Egyptian Journal of Zoology (EJZ) p-ISSN: 1110-6344
Publisher: The Zoological Society of A. R. Egypt e-ISSN: 2682-3160
DOI: 10.21608/ejz.2024.291908.1115

RESEARCH ARTICLE

BRAIN ALTERATIONS OF THE CATTLE EGRET (*BUBULCUS IBIS*) INDUCED BY AIR AND SOIL POLLUTIONS AT SHARKIA GOVERNORATE, EGYPT

Zeinab Z. Khater*; Safaa E. Nassar

Zoology Department, Faculty of Science, Zagazig University, Sharkia, Egypt

Article History:
Received: 22 May 2024
Accepted: 10 August 2024

Published Online:
21 August 2024

Keywords:
Biomonitoring
Cattle egret
Heavy metals
Pollutions
Ultrastructural changes

***Correspondence:**
Zeinab Z. Khater
Zoology Department
Faculty of Science
Zagazig University
Sharkia, Egypt
E-mail:
z_sci.egy@zu.edu.eg

ABSTRACT

One of the main health problems is air quality, which has recently been faced in the urban regions. This study aimed to evaluate the quality of air and soil at Zagazig City, Sharkia governorate, Egypt, and their effects on the nervous state of the cattle egret (*Bubulcus ibis*) brain. Implementing continuous monitoring of physical and chemical air pollutants (CO, NO, NO_2, O_3, SO_2, NH_3, and particulate matters “$PM_{2.5}$ and PM_{10}”) was performed in Zagazig City with the help of Google Earth of urban air quality during summer 2022 and winter 2023. The fine dust, soil, and the cattle egrets’ brain samples were collected from three localities in the city (El-Henawy, El-Ahrar, and University areas)' for measuring heavy metals concentrations (mercury, lead, arsenic, cadmium, selenium, and chromium). According to the obtained results, the air quality parameters were in a good state when compared with World Health Organization (WHO) standards. The physicochemical properties of the soil samples were within the safe limit that was recommended by the international guidelines. The soil samples and cattle egrets’ brains of El-Henawy area achieved the highest heavy metal concentration. Investigations of such heavy metals indicated health risks in the ultrastructure of cattle egrets’ brain tissues related to air and soil pollutions. The study concluded that potential harmful impacts on the cattle egrets’ brain tissues might be avoided if the soil and air were adequately treated, and by minimizing the usage of heavy metals as much as possible.

INTRODUCTION

Recently, pollution in cities has emerged and grown quickly due to the development of modern technologies and population growth. The country's metropolitan environment is experiencing a decline in air quality due to several significant factors brought on by the rapid population growth in urban areas[1]. These include water inequality, air quality deterioration, land degradation, infra-structure challenges resulting from high construction levels, fast industrialization, factory growth, and rising living standards worldwide[1]. Nowadays, many cities have set up a comprehensive environmental quality monitoring system that measures six factors: wind direction, noise, temperature and humidity, light, negative oxygen ions, air quality index (AQI), particulate matters “$PM_{2.5}$ and PM_{10}”, SO_2, NO_2, CO, and O_3. Real-time monitoring of air quality is especially focused on $PM_{2.5}$ and PM_{10}, as respirable PM that are known to be carcinogens. People may avoid outdoor activities because of urban air pollution, which also raises the prevalence of cancer[2]. Exposure to various air contaminants impacts all the ecological systems comprising wildlife and humans living in such a polluted environment[3]. The environmental quality can be monitored by the population status, function of organisms, or groups of species, which are used as bioindicators. Changes in the physiology, behavior, and population status of such creatures are utilized to predict the presence of any environmental hazard within the ecological ecosystem. Resident wild birds are valuable indicators of trace element limits in the environment, as they are widely dispersed, have a wide variety of food resources, are sensitive to various environmental poisons, and live in the same habitat their entire lives[4]. Birds as bioindicators can give a good image of the potential hazards to humans rather than determining the physical factors of the ecosystem itself[5]. Many airborne trace elements are biologically reactive substances that interact with various biochemical and metabolic processes in living creatures[6]. They cause poisonous impacts by changing the activity of various enzymes, damaging the antioxidant reactions, and raising free radicals[7]. Numerous investigations have been carried out to assess the accumulation of trace elements in biological samples such as feathers, eggs, brain, liver, and kidney[8]. Determining the accumulation of the trace elements and their concentration is not a sufficient tool to evaluate the potential hazards for the animal status, but it is necessary to estimate the impact of such contaminants on various physiological activities instead of their concentrations[9].

