DETOXIFICATION OF SEWAGE WATER HAZARDS ON RABBITS' HEALTH

Shimaa S. Sayed [(1)]; Khaled A. Soliman [(2)]; Mary G. Abdel-Malak [(3)] and Asmaa M. Ali [(2)]
1) Faculty of Graduate Studies and Environmental Research, Ain Shams University. 2) Department of Genetics, Faculty of Agriculture, Ain Shams University.3) Artificial Insemination and Embryo transfer Department, Animal Reproduction Research Institute, Agriculture Research Center, Giza, Egypt.
Email: shimaaali.samir.2840.std@iesr.asu.edu.eg
shimaa.samir.5095@gmail.com

ABSTRACT

This study was carried out to evaluate the kidney and liver functions as well as lipid profile in New Zealand rabbits fed on a diet containing contaminated plants grown through sewage water. Moreover, the beneficial effects of Propolis as a natural antioxidant for detoxification of sewage water hazards on rabbits' health was also studied. Nine male rabbits were randomly assigned into three experimental groups in which three rabbits were reared on sewage water and a basal plant diet grown in a pond containing sewage water for 14 days and were assigned as group 1 (G1). At the end of the experimental period blood samples were collected from the rabbits; centrifuged to separate their sera. The residual six rabbits were subdivided into two groups, three rabbits each. Group 2 (G 2) was reared on tap water and fed on a basal diet containing alfalfa for 35 days. Group 3 (G 3) was reared on tap water and fed on a basal diet containing alfalfa and Propolis for 35 days. At the end of the experiment period, blood samples were collected, and the sera were kept at -20°C for biochemical assay. Liver function (AST, ALT, ALP), kidney function (BU, Cr) and lipid profile (TC, TG, HDL, LDL) were investigated. Results showed that the AST, ALT, and ALP were within the normal values at the beginning of experiment. At the end of the 14 days intake, the liver enzymes significantly ($p \leq 0.01$) increased while, the results in the group (2) indicated that the AST, ALT, and ALP decreased, at the end of the experimental period (35 days from the beginning of the experiment). Regarding liver enzymes in group (3), the values were the lowest at the end of experimental

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periods (35 days). The BU and Cr in the group (1) the kidney indices reached the highest. For group (2), the BU and Cr level lowered significantly ($p \leq 0.01$). However, group (3) the urea and creatinine reached the lowest value after 35 days. The concentrations of TC, TG, and LDL after one day were significantly ($p \leq 0.01$) increased. Meanwhile, HDL was lowered significantly ($P \leq 0.01$) after 14 days. Results of groups (2 and 3) the value of TC, TG. d LDL were significantly decreased ($p \leq 0.01$) at the end of experiment. While the level of HDL reached significantly to the highest value at the end of experiment. This study concluded that using contaminated plants grown through sewage water as a diet has adverse effects on animal and human health. Moreover, Propolis has beneficial effect as a natural antioxidant for detoxification of sewage water hazards on rabbits and human' health.

Keywords: Sewage water, Rabbits, Propolis, Kidney and Liver functions, Lipid profile.

INTRODUCTION

Water is crucial to human and animal life. Water is vital to facilitate numerous functions of the body like digestion, metabolism, and elimination of waste **(Guyton and Hall 2016).** Sewage pollution is considered one of the foremost pollution issues that threaten human health at the international level. Pollution will adversely influence water resources. Major harmful water pollutants embody organic matter and maladies inflicting organisms from waste discharges **(Corcoran *et al.*, 2010).**

Accumulation of heavy metals in the environment can pose a potential risk to living organisms. Ingestion of leafy vegetables, containing heavy metals, is one of the main routes through which these elements enter the human body. The bio-assimilation of Pb and Zn in the blood, essential organs, and bones depicted the serious health risks associated with consuming the metal-contaminated vegetable (**Hussain *et al.*, 2021).**

Urbanization and rapid industrialization, together with the long-term application of substantial amounts of agrochemicals and the use of untreated wastewater for irrigation has

