Meteorological Organization" (SSMO), which set the maximum allowable limits for CO to be (26 mg/m^3).

Average Concentrations of Nitrogen Dioxide (NO_2)

Nitrogen oxides form, when fuel is burned at high temperatures in a combustion process. The primary man-made sources of NO_2 include motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels. Nitrogen oxides cause a wide variety of health and environmental impacts. Nitrogen oxides are one of the main ingredients involved in the formation of ground-level ozone, which can trigger serious respiratory problems. It reacts to form nitrate particles, acid aerosols, as well as NO_2 which also cause respiratory problems. NO_2 contribute to the formation of acid rain and nutrient overload that deteriorate water quality (Table 1). It also contributes to atmospheric particles that cause visibility impairment. NO_2 reacts to form toxic chemicals and contributes to global warming. Average concentrations of NO_2 ranged between (0.14 - 0.39). According to Occupational Safety and Health Administration (OSHA), the recommended allowable limit of NO_2 is 0.05 mg/m^3. As shown in the results, the maximum concentration is (0.39) which is above the allowable limit. Nevertheless, these results are also coincided with the allowable limits of the local Sudanese Standards and Meteorological Organization (SSMO), which set the maximum allowable limits for Nitrogen oxides to be (0.22 $mg/m^{3)}$ for annual exposure time.

Table 1. Average concentrations of pollutants at fuel stations in Khartoum North, Greater Khartoum, and Omdurman City (mg/m^3).

Khartoum North City					
Sample Number	**CO**	**NO_2**	**SO_2**	**TVOC**	**PM_{10}**
1	10.53	0.112	2.16	9.19	0.04
2	14.95	0.194	1.19	o.60	0.12
3	18.50	0.300	0.05	0.49	0.24
4	7.13	0.281	ND	4.99	0.18
5	5.33	0.584	ND	5.21	0.17
Average	11.29	0.294	1.13	4.09	0.15
Greater Khartoum City					
Sample Number	**CO**	**NO_2**	**SO_2**	**TVOC**	**PM_{10}**
1	8.71	0.06	0.42	9.84	0.16
2	4.43	0.14	0.06	6.25	0.18
3	14.04	0.18	0.65	3.78	0.16
4	1.78	0.19	0.01	2.00	0.25
5	6.48	0.12	0.34	13.04	0.15
Average	7.09	0.14	0.29	6.98	0.18
Omdurman City					
Sample Number	**CO**	**NO_2**	**SO_2**	**TVOC**	**PM_{10}**
1	5.55	0.45	ND	2.11	o.19
2	5.30	0.43	ND	0.79	0.25
3	5.33	0.39	ND	5.21	0.17
4	8.59	0.33	ND	4.89	0.15
5	6.56	0.35	ND	6.20	0.22
Average	6.27	0.39	ND	3.84	0.19

Average Concentrations of Sulfur Dioxide (SO_2)

Sulfur dioxide (SO_2) dissolves easily in water. SO_2 gas is formed, when fuel-containing sulfur is burned. Sulfur dioxide causes a wide variety of health and environmental impacts. It contributes to respiratory illness, and aggravates existing heart and lung diseases. SO_2 contributes to formation of acid rain and atmospheric particles that cause visibility impairment. SO_2 and the pollutants formed from SO_2 such as sulfate particles, can be transported over long distances and deposited far from the point of origin. This means that, problems with SO_2 are not confined to areas where it is emitted (US EPA). Average concentrations of Sulfur Dioxide ranged between (0.29 - 1.13) (Table 1). According to National Institute of Occupational Safety and Health (NIOSH), the recommended exposure limit for 8 hours for SO_2 is (0.05 mg/m^3), as shown in the results, the maximum reading was (2.16 mg/m^3) which is far above the allowable limit. Nevertheless, these results are also higher than the allowable limits of the local Sudanese Standards and Meteorological Organization (SSMO), which set the maximum allowable limits for SO_2 to be (0.031 mg/m^3) for annual exposure time.

