

The effect of electricity generator exhausts on the human and domestic animal health

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ABSTRACT

The purposes of the study was to investigate the impact of exposure to the exhausts of electricity generators that operate with gasoline or gas on some biochemical measurements as an indicator of public health. As a comparison group of people and animals far from the exhaust of electricity generators, as well as a group of experimental animals (Rabbits), blood samples were taken from both groups to perform some biochemical analysis. Creatinine, uric acid, aspartate aminotransferase, alanine aminotransferase, albumin, glomerular filtration rate, cholesterol, vitamin C, total protein, glutathione, insulin, and alkaline phosphatase. The findings revealed a notable increase in all previous values among the persons who were exposed to the exhausts of generators, compared to ones were not exposed to exhausts. Also, increase in the levels of all above mentioned parameters in rabbits that were exposed to generator exhausts were noticed compared to the rabbit group that were not exposed to these exhausts.

Keywords: Bani Waleed city, Biochemical parameters, Exhaust of electricity generators, Rabbits

1. Introduction

So far, some Libyan cities are still using generators of various types regularly. This behaviour resulted from the substantial decline in electricity generation from power plants nationwide, which was brought on by the effects of conflicts that destroyed local electrical grids for almost a decade (Kazem and Chaichan, 2012). There are two primary forms of pollution brought on by generator running. The first is air pollution brought on by the usage of petrol and diesel as fuel for generators. In addition to being used for housing during blackouts, the use of non-renewable energy sources like petrol and gas generators will only rise in the future to accommodate the world's expanding population (Ahmed et al., 2020). Therefore, to lessen their effects on the environment and human health, these resources must be used effectively (Mehdi and Mehde, 2014). Carbon dioxide (CO₂) is one of the gases that cause a slight suffocation (Aerias, 2005). As it enters the body from the

atmosphere and reaches the lungs and the blood, it can increase in the acidity of the blood as well as inhibition of the central nervous system (Priestly, 2003). The acidity of the blood occurs when large amounts of it are available in the blood, and the blood circulation must transfer CO₂ gas from the blood to the lungs and exhale it. The presence of CO₂ gas in the blood led to formation of the weak acid H₂CO₃ which decomposes into hydrogen ions (H⁺) + ions bicarbonate (HCO⁻³). The pH value is what makes the blood condition move toward acidity (Priestly, 2003). These generators emit toxic fumes into the oxides, fluoride, and heavy metals, particularly lead (Pb), all of which have a range of negative effects exhaust, including hydrocarbons, carbon oxides, sulphur oxides, benzopyrene, nitrogen on the environment, animals, plants, and public health (Chatterjee and Das, 2013). These generators emit gases that contain compounds that are carcinogenic

and mutagenic, such as carbon monoxide, carbon dioxide, and heavy metals (Moore and Ramamoorthy, 1984). According to previous studies, heavy metals are harmful to humans if their levels were increased (Ifeanyi and Nnaji, 2023).

Initially, they may combine with proteins and not be harmful, but when their concentration was beyond the threshold level, they pose a serious risk to human health (Fadhel et al., 2016). Furthermore, both essential and non-essential metals can harm cell membranes, change enzyme specificity, interfere with cellular function, and damage DNA structure when they reach high concentrations. Toxic metals may also interact with essential cell components through covalent and ionic bonding (Bruins et al., 2000). Because of their impact on red blood cell proliferation and interference with haemoglobin production, heavy metals like Pb that may be present have been shown in recent research to limit haemoglobin synthesis (Ghazi, 1995). Pathophysiological electrolytes that produce radicals such reactive oxygen species (ROS), hydroxyl radicals and hydrogen peroxide (H_2O_2) can be produced by heavy metals like Pb, cadmium, and mercury (Alfarhani et al., 2016). Only diesel vapour produced by generators contains aromatic hydrocarbons which are harmful due to creating mutagenic AH-DNA complexes (Svecova et al., 2009).

Numerous epidemiologic studies have found a consistent correlation between elevated levels of particulate matter in the ambient air and increased rates of cardiovascular and respiratory death and morbidity. Throughout in addition to generating other pollutants, so diesel exhaust is considered from the major sources of particulate matter pollution throughout most of the world (Miller, 2022). Despite the substantial epidemiologic evidence, no accepted biological pathways currently account for the toxicity of particulate matter in humans to determine how people's airways were impacted by diesel exhaust (Ahmed et al., 2020).

Damage to kidney tissues will impair their ability to function. Along with air pollutants, particularly particulate matter (PM), they have been closely linked to negative impacts on

cardiovascular and respiratory health, which may Pb to death (AL-Maraashi and AL-Hakkak, (2022).