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resulted in a build-up of toxic heavy metals in soil, water, air, and ultimately in food crops **(Jiang *et al.*, 2019).** Accumulation of heavy metals in vegetables cultivated near industrial and peri-urban areas are causing serious health hazards**.** The wastewater treatment plants (WWTP) effluents also comprise microorganisms and excess nutrients, along with engineered nanomaterials, microplastic, metals, pharmaceutically active compounds, organic pollutants, endocrine disrupting chemicals, and a plethora of other compounds **(Mehdi *et al.*, 2021).**

Propolis (PRO) is a complex mixture of resinous, gummy, and balsamic substances collected by bees from plant buds, flowers, and exudates (**AL-Kahtani *et al.*, 2022).** It has been reported that PRO contains more than 180 volatile compounds, polyphenols (**Bhargava *et al.*, 2021).** The primary polyphenols in PRO are flavonoids and phenolic acids, which have antioxidant, immunostimulant and antimicrobial properties (**Hashem *et al.*, 2017).** It has been reported that PRO supplementation improves cecum morphology and reduces the presence of *Escherichia coli* and *Salmonella spp*. in the cecum of growing rabbits (**Al-Homidan *et al.*, 2022).** For these reasons, PRO is widely used in popular medicine and apitherapy, with extensive use in food and beverages to improve health and prevent diseases **(Toreti *et al.*, 2013)**

Therefore, this study was conducted to alleviate the adverse effects of sewage water on rabbits' health using diets containing plants or alfalfa or propolis as antioxidants and antitoxic nutrients. Lipids profile, kidney and liver functions were evaluated as indicators of the general health of male rabbits in the separate groups.

MATERIALS AND METHODS

1. Materials and experimental animals

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This experiment was conducted on liquid sewage sludge collected from the Arab Abo-Saeed wastewater treatment plant (WWTP), in Helwan City, Cairo Governorate. The treatment plant receives wastewater from municipal as well as industrial activities. The selected plant was cultivated in a pond containing sewage water and the capacity of each tank was 250 liters (H) 100x (W) 50 × (L) 50, filled with only 200 L of the studied sludge effluents. Alfalfa (*Medicago sativa* L.), yellow corn, soybean meal, wheat bran, and molasses were obtained from Giza-Egypt. Nine native healthy male New Zealand rabbits aged approximately four weeks old and weighed 1.2-1.3 kg purchased from Giza-Egypt. All animals were acclimatized for two weeks before starting the experiment and were provided with pelleted food and tap water ad libitum during this period. They were kept in iron cages under optimum temperature (24±2°C) and hygienic conditions with observation of light and dark cycles of 12 hours in the animal facility at the National Research Center, Dokki, Giza, Egypt.

2. Experimental design:

Nine rabbits were randomly assigned into three experimental groups. They were reared on sewage water and fed on a basal diet containing plant grown in a pond containing sewage water for 14 days during an experimental period. At the end of this period, the blood samples were collected from three rabbits and centrifuged to separate their sera which were stored at −20°C for biochemical parameters and they considered as group 1 (G1). The residual six rabbits were re divided into two groups' three rabbits for each. Group 2 (G 2) was reared on tap water and fed on a basal diet containing alfalfa till the end of experiment (35 days), and Group 3 (G 3) was reared on tap water and fed on a basal diet containing alfalfa and propolis for 35 days. At the end of the

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experiment, the blood samples were collected, and the sera were kept at -20°C until their analysis for biochemical assay as previously mentioned.