Cattle egret (*Bubulcus ibis*), a member of the Ardeidae family, is a resident wild bird that serves as omnivorous bird species feeding on some animals and edible refuse from garbage. They feed on a wide variety of vertebrates and invertebrates[10], and can accumulate pollutants through bio-magnifications and bioaccumulation[11]. The polluted soil is the essential origin for heavy metals, which are accumulated in the egret species through food[12]. Egyptian cattle egrets are widespread in farms, pastures, road sides, and nests in trees. The present study was conducted in Zagazig City and aimed to (1) determine the alterations in ultrastructure of cattle egrets' brains to assess air and soil pollutions with heavy metals in three different areas at Zagazig City, (2) compare the selected heavy metals between the three areas and in the biological samples (brain) during summer and winter seasons of 2022-2023.

MATERIAL AND METHODS

The study sites

The air, soil samples, and adult cattle egrets (*Bubulcus ibis*) were collected seasonally during summer 2022 and winter 2023 from Zagazig City, Sharkia governorate, Egypt (Latitudes 30° 32′ - 30° 40′ N, Longitudes 31° 28 ′ - 31° 32′ E). Three studied areas were selected site "I" (El-Henawy area), site "II" (El-Ahrar area), and site "III" (University area) as shown in Figure "1'.

Sampling technique of air quality data

Analysis and processing of air quality data were done with Google Earth of urban air quality. Air quality parameter indicator samples such as carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), PM_{10}, and $PM_{2.5}$ were collected in the early hours of the morning between 8:30 am to 9:00 am and 4:00 to 4:30 pm for the evening sampling of air quality parameters in each sampling day to ascertain the daily variation of some of the detected air pollutants level, as well as their rates of contaminating the stratosphere during summer 2022 and winter 2023 at Zagazig City, Sharkia governorate, Egypt.

Physicochemical parameters of the soil samples

Soil quality was estimated by measuring the physicochemical properties of the soil samples. Soil temperature was measured by a mercury (Hg) thermometer of 0 to 50°C range[13]. The pH value was determined by a glass electrode pH meter (Digital Mini-pH meter model 55, USA). In addition, moisture, pore space, chloride content, and alkalinity (calcium carbonate ($CaCO_3$) and bicarbonate (HCO_3) were calculated[14].

