Effecting of Radon Gas on Some Antioxidant and Liver Enzymes of Female Rats

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Abstract

Uranium and its daughters such as radium-226 and radon gas are harmful elements to the human body, it is considered a known carcinogen. Radon exposure can significantly affect the enzymes such as antioxidant enzymes and Liver enzymes. Liver function tests measure how well the liver performs its normal protein-making function and eliminates bilirubin. Other tests on liver function measure the enzymes released by liver cells in response to damage or disease. The present study aimed to determine the effect of radon gas (radium-226 source) on the female rats including a survey change in some antioxidant enzymes (Catalase, Glutathione, LDH, and SOD) and liver enzymes (ALT and AST). The current study included divided the animals to five groups each group contain five animals. The first group rats were no exposed to radon gas which it is as control group. While other groups of rats (4 groups) were exposed to radon gas concentrations 588.51 Bq/m3 of 4 days, 714.62 Bq/m^3 of 8 days, 756.66 Bq/m^3 of 12 day, and 840.73 Bq/m^3 of 16 days, respectively. The result of body weight shows no significance ($P>0.05$) in the body weight of rats in groups exposed to radon gas in comparison with the control group. In addition, the result of the Catalase, Glutathione, SOD, ALT and AST shows a significant decrease ($P<0.05$) in groups exposed to radon gas in comparison with the control group, while the LDH is significantly increased ($P<0.05$) in groups exposed to radon gas in compare with the control group. Therefore, it may be concluded the radon gas at high-time exposure causes effective on antioxidant and liver enzymes in female rats.

Keyword: SOD, CAT, GSH, LDH, ALT, AST female rats, and radon gas.

Introduction

Radiological pollutants are a kind of environmental pollution that may lead to cancer and other health issues in individuals and the whole ecosystem, significantly impacting the environment (**Rühle et al., 2017**). Uranium is a naturally occurring radioactive element widely present across the Earth. It may be found in the Earth's crust at a depth of around 2900 km (**Gaisberger et al.,2021**). It can exist in several states: gas, liquid, or solid compounds (**Maier et al., 2021**). Uranium metal has a substantially increased threat of death from lung cancer, due to cumulative exposure to radon decay products. Radon is one of the radioactive gases and sometimes refers to ^{222}Rn) represents one of the main natural radiation sources. The average radiation amount that human is exposed to is 2.4 mSv/y, half of this amount (1.2 mSv/y) is due to the effect of inert gas (radon). Humans are inherently exposed to varying degrees of radioactivity, which rely on the natural radioactivity found in the region and the geological characteristics of the environment, including the presence of thorium, uranium, and potassium in the rocks that make up the soil. Radon (^{222}Rn) is a naturally occurring radioactive noble gas that is produced through the alpha decay of radium (^{226}Ra) in the uranium decay series. Radon, being an inert radioactive gas, does not undergo chemical reactions with other elements and tissues. It has a preference for remaining in a gaseous state rather than dissolving in water. Radon, with a half-life of (3.82 days), constitutes the greatest proportion (42%) of the typical radiological exposure dose to the general public, as stated by the United Nations Environment Programmed (UNEP) (**Abojassim et al., 2021**). Aerobic organisms have antioxidant defense mechanisms that manage reactive oxygen species (ROS) generated due to aerobic respiration and substrate oxidation. During cellular metabolism, oxygen undergoes a sequence of step-by-step reductions, generating of O^{2-}, hydrogen peroxide (H_2O_2), and finally water (H_2O). Possible enzymatic sources of reactive oxygen species (ROS) consist of constituents of the mitochondrial electron transport chain, xanthine oxidase, the cytochrome p450 monooxygenases, lipoxygenase, nitric oxide synthase (NOS), and NADPH oxidase (**Guzik & Harrison, 2006**). Liver enzymes, specifically aspartate aminotransferase (AST) and alanine aminotransferase (ALT), are linked to the occurrence and outlook of hepatocellular carcinoma and liver metastases, as well as various other forms of cancer. There was a positive correlation between elevated liver function tests and gallbladder cancer (**Singh et al., 2012**). The objective of this study is to investigate the impact of different durations of radon gas exposure (4, 8, 12, and 16 days) on the antioxidant enzymes in female Albino rats.