3. Feeding and management:

Diet ingredients are shown in Table (1) as iso-nitrogenous, and iso-fibrous according to the nutrient requirements of **NRC (1977), as well as de Blas and Weiseman (2010).**

Table (1): Diet ingredients (%) as provided to different groups of rabbits**:**

INGREDIENTS	GROUP (1)	GROUP (2)	GROUP (3)
plants	25	-----	----
Alfalfa	-----	25	25
Propolis	------	----	10
Yellow corn	25	25	15
Soybean meal (44%CP)	25	25	25
Wheat bran	15	15	15
Molasses	4.0	4.0	4.0
DL-Methionine	0.5	0.5	0.5
L- Lysine	0.5	0.5	0.5
Vita. &Min. mix	4.0	4.0	4.0
Salt	1.0	1.0	1.0
Total	100	100	100
Water	Sewage water	Tap water	Tap water

G1 rabbits were reared on sewage water and fed on a basal diet of contaminated plants for 14 days**.**

G2 rabbits were reared on tap water and fed on a basal diet containing alfalfa till 35 days**.**

G3 rabbits were reared on tap water and fed on a basal diet containing alfalfa and propolis till 35 days**.**

4. Blood sampling and analysis:

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Blood samples were collected from three groups of rabbits by withdrawing from the orbital plexus in vacationer 3 ml then samples were centrifuged at 3000 rpm/ 10 min to separate their sera which were stored at −20°C for biochemical parameters.

Liver function as alanine (ALT) and aspartate (AST) transaminases was determined according to the method described by Yap and Aw, (2010). Alkaline phosphates activity (ALP) was determined using modified kinetic method of Belfied and Goldberg (1971).

Kidney function as creatinine (Cr) and urea (BU) were quantified according to the method described by **Patton and Crouch (1977).** Triglycerides (TG), total cholesterol (TC), HDL and (LDL) were determined according to the method of **Fossati and Principe (1982)** and **Allain *et al.* (1974),** respectively.

The kits used for liver and kidney functions were obtained from DIMOND DIAGNOSTICS® while kits used for detection of lipid profile obtained from BIOMED PHARMA® made in United States.

5. Statistical analysis:

Data were analyzed using the ANOVA procedure **(SAS, 2004).** The least significant difference test (LSD) was used at ($p \leq 0.05$) level to compare between means. Data was presented as mean ± SE. Data was considered significant at $p \leq 0.01$.

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RESULTS AND DISCUSSION

Effect of sewage water and propolis on liver functions:

The liver is the principal detoxifying organ, and the effects of consistent pollutant exposure can be evident in its cellular and tissue level **(Minarik *et al.* 2014).** It is the principal organ storing heavy metals **(Ardeshir *et al.* 2017).** Results in table (2) illustrated that the AST, ALT, and ALP at the beginning of the experiment were 8.43±0.21, 12.66±0.52, and 11.58±0.46 U/L, respectively. These elevated values might be due to by the rabbits being fed a healthy diet and drinking clean water. After seven and fourteen days the liver functions were significantly increased from 21.27±2.11, 29.14±0.99, and 35.85±3.03 U/L to 47.99±3.29, 60.85±2.71, and 75.30±4.59 U/L, respectively. The increased activity of hepatic enzymes in G1 may be due to accumulation of heavy metals in liver from dietary intake of contaminated plant with sewage water **(Miclean *et al.*, 2019)** which combine with different enzymes and proteins **(Duruibe *et al.*, 2007)** causing oxidative stress (**Aladaileh *et al.*, 2020)** which produce reactive oxygen species (ROS) leading to reduce cell protection **(Maria *et al.*, 2009).**

Table (2): Activities of the liver enzymes (U/L) in G1 rabbits that fed on contaminated plants and sewage water during the whole experimental period entire.

DAYS	AST	ALT	ALP
Control	8.43±0.21 ^{c}	12.66±0.52 ^{c}	11.58±0.46 ^{c}
1 Day	11.31±1.06 ^{c}	15.23±1.27 ^{c}	15.51±2.56 ^{c}
7 Days	21.27±2.11 ^{b}	29.14±0.99 ^{b}	35.85±3.03 ^{b}
14 Days	47.99±3.29 ^{a}	60.85±2.71 ^{a}	75.30±4.59 ^{a}
F value	237.24	575.18	252.57
p value	<0.0001	<0.0001	<0.0001
LSD	3.82	3.01	5.99

Means with different letters in the same column are significantly different at ($p \leq 0.01$).