Average Concentrations of Total Volatile Organic Compound (TVOC)

Total Volatile Organic Compounds (TVOC) are emitted as gases from certain solids or liquids. The ability of organic chemicals to cause health effect varies greatly from those that are highly toxic, to those with no known health effect. TVOC are emitted by a wide array of products numbering in the thousand examples include: paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials and furnishings, including lot of office equipment. Respiratory tract irritation, headaches, dizziness, visual disorders, and memory impairment are among the immediate symptoms that some people have experienced soon after exposure to some organics. Many organic compounds are known to cause cancer in animals; some are suspected of causing or are known to cause cancer in humans (US EPA). Average concentrations ranged between (3.8 -6.9 mg/m^3), in fact, there are no standards for TVOCs set by OSHA (Occupational Safety and Health Administration). The obtained results are exceeding the prescribed limits recommended by Sudanese Standards and Meteorological Organization (SSMO), (0125 mg/m^3) (Table 1).

Average Concentrations of Particulate Matter) PM10

Particulate matters are a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark, are enough to be seen with the naked eye. Others are small and they can only be detected by using an electron microscope. Particulate matter includes 'inhalable coarse particles' with diameters that are 2.5 micrometers and smaller. Particulate matters especially fine particles contain microscopic solids or liquid that are so small they can get deep into the lungs and cause serious health problems. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing (US EPA). The average obtained results as shown in Table 1, ranged between (0.15 to 0.19 mg/m^3) which are below the recommended limits of OSHA of (1.0 mg/m^3).

Soils Samples Analysis

Soils samples were collected from different depth near by the fuel station's storage tanks (Tables 2 and 3).

Car Washing Waste Water

Waste water samples were collected from the fuel

Table 2. Results of the analysis of some selected tested parameters.

Sample Number	Cd (ppm)	Pb (ppm)	Ca+Mg (me/l)
1	0.02	0.75	36.5
2	0.01	0.56	41.5
3	0.09	0.8	46.5
4	0.03	0.5	52.5
5	0.004	0.74	40.5
6	0.009	0.69	52.0
7	0.011	0.66	45.6
Average	0.03	0.68	45.03

- Cd content average was (0.03) ppm
- Pb content average was (0.68) ppm
- Ca+Mg content average was (45.03) me/l

Table 3. Results of the analysis of the waste water samples.

Sample Number	Cd (ppm)	Pb (ppm)	Ca+Mg (me/l)
1	0.0042	0.18	0.172
2	0.0003	0.24	0.332
3	0.0043	0.40	0.308
4	0.0041	0.337	0.252
5	0.006	0.345	0.172
6	0.0052	0.207	0.092
7	0.0049	0.320	0.288
Average	0.01	0.29	0.24

stations providing the car washing services to determine the types and levels of pollutants that could be produced by these activities in particular: Pb, Cd and Ca+Mg levels.

The produced waste water has been used to discharge directly into the groundwater without any kind of treatment. The results revealed that average level of Cd was (0.01ppm); while for Pb was (0.29 ppm) compared to the (SSMO) national standards maximum recommended limits for Pb is (0.007 ppm). There are no national standard limits for Cd in the country. A study evaluated the toxicity of soil in vegetated and unvegetated plots using Microtox, earthworm, and seed germination assays. The results showed that establishment of plants results in the reduction of toxicity as compared to contaminant aging (Moubasher, *et al*., 2015).

Signal transduction pathways can be modulated as a result of chronic exposure to low dose benzene, which is activated by oxidative stress. It shows significant involvement with cell apoptosis as well as cell proliferation. Employees in fuel stations can easily be exposed to high levels of gasoline vapors during refueling as well as high concentrations of emissions from tail pipe exhausts (Mohammadyan, *et al*., 2016; WHO, 2005). Therefore, service station employees are vulnerable sector of the population because of their exposure during their shifts.

CONCLUSION

It is concluded that the results were below the permissible recommended standards as per (SSMO and Ministry of Health, Khartoum State, 2015) in regards to sound levels. The averages concentrations for NO_2, SO_2, and TVOC's were above the recommended permissible levels as per SSMO and OSHA. Average concentrations of CO and PM_{10} were within the recommended permissible limits set by both OSHA and SSMO. The results of soil samples showed that pH average value was neutral (6.7), Cd average level was (0.03 ppm), Pb average level was (0.68 ppm) (OSHA; SSMO, 2007; SSMO; 2011). The results of waste water samples revealed that pH average value was acidic (9.1); Cd average level was (0.01 ppm); and Pb average level was (0.29 ppm).

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CONFLICT OF INTEREST

The research has no conflict of interest and is not funded through any source.

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