Materials and methods

Preparing laboratory animals:

The research included 25 Bulb/C female albino Swiss Rats aged 8–12 weeks and weighing 132–208 g. These animals were chosen for fertility testing because they were fertile. These animals came from the University of Kufa Faculty of Science animal house. The animals entered the Faculty of Science/University of Kufa Animal House. Plastic cages with mesh coverings and sawdust floors housed them. Weekly sawdust changes. Animals were housed in controlled lab settings at 21-30°C. The lighting system offered 13 hours of light and 11 hours of darkness. The animals received water and blackberries from Baghdad agriculture shops as needed.

Irradiation Source and Radon detector:

Female rat samples have been irradiated with radium-226 for research objectives. 2009 saw the generation of a source with an activity of 6600 Bq for radium-226. This source consists of a container with a rod inside which a radioactive nucleus releases radon fume.

CR-39 nuclear track detector sheets are sensitive polymeric plastic. They are often employed to measure radionuclides that release α-particles, such as radon gases. These sheets are compact, simple, and durable (**Hamzah et al., 2022**). "CR-39" refers to the Columbia Resin No. 39 detector. Formula for CR-39: C12H18O7. Each detector has a code to differentiate it. UK-based TASTRAK Analysis System, Ltd. marketed the CR-39 detector. The CR-39 detector sheet was 2.5cm×2.5cm and had a thickness of 1mm. TASL-compatible codes were issued to each page. The sheet has a density of around 1.32 g/m³.

Experimental Design

The rats were housed in an animal facility for a period of two weeks to adapt to the laboratory environment prior to being utilized for the experiment. Each group consisted of five rats that were exposed to varying levels of radon gas (^{222}Rn), depending on the duration of exposure.

The females Rat was explained after being anesthetized with chloroform on the end of each group. The abdominal cavity was opened and the various organs of the female reproductive system that included the Uterus were removed, placed in a solution of formalin (10%), after removing the fatty substances attached to it. It was dried by filter paper and then weighed using a sensitive scale type (Sartorius, Germany) after which the textile and physiological manifestations were studied according to the experiments designed in this study.

Results

The results from Table (1) suggest that there is no statistically significant distinction (p>0.05) between the radiation groups and control groups (before and after weights) at different weights (186.67±32.32, 186.33±19.0, 208±35.76, 174.33±10.07, 163±13.11, 180.67±42.15, 177±28.05, 198.33±20.21, 178.33±15.89, 172.33±15.01) respectively.

Table (1): Results of treated periods and weights (before and after) radiation.

Treated groups	Treated Periods	Weight before (g)
Control	D.W	163±13.11
RAD	4 days	186.67±32.32
	8 days	186.33±19.01
	12 days	208±35.76
	16 days	174.33±10.07
Univariate	LSD	44.250
	p-value	0.296

The findings from Table (2) demonstrate a statistically significant reduction (p>0.05) in the catalase in both the radiation groups and the control groups (7.4±0.36, 3.24±0.72, 6.78±0.93, 8.07±0.66, 15.13±0.62, 14.8±0.32, 17.3±0.42 and 16.33±0.35) respectively.

Table (2): Results of Effect of RAD for (4, 8, 12, 16) day on Catalase in female Rats in compered with control groups and radiation groups

Catalase (U / MG/KG)		
Treated groups Periods	Control	RAD
4 days	15.13±0.62	7.4±0.36
8 days	14.8±0.32	3.24±0.72
12 days	17.3±0.42	6.78±0.93
16 days	16.33±0.35	8.07±0.66
p-value	0.014*	0.0001*
LSD	1.442	3.133

The findings from Table (3) demonstrate a statistically significant rise (p>0.05) in glutathione levels in both the radiation groups and control groups (23.69±0.96, 24.13±1.46, 27.83±1.19, 28.23±1.19, 27±1.15, 26±1.14, 25.3±1.17 and 26.15±0.62) respectively.