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Table (3) reveals that the AST, ALT, and ALP significantly decreased (P≤ 0.01) from 29.20±0.95, 36.58±0.64, and 51.33±1.17 U\L after 21 days to 21.47±0.78, 24.77±0.95, and 24.20±1.45 U/L respectively in G 2, at the end of the experimental period (35 days). This gradual decrease of hepatic enzymes activity compared to the control (after 14 days of contaminated diet intake) may be due to feeding on healthy diet containing alfalfa. Alfalfa contains vitamins, amino acids, sugars, proteins, minerals, and other nutrients, these components were scavenging the free radicals **(Salih and Azeez, 2019)** leading to hepatic function improvement.

Table (3): Liver enzymes (U/L) in G2 rabbits fed on healthy diet and provided water during the whole experimental period:

DAYS	AST	ALT	ALP
Control	47.99±3.29 [a]	60.85±2.71 [a]	75.30±4.95 [a]
21 Days	29.20±0.95 [b]	36.58±0.64 b	51.33±1.17 [b]
28 Days	21.47±1.20 [c]	28.15±0.99 [c]	33.27±2.35 [c]
35 Days	21.47±0.78 [d]	24.77±0.95 [d]	24.20±1.45 [d]
F value	174.32	336.32	181.97
p value	<0.0001	<0.0001	<0.0001
LSD	3.49	2.90	5.45

Means with different letters in the same column are significantly different at ($p \leq 0.01$).

Results in Table (4) revealed that at the end of the experimental period, levels of AST, ALT, and ALP in G3 were significantly lowered than the control group and reached 16.63±1.11, 21.51±1.37, and 22.40±2.10 U/L respectively. This significant decrease may be due to feeding rabbits on healthy diet containing alfalfa and propolis (a natural antioxidant). It has been reported that PRO contains more than 180 volatile compounds, mainly polyphenols **(Bhargava *et al.*, 2021).** The primary polyphenols in PRO are flavonoids and phenolic acids **(Volpi, 2004)**, which have antioxidant, immunostimulant, and antimicrobial properties **(Hashem *et al.*, 2017)** which

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Lead to improve the hepatic function by scavenging ROS **(Nassar *et al*., 2012).** In addition, the significant improvement may be due to synergistic action of propolis and healthy diet ingredient which can detoxify the hazards effect of contaminated diet of sewage water. However, **Al-Homidan *et al*. (2022)** reported that PRO supplementation through the basal diet has no positive effect on rabbit performance.

Table (4): Liver enzymes (U/L) in G3 rabbits fed on clean water, healthy diet and propolis during the experimental period entire:

DAYS	AST	ALT	ALP
Control	47.99±3.29 [a]	60.85±2.71 [a]	75.30±4.95 [a]
21 Days	35.30±1.08 [b]	30.43±0.69 [b]	49.00±2.41 [b]
28 Days	29.43±0.91 [c]	25.67±1.11 [c]	28.23±2.61 c
35 Days	16.63±1.11 [d]	21.51±1.37 [d]	22.40±2.10 [d]
F value	136.32	236.29	126.51
p value	<0.0001	<0.0001	<0.0001
LSD	3.53	3.11	6.06

Means with different letters in the same column are significantly different at ($p \leq 0.01$).

Effect of sewage water and propolis on rabbits' kidney functions:

Table (5) shows the effect of sewage water and contaminated plant in the basal diet on kidney functions as indicated by the concentrations of BU and Cr for 14 days intake. The BU and Cr at the start of the experimental were 51.43±0.61 and 2.11±0.09 mg/dl, respectively. After seven days the values were increased significantly ($p \leq 0.01$) to 74.00±2.95 and 2.95±0.12 mg/dl, respectively. Kidney functions reached the highest level as compared to control being 86.13±3.59 and 3.63±0.15 mg/dl, respectively. This increase might be due to the accumulation of heavy metals in the kidney especially cadmium in the renal cortex leads to proximal tubular damage, deplete endogenous glutathione, and decrease the relative activities of certain enzymes

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which may lead to increased oxidative renal stress **(Wang *et al.*, 2012).** Oxidative stress could be the reason for renal damage and thereby an increment in serum creatinine level **(Kostial, 1986; Fox, 1988).**

Table (5): Activities of the Kidney enzymes (mg\dl) in G1 rabbits fed on contaminated plant and sewage water for 14 days.