Diesel generators are expected to produce a wide range of gases and compounds that pollute the air and have a detrimental impact on the health of individuals who operate them (Zalakeviciute et al., 2024). According to the estimated results, the emissions are approximately 25–68 tonnes from carbon monoxide (CO) (189–515), nitrogen oxides (NO) (10428–28335), CO₂ (8–21 tonnes), volatile organic compounds (66–180 tonnes), sulphur oxides and particulate matter (23–64 tonnes) (Townsend and Maynard, 2002; Gorman et al., 2003). The body easily ionises and eventually absorbs all of the chemical components present in the form of free ions. Depending on their chemical properties, such as their oxidation state, transition metals usually interact as components of macromolecules and easily form stable covalent complexes (Schoof, 2003a; b). The electrochemical rule controls how metal ions are released into the biofluid. Because an active metal ion instantly forms an oxide, hydroxide, or inorganic salt with a nearby water molecule or an anion, released metal ions do not always react with biomolecules to seem hazardous (Ifeanyi and Nnaji, 2023). Therefore, the likelihood of the ions combining with biomolecules to produce cytotoxicity, allergies, and other biological effects is quite low (Hanawa, 2004). These metals form complexes with proteins such as transferrin, ferritin, lactoferrin, hemosiderin, ceruloplasmin and melanotransferrin, and amino acids such as glutathione (GSH), cysteine, and histidine. Toxic metal exposure can produce acute or less severe health problems. These reactive dietary ingredients are poorly absorbed, have poor intestine solubility, and form complexes with fibre (Jacobs and Porta, 2007). Low fibre content and the absence of phytates and oxalates in the diet improve absorption of these minerals (Varsha et al., 2010). The characteristics of poisoning vary depending on whether the toxin is an inorganic or organic chemical (Karri et al., 2008). Depending on the individual and the length of time spent exposed to Pb, Pb poisoning can present with a wide range of

symptoms and indicators (Rossi, 2008; Munzir et al., 2015). A person with high levels of Pb may not have any symptoms at all, and symptoms are vague and can be mild (Hanawa, 2004). The objective of the current study is to assess the biochemical characteristics of people living in Bani Walid city who are near generators while they are operating as markers of human health. Additionally, rabbits that live with them in homes and are exposed to these exhausts may also have health issues.

2. Materials and methods

This study was carried out in the city of Bani Walid, Libya in 2020, which has used small diesel generators for a period of not less than 6 hours per day since 2011 until today as a result of reducing the loads on the electricity network, which cannot continue to work due to the breakdowns and damage caused to it as a result of the wars and conflicts that occurred. Forty persons who live far from these generators and were selected (control group). The second group included 40 people were selected from families that use electricity generators that operate on gasoline or gas. A group of 10 rabbits was placed in another place in the house away from the exhaust (control) and other 10 rabbits were placed in the same place where the generator was located and were exposed to the exhaust. Blood samples were taken from all groups (humans and animals), then the following measurements were estimated in their blood.

Five milliliters of blood drawn from each person were collected in simple disposable tubes to clot

at 37 °C for 10-15 minutes and centrifuged at 300 rpm/ minute for about 10-15 minutes. Serum was stored at -20 °C until use. Creatinine, urea, glomerular filtration rate (GFR), total protein and albumin (Watson, 1960). Total serum bilirubin (TSB), aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP) (Doumas et al., 1971). Cholesterol level was estimated according to Armstrong and Carr (1964), plasma vitamin C estimation using the colorimetric assay kit, glutathione, uric acid, and insulin (Mitrakou et al., 1992).

Ethical approval and consent

The care and use of animals were approved by ethics committee of Al-Azhar University in accordance with the laws and regulations of Egypt with Ethical approval number 04/2025/1230. The consent number KFS1345/1.

Statistical analysis:

The T-test models approach, which SPSS was used to statistically assess the data collected for this investigation (SPSS for Windows, 1997).

3. Results

The findings in Table 1 demonstrated the effects of diesel generator exhaust exposure and control on total protein, albumin, creatinine, uric acid, and the activity of ALP, AST, and ALT were significantly higher in diesel generator exhaust exposure than in control group of peoples and animals.