Table (3): Results of Effect of RAD for (4, 8, 12, 16) day on Glutathione in female Rats in compered with control groups and radiation groups

Glutathione (Umole /L)		
Treated groups Periods	Control	RAD
4 days	27±1.15	23.69±0.96
8 days	26±1.14	24.13±1.46
12 days	25.3±1.17	27.83±1.19
16 days	26.15±0.62	28.23±1.19
p-value	0.73	0.003*
LSD	3.428	2.283

The results from Table (4) demonstrate a statistically significant rise (p>0.05) in LDH levels in both the radiation groups and the control groups (1235.9±10.42, 1230.33±14.08, 1314.33±76.83, 1467.33±78.36, 795.67±44.55, 925±120.45, 1234.67±8.97, and 1245.37±7.46) respectively.

Table (4): Results of Effect of RAD for (4, 8, 12, 16) day on lactate dehydrogenase in female Rats in compered with control groups and radiation groups

LDH (U / L)		
Treated groups Periods	Control	RAD
4 days	795.67±44.55	1235.9±10.42
8 days	925±120.45	1230.33±14.08
12 days	1234.67±8.97	1314.33±76.83
16 days	1245.37±7.46	1467.33±78.36
LSD	19.078	159.028
p-value	0.0001*	0.0001*

The results from Table (5) results a statistically significant rise (p>0.05) in SOD levels in both the radiation groups and the control groups (1235.9±10.42, 1230.33±14.08, 1314.33±76.83, 1467.33±78.36, 795.67±44.55, 925±120.45, 1234.67±8.97, and 1245.37±7.46) respectively.

Table (5): Results of Effect of RAD for (4, 8, 12, 16) day on superoxide dismutase dehydrogenase in female Rats in compered with control groups and radiation groups

SOD (U / mg/kg)		
Treated groups Periods	Control	RAD
4 days	6±0.29	4.6±0.83
8 days	6.2±0.35	2.75±0.17
12 days	6.27±0.69	2.32±0.6
16 days	6.47±0.69	1.47±0.45
LSD	1.754	1.064
p-value	0.938	0.001*

The results from Table (6) demonstrate a statistically significant reduction (p>0.05) in ALT levels in both the radiation groups and control groups (67±2.65, 62.33±6.03, 83.33±12.58, 93±7.21, 110±1.15, 109.17±1.36, 111.17±3.11 and 112.57±2.72) respectively.

Table (6): Results Effect of RAD for (4, 8, 12, and 16) day on ALT in female Rats in compered with control group

ALT (U / L)		
Treated groups Periods	Control	RAD
4 days	110±1.15	67±2.65
8 days	109.17±1.36	62.33±6.03
12 days	111.17±3.11	83.33±12.58
16 days	112.57±2.72	93±7.21
p-value	0.737	0.005 *
LSD	7.342	14.994

The results of Table (7) indicate that there is a significant decrease ($p>0.05$) in radiation groups and control groups for AST level (108.67±3.21, 95.33±6.43, 133±2.65, 182.67±11.85, 198±4.36, 195±3.21, 190.7±4.78 and 192.1±5.97) respectively.

Table (7): Results of Effect of RAD (4, 8, 12, and 16) day on AST in female Rats in compered with control group

AST (U / L)		
Treated groups Periods	Control	RAD
4 days	198±4.36	108.67±3.21
8 days	195±3.21	95.33±6.43
12 days	190.7±4.78	133±2.65
16 days	192.1±5.97	182.67±11.85
p-value	0.706	0.0001 *
LSD	15.285	13.280

Discussion

The study reveals no significant difference in radiation groups and control groups (before and after weights) at different weights as present in table (1). Which female rats' exposure to radon gas source for different periods, the outcome not found significant change in body weight of female rats. Our study agreement with previous study such elsewhere, (**Xuexian Pei et al, 2015**) that showed no difference was found for the change of weight in mice that exposed radiation.

The study demonstrates that radon gas leads to a considerable drop in catalase levels, as shown in Table (2). The stochastic nature of radioactive decay dictates that certain atoms within a sample persist while others of the identical type undergo decay. This distinction is not made based on any attribute variation among the atoms, but rather on probabilities. Consequently, it implies that only a fraction of indistinguishable atoms will have undergone decay at any specific moment. Reactive oxygen species (ROS) have dual functions, both in normal physiological processes and in abnormal pathological processes, not just in the uterus and ovaries but also in the process of placentation, as previously discussed (**Mendes et al., 2019**).