DAYS	UREA	CREATININE
Control	51.43±0.61 ^{c}	2.11±0.09 ^{c}
1 Day	54.47±0.78 ^{c}	2.31±0.07 ^{c}
7 Days	74.00±2.95 ^{b}	2.95±0.12 ^{b}
14 Days	86.13±3.59 ^{a}	3.63±0.15 ^{a}
F value	144.24	115.32
p value	<0.0001	<0.0001
LSD	4.47	0.21

Means with different letters in the same column are significantly different at ($P \leq 0.01$).

The results of urea and creatinine in G2 were recorded in Table (6). UB and CR gradually decreased significantly ($p \leq 0.01$) till reached to the lowest value as compared to the control being it 49.13±0.95 and 2.19±0.01 mg/dl, respectively. The gradual decrease it might be due to feeding on the healthy diet containing alfalfa and other nutrients which scavenging the free radicals. **(Salih and Azeez, 2019)** leading to gradual improvement in kidney function.

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Table (6): Activities of the Kidney enzymes (mg\dl) in G2 rabbits fed on healthy diet and provided tap water during the experimental period:

DAYS	UREA	CREATININE
Control	86.13±3.59 [a]	3.63±0.15 [a]
21 Days	69.43±1.06 [b]	2.91±0.04 [b]
28 Days	58.20±1.00 [c]	2.36±0.04 [c]
35 Days	49.13±0.95 [d]	2.19±0.01 [d]
F value	191.38	195.43
p value	<0.0001	<0.0001
LSD	3.76	0.15

Means with different letters in the same column are significantly different at ($p \leq 0.01$).

Table (7) pointed out that Bu and Cr reached to the lowest value after 35 days if compared with control being23.94±0.50 and 2.04±0.06 mg/dl, respectively vs 86.13±3.59 and 3.63±0.15mg/dl, respectively. This strong decrease may be due to the synergistic action of propolis, alfalfa and diet nutrients as strong antioxidants and free radical scavengers that ameliorated the hepato-renal toxicity in rabbits **(EL-Hallawany and EL-Metwally, 2017).**

Table (7): Activities of the Kidney enzymes (mg\dl) in G3 rabbits provided on clean water,

DAYS	**UREA**	**CREATININE**
Control	86.13±3.59 [a]	3.63±0.15 [a]
21 Days	63.10±2.65 [b]	2.81±0.02 [b]
28 Days	56.27±1.15 [c]	2.31±0.03 c
35 Days	23.94±0.50 [d]	2.04±0.06 [d]
F value	162.73	219.65
p value	<0.0001	<0.0001
LSD	4.37	0.15

healthy diet and propolis during the experimental period:

Means with different letters in the same column are significantly different at ($p \leq 0.01$).

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Effect of sewage water and propolis on lipid profile in rabbits.

Table (8) revealed that the lipid profile in G1gradually increased significantly in TC, TG, and LDL after one day 187.90±2.62, 120.10±2.21, and 111.47±2.40 mg/dl, after 14 days being 325.40±5.40, 287.10±15.8, and 239.93±3.41 mg/dl, respectively. While HDL was lowered after one day was 77.50±2.52 mg/dl to 27.77±2.25mg/dl after 14 days. These results corroborate those from liver and kidney functions. The obtained results might be due to feeding rabbits a basal diet containing contaminated plants and drinking sewage water which might contain heavy metals. It is well known that lipid peroxides are produced through a free radical chain process of autoxidation of lipids containing polyunsaturated fatty acids, their formation by ROS action has been implicated in the pathogenesis of various diseases. The underlying mechanisms in disease development are different. In the case of atherosclerosis and cardiovascular complications, the primary risk factor is endothelial dysfunction, which is associated with LDL oxidation **(Chua, 2013).**