Table 1. Effect of electricity generator exhausts on some biochemical parameters and some enzyme activity

Parameters	Peoples			Animals		
	Control	Exposed to exhausts	P. value	Control	Exposed to exhausts	p value
Total protein (g/dl)	5.79 ± 0.011 ^b	6.51 ± 0.0358 ^a	<0.0001	5.38 ± 0.07 ^b	6.06 ± 0.07 ^a	0.0001
Albumin (g/dl)	3.44 ± 0.004 ^b	4.08 ± 0.0013 ^a	<0.0001	3.30 ± 0.03 ^b	3.90 ± 0.05 ^a	<.0001
Creatinine (mg/dl)	0.75 ± 0.002 ^b	0.85 ± 0.0013 ^a	<0.0001	0.69 ± 0.007 ^b	0.80 ± 0.004 ^a	<.0001
Uric acid (mg/dl)	5.10 ± 0.002 ^b	5.60 ± 0.0024 ^a	<0.0001	4.38 ± 0.18 ^b	4.94 ± 0.04 ^a	0.0149
ALP (Iu/L)	3.44 ± 0.002 ^b	4.08 ± 0.0023 ^a	<0.0001	3.10 ± 0.06 ^b	3.86 ± 0.05 ^a	<.0001
AST (U/L)	17.70 ± 0.00 ^b	31.87 ± 0.0030 ^a	<0.0001	19.12 ± 0.41 ^b	26.16 ± 0.34 ^a	<.0001
ALT (U/L)	16.82 ± 0.01 ^b	29.64 ± 0.0389 ^a	<0.0001	15.29 ± 0.13 ^b	22.9 ± 0.77 ^a	<.0001
Total Bilir. (mg/dl)	0.42 ± 0.003 ^b	0.69 ± 0.0018 ^a	<0.0001	0.39 ± 0.004 ^b	0.52 ± 0.028 ^a	0.0017

^a and ^b: Within the same row, the means are considerably different at ($p < 0.05$).

Data in Table (2) had shown that glomerular filtration rate (GFR) and Cholesterol were lower

in control than in Exposed to exhausts of diesel generators of peoples and animals. But, Vitamin

C, GSH, TSB and insulin were higher in control than in exposed to exhausts of diesel generators.

Table 2. Effect of electricity generator exhausts on health of peoples and animals

Parameters	Peoples			Animals		
	Control	Exposed to exhausts	p value	Control	Exposed to exhausts	p value
GFR (ml/min/ 1.73m ²)	101.88 ± 0.006 ^b	117.90 ± 0.0056 ^a	< 0.0001	99.64 ± 0.41 ^b	105.62 ± 1.47 ^a	0.0044
Cholesterol (mg/dl)	158.50 ± 0.018 ^b	166.30 ± 0.012 ^a	< 0.0001	131.85 ± 28.96	146.78 ± 0.93	0.6202
Vitamin C (mg/dl)	0.80 ± 0.005 ^a	0.31 ± 0.0028 ^b	< 0.0001	-	-	-
GSH (μmol/l)	13.20 ± 0.013 ^a	9.50 ± 0.0017 ^b	< 0.0001	12.16 ± 0.09 ^a	10.10 ± 0.11 ^b	< 0.0001
TSB (mg/dl)	0.73 ± 0.011 ^a	0.32 ± 0.0002 ^b	< 0.0001	0.70 ± 0.004 ^a	0.37 ± 0.020 ^b	< 0.0001
Insulin(μu/ml)	9.87 ± 0.002 ^a	7.70 ± 0.0017 ^b	< 0.0001	8.9 ± 0.12 ^a	7.34 ± 0.17 ^b	< 0.0001

GFR: Glomerular filtration rate, GSH: Glutathione, TSB: Total Serum Bilirubin. ^a and ^b: Within the same row, the means are considerably different at ($p < 0.05$).

4. Discussion

Creatinine may rise as a result of the elevated levels of heavy metals caused by pollution over time. As the length of time spent working at a fuel station grew, creatinine levels rose noticeably (Sushil and Madhur, 1993). The exhaust group's levels were higher than those of the control group. Particulate matter can damage the liver and activate Kupffer cells as a result of extended exposure to generator fumes, which triggers an inflammatory response and raises ALP activity (Ali and Majeed, 2023). Measuring the level of the alkaline phosphatase enzyme is important and useful in order to know liver and bile diseases, as well as bone diseases, and its activity increases clearly when the bile ducts are blocked, for example (Wolkoff, 2005).

The basic phosphatase enzyme facilitates the calcification of bones, and therefore it has great clinical importance in the diagnosis of some pathological conditions, including bone diseases, bone cancer, liver and bile diseases (Ali and Majeed, 2023)..