The study demonstrates that radon gas induces a notable alteration in glutathione levels, as seen in table (3). Glutathione peroxidase (GPx) is crucial for eliminating hydroxyl radicals through the action of t-GSH.

Research concordance with prior investigations, including (**Yusuke et al.2020**). The results revealed that mice's livers contained much more t-GSH after being exposed to radiation (thoron). However, this shift was just temporary, as the liver's t-GSH contents significantly dropped after two or four days of thoron inhalation.

The study corroborated findings from a prior study by (**Kojima et al.2019**). A study has demonstrated that serum LDH levels increased in patients with autoimmune disorders who had radiation. Additionally, there is a consensus with (**Augoff et al., 2015**). Research has demonstrated that the serum concentration of LDH is elevated in cases of ovarian cancer. The metabolic alterations in rapidly proliferating cancer cells are strongly linked to the heightened absorption of glucose and aberrant functioning of lactate dehydrogenase (LDH). This enzyme controls the conversion of glucose into lactic acid. Elevated LDH levels in cancer patients are frequently observed in serum and are associated with unfavorable clinical prognosis and resistance to treatment (**Forkasiewicz et al., 2020**).

The study indicates that radon gas causes diminution significant in superoxide dismutase level as presented in table (4). High effects of radon gas that led to decrease SOD level was at concentration 840.73 Bq/m^3 of 16 days.

The investigation corroborated the findings of a prior study conducted by (**Kataoka et al., 2021**). A study demonstrated that inhaling a high dose of radon (20 kBq/m^3) for a duration of 10 days resulted in a reduction in Mn-SOD levels in the kidney and small intestine. The reduction in Mn-SOD levels after inhaling radon for 10 days could lead to excessive oxidative stress. As a result, other antioxidants like catalase and glutathione may make up for the lack of Mn-SOD and counteract the oxidative stress. Elevated levels of reactive oxygen species (ROS) lead to oxidative stress. The induction of oxidative stress is caused by an increase in free radicals such as $O^{2-,}$ OH^-, and H_2O_2, NO, or a decrease in the concentration of superoxide dismutase (SOD), glutathione peroxidases (GPs), and catalase, which are antioxidant enzymes that protect against oxidative damage. Sperm capacitation is an essential process for acquiring fertilizing ability, and reactive oxygen species (ROS) such as H_2O_2, superoxide, nitrogen oxide (NO), and superoxide anion radical play a role in this operation (**Wagner et al. 2018**).

The study indicates that radon gas causes diminution significant in ALT level as compared with control groups as presented in table (6). High effects of radon gas that led to decrease ALT level were at concentration 714.62 Bq/m^3 of 8 days. The study agreement with previous studies, (**Kanzaki et al.,2017**). Demonstrated that the results of the study also suggested that radon inhalation at a concentration of 2000 Bq/m^3 causes liver damage and led to decrease AST and ALT level.

The study indicates that radon gas causes diminution significant in AST level as presented in table (7). High effects of radon gas that led to decrease AST level were at concentration 714.62 Bq/m^3 of 8 days. The stochastic nature of radioactive decay enables us to determine the likelihood of an atom's survival at a given time. After reaching its half-life, there remains a probability that an atom within a sample has not yet undergone decay. After undergoing eight half-lives, there is a possibility that an atom has not yet decayed. After eight half-lives, it is quite probable that only a fraction of the initial atoms will still be present. The stochastic nature of decay implies that it is impossible to determine precisely which atoms are still present (**Abojassim et al., 2021**). Consequently, may be the radon gas cause rapture of hepatocytes this led to release of two blood stream.

Conclusion

Radon gas does not impact the body weight of female rats, but it significantly affects the levels of some antioxidants and liver enzymes. Prolonged or permanent exposure to high levels of radon gas might cause alterations in the levels of some liver enzymes and antioxidant enzymes. Hence, our study unequivocally demonstrates that exposure to elevated quantities of radon gas has a detrimental impact on liver functions.

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