`Table (8): Lipid Profile (mg\dl) in G1 rabbits that fed on contaminated plant and provided sewage water during the experimental period:

DAYS	TC	TG	HDL	LDL
Control	110.67±2.08^{d}	117.27±3.67^{d}	90.00±5.57^{a}	83.27±5.54 ^{d}
1 Day	187.90±2.62^{c}	120.10±2.21^{c}	77.50±2.52 ^{b}	111.47±2.40 ^{c}
7 Day	283.27±11.1^{b}	228.10±2.67^{b}	51.90±3.18^{c}	185.80±13.7^{b}
14 Day	325.40±5.40^{a}	287.10±15.8^{a}	27.77±2.25^{d}	239.93±3.41^{a}
F value	203.14	90.46	174.88	258.20
p value	<0.0001	<0.0001	<0.0001	<0.0001
LSD	12.01	15.57	6.83	14.45

Means with different letters in the same column are significantly different at ($p \leq 0.01$).
TC: cholesterol **– TG:** triglycerides – **HDL:** High Density Lipoprotein – **LDL:** Low Density Lipoprotein.

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The results in Table (9) indicated that the TC, TG, and LDL were decreased significantly ($p \leq 0.01$) in G2 at the end of the experimental period (35 days) to 200.60±5.76, 195.17±4.77, and 102.00±4.20 mg/dl, respectively as compared to the control. In addition, the increase in HDL was 80.67±2.08 mg/dl in (G 2) which fed on healthy diet as well as drank tap water. These decreased values may be due to the healthy diet which contained the nutrition values and a natural antioxidant which remove free radicals, increase the body's antioxidants, and enhance immunity in a livestock **(Xiong *et al.*, 2012).** It also resulted in the reduction in the accumulation of cholesterol in the aorta tissue and reduction in the oxidation of LDL cholesterol (**Xia *et al.* 2003).**

Table (9): Lipid Profile (mg\dl) in G2 rabbits fed on fed on healthy diet and drank during the experimental period:

DAYS	TC	TG	HDL	LDL
Control	325.40±5.40[a]	287.10±15.8 [a]	27.77±2.25 d	239.93±3.41 a
21 Day	275.33±4.70[b]	242.57±2.65[b]	41.20±3.68 c	185.60±1.40 [b]
28 Day	245.73±4.19[c]	205.37±1.86[c]	62.77±2.93[b]	141.67±1.92 [c]
35 Day	200.60±5.76[d]	195.17±4.77[c]	80.67±2.08[a]	102.00±4.20[d]
F value	231.56	74.15	207.91	1206.84
p value	<0.0001	<0.0001	<0.0001	<0.0001
LSD	9.51	15.79	5.28	5.56

Means with different letters in the same column are significantly different at ($p \leq 0.01$).

TC:cholesterol **– TG:** triglycerides – **HDL:** High Density Lipoprotein – **LDL:** Low Density Lipoprotein.

X Results from Table (10) showed that the lipid profile as TC, TG, and LDL were reached the lower significantly value at the end of experiment While the HDL increased by 93.30±1.57 mg/dl, These results indicated the synergistic action of propolis, alfalfa and other nutritional compounds as a potent antioxidants in healthy diet could improve the lipid profile by

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peroxidation of lipids (**Kurek-Gorecka *et al.*, 2014).** Also, propolis may prevent the rise of triglycerides (TG) as well as low and very low-density lipoprotein cholesterol (LDL-c and VLDL-c), (**Ichi *et al.*, 2009).**

Table (10): Activities of the Lipid Profile (mg\dl) in G3 rabbits that fed on clean water, healthy diet and propolis during the experimental period:

DAYS	TC	TG	HDL	LDL
Control	325.40±5.40 [a]	287.10±15.8 [a]	27.77±2.25 [d]	239.93±3.41[a]
21 Day	257.97±2.65 [b]	232.77±2.54 [b]	39.90±2.86 [c]	168.80±2.71[b]
28 Day	219.60±1.91 [c]	198.23±2.65 [c]	65.53±1.96 [b]	114.70±1.04[c]
35 Day	180.23±2.48 [d]	186.77±4.21 d	93.30±1.57 a	78.67±2.21 d
F value	692.95	87.24	518.63	2371.89
p value	<0.0001	<0.0001	<0.0001	<0.0001
LSD	6.52	15.73	4.16	2.31

Means with different letters in the same column are significantly different at ($p \leq 0.01$).

TC: Cholesterol **– TG:** triglycerides – **HDL:** High Density Lipoprotein – **LDL:** Low Density Lipoprotein.

CONCLUSION

This study concluded that using contaminated plants grown through sewage water as a diet has adverse effect on animal and human health. Moreover, Propolis has beneficial effect as a natural antioxidant for detoxification of sewage water hazards on rabbits and human' health. So, the present study recommended that the plants must be not irrigated by sewage water and the use of herbal products for the detoxification of heavy metals can be one of the practical and valuable treatment strategies.

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أخطار سمية مياه الصرف الصحي على صحة الأرانب

شيماء سمير سيد [1]– خالد عبد العزيز سليمان[2]– ماري جاد عبد الملك [3]– أسماء محمد علي [2]

1) كلية الدراسات العليا وبحوث البيئة، جامعة عين شمس 2) قسم الوراثة، كلية الزراعة، جامعة عين شمس 3) قسم التلقيح الصناعي ونقل الأجنة، معهد بحوث التناسل الحيواني، مركز البحوث الزراعية – الجيزة مصر.

المستخلص

أجريت هذه الدراسة لتقييم وظائف الكلى والكبد بالإضافة إلى محتوى الدهون في تسعة أرانب تتغذى على نظام غذائي صحي يحتوي على نباتات ملوثة تزرع من خلال مياه الصرف الصحي وتم تناوله مياه الصرف الصحي (المجموعة 1). بعد أربعة عشر يومًا، تم جمع عينات الدم من ثلاثة أرانب. بينما تم تقسيم الأرانب الستة إلى مجموعتين. المجموعة الثانية كانت تتغذى على نظام غذائي صحي وتشرب ماء الصنبور. تم تغذية المجموعة (3) بنظام غذائي صحي يحتوي على البروبوليس وماء الصنبور. أظهرت النتائج أن AST وALP وALK كانت طبيعية في وقت الصفر. بعد 14 يومًا، زادت وظائف الكبد بشكل ملحوظ في المجموعة (1). بينما انخفضت AST وALP وALK بشكل ملحوظ في نهاية الفترة التجريبية (35 يومًا) في المجموعة (2). النتائج في المجموعة (3) كانت أقل القيم في نهاية الفترات التجريبية. تم تأكيد نفس النتائج مع وظائف الكلى (اليوريا والكرياتينين) ومجموعة الدهون (الكوليسترول والدهون الثلاثية وLDL) في المجموعات الثلاث المذكورة أعلاه. ومع ذلك، انخفض HDL بشكل ملحوظ بعد يوم واحد حتى 14 يومًا في المجموعة (1). بينما في المجموعتين (2 و3) زادت المستويات معنوياً حتى وصلت إلى أعلى مستوى في نهاية التجربة. تشير النتائج التي توصلنا إليها إلى الفوائد المحتملة لمادة البروبوليس على صحة الإنسان حيث يبدو أن استخدام هذه المادة لها آثار إيجابية على حالة الأكسدة وتحسين وظائف الكبد والكلى بالإضافة إلى الدهون التي تساهم في تقليل أخطار الإصابة بأمراض القلب والأوعية الدموية وغيرها من الأمراض.

الكلمات المفتاحية: مياه الصرف الصحي، الأرانب، البروبوليس، وظائف الكلى والكبد , الدهون.