The high activity of this enzyme was also observed in the case of pancreatic cancer (Sushil and Madhur, 1993). AST catalyzes the transfer of an amino group between the amino acid (Aspartate) and the amino acid glutamate and vice versa. This enzyme is of great importance in the metabolism of amino acids and is present in the liver, heart, skeletal muscles and kidneys (AL-Maraashi and AL-Hakkak, (2022). AST

enzyme converts the amino acid aspartate and α-ketoglutarate to oxaloacetate and glutamate, respectively (Athayde and Cocuzza, 2007). The ALP, AST, TSB, and albumin levels were substantially higher ($p < 0.0001$) than those of the control group, while GFR levels were significantly different ($p < 0.0001$) from the control group in people and ($p < 0.01$) in animal (Table 1 and 2). Tan et al.'s findings were in agreement with these findings (Tan et al., 2009). Heart, skeletal muscle, kidney, liver, and plasma all contain the mitochondrial enzyme AST. Because of its high serum level, ROS are produced, intracellular Ca²⁺ is increased, and the mitochondrial membrane is disrupted. Each of these effects is an example of a cytotoxic mechanism that exhaust pollutants can produce (Liu et al., 2009). Because the hepatic cells' cystol contains substantial amounts of the enzyme ALT, altered levels of this enzyme are a specific sign of liver injury. Since ALT is present in significant amounts in the cystol of the hepatic cells but in small amounts in other organs, altered levels of this enzyme are specific indicators of liver injury (AL-Maraashi and AL-Hakkak, 2022).

The liver cell damage brought on by the exhausts from the energy generators is specifically responsible for the elevated ALT levels seen in this study (Hussein, 2015). Some researchers attribute the rise in ALT to an increase in cell permeability due to hypoxia (Penny et al., 1983). Or it may be the reason for the rise in this enzyme to diseases associated

with damage and breakage of liver cells and cells of other tissues as a result of long and continuous exposure to pollutants emitted from electricity generators (Rokho et al., 1996). This study agrees with many studies, some of which indicated the effect of carbon monoxide on enzymes in experimental animals, and others indicated the effect of cadmium on ALP.

Chronic exposure to Pb has been shown to lower GFR, which is followed by renal tubular fibrosis, renal atrophy, and disruptions of renal functioning (Scholtz et al., 2004). Diseases like atherosclerosis and stroke may result from elevated serum cholesterol levels. It has also been noted that elevated serum cholesterol lowers the levels of serum GSH and circulating insulin (Tangvarasittichai, 2015). There was a substantial difference between transferrin saturation (%) and cholesterol. This result was consistent with that of Welinder et al. (1977). An increase in LDL cholesterol levels is likely to result in cholesterol buildup on artery walls, which can cause atherosclerosis and other heart conditions (Abe et al., 2011). The antioxidant route has also been negatively impacted by Pb (Chavez et al., 2007). As a result, there was a decline in selenium, GSH, vitamin A, vitamin C, and vitamin E. Ascorbyl radical and dehydroascorbate are the initial forms of vitamin C's oxidation, which scavenges free radicals and stops lipoproteins and other macromolecules from being harmed by them (Srilaxmi et al., 2010). The primary soluble antioxidant in the cell compartment and a significant antioxidant produced by liver cells is GSH.

Its numerous defensive functions against oxidants may be the cause of the notable drop in GSH content. As the length of time that fuel station employees worked increased, glutathione levels dramatically dropped (Ali and Majeed, 2023). According to Srilaxmi et al. (2010), rats exposed to organic and particulate matter from motorcycle exhaust showed increases in glutathione S-transferase and cytochrome P-450-dependent monooxygenase in their lung microsomes, kidney, and liver that were time and dose dependent. It is well known that these enzymes change the polycyclic aromatic hydrocarbons (PAHs) into polar nucleophilic substances that interact with the guanine and

adenine bases of DNA (Ewa and Danuta, 2017). Diesel engine workers exposed to high-pressure resistant lubricants containing Pb naphthanate were found to have elevated total bilirubin (Seema and Tripathi, 2012). In addition to the fact that Pb can be absorbed through the lungs, they attributed the rise in total bilirubin to the workers' noncompliance, which resulted in skin exposure where Pb absorption may have happened through damaged skin (Mortada et al., 2001).

Conclusion

Available evidence indicates that there are risks to human and animal health associated with exposure to exhaust emissions from diesel engines manufactured before the mid-1990s. The kidneys' roles include controlling water and electrolyte balance and eliminating metabolic waste products like urea and creatinine. Kidney failure is indicated by abnormal blood levels of these metabolic wastes. Thus, the level of uric acid was greater. Exposure to several nephrotoxic chemicals may result in impairment of renal function. Exposure to heavy metals, such Pb, from generators or vehicle exhaust is linked to nephrotoxicity.

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