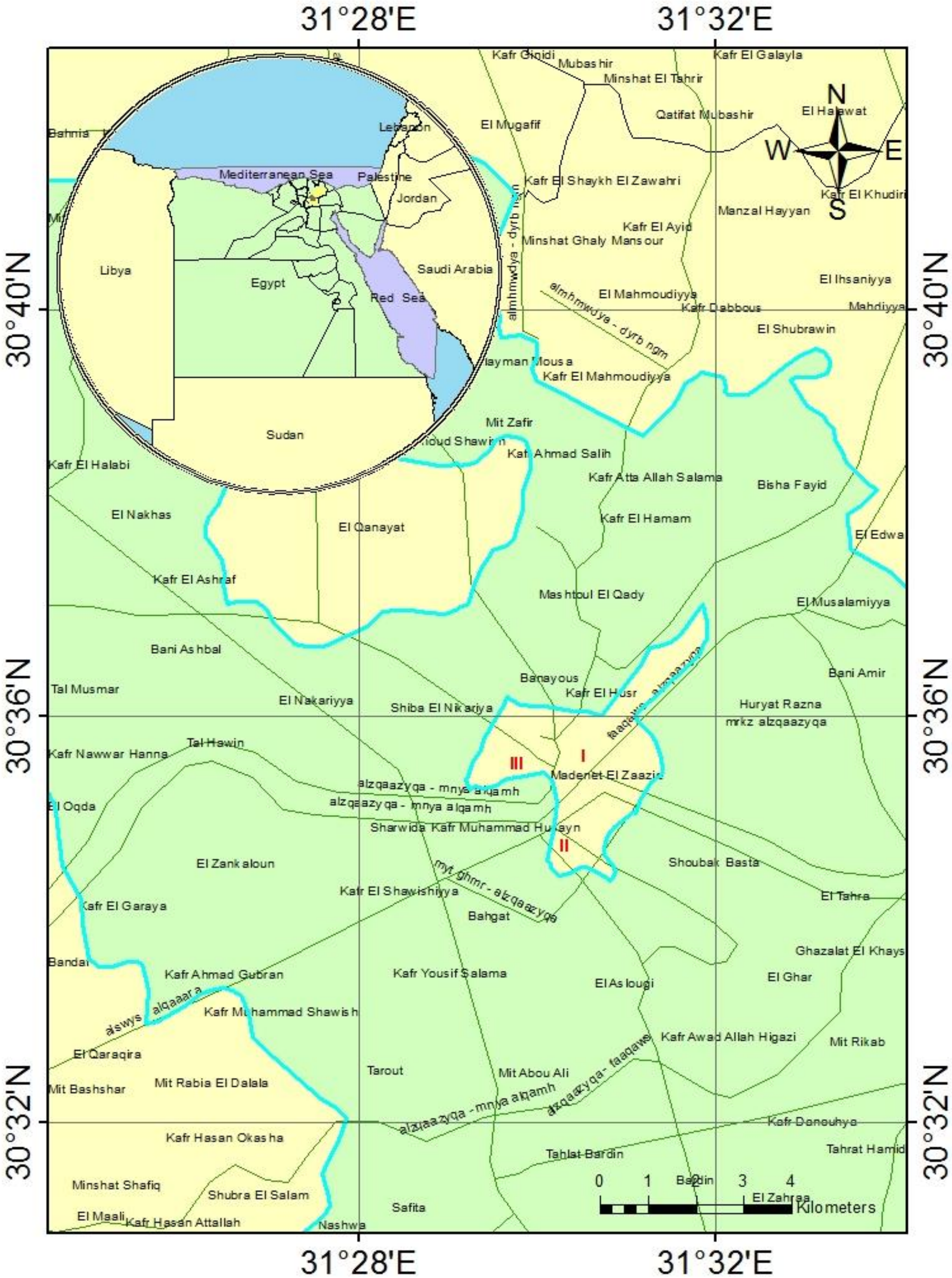

Figure 1: Map of the studied areas location in Sharkia governorate, Egypt, and its close-up view. Site "I": El-Henawy area; site "II": El-Ahrar area; site "III": University area.

Examined birds and sampling method

The cattle egret (*Bubulcus ibis*) belongs to family: Ardeidae (heron) and order: Pelecaniformes. It is a heron-shaped bird that is gregarious and lives near livestock, weighing about 0.5-0.7 kg and with a white body plumage in non-breeding season[15]. Forty-five adult alive cattle egrets (5 birds per month for each site) and the soil samples (48 samples from each site, 4 samples/week for a month) were caught and collected seasonally during summer 2022 and winter 2023 from each study site. In parallel, the sampling of deposited urban dust was performed outside residential houses (48 fine dust samples from each site, 4 samples/week for a month). The outdoor dust samples were taken by brush from a specified area of 1.0 m. The samples were sieved to remove plant particles or coarse particles.

The heavy metals: Hg, lead (Pb), arsenic (As), cadmium (Cd), selenium (Se), and chromium (Cr) were analyzed by atomic absorption spectrophotometer (Buck Scientific 210 VGP, Norwalk, CT, USA) in the fine dust, soil samples, and the brain of the cattle egrets, after acid digestion. The cattle egret birds were slaughtered, and the brain samples (cerebrum and cerebellum) were eviscerated from the skull, some samples were put in a fixative (glutaraldehyde) for ultrastructural studies and the others were stored in a freeze until utilized for trace element estimation[16].

Electron microscopy of the cattle egret's brain

The brain samples of cerebrum and cerebellum (90 specimens) were collected from the investigated cattle egret birds and undergone histological techniques and microtome slicing to prepare for electron microscopy examination (JEOL-JEM100CX transmission electron microscope at Faculty of Science, Zagazig University, Sharkia governorate, Egypt)[17].

Statistical analysis

The current results were presented as means ± their standard errors. Data were statistically analyzed using t-test (paired and unpaired) and one-way ANOVA and subsequent *post-hoc* multiple comparison with LSD multiple range test (software SPSS; version 14.0). The significance level was considered at $P<0.05$.

RESULTS AND DISCUSSION

Air quality of the studied areas

Air quality measurements of some different pollutant parameter indicators such as temperature, wind, humidity, pressure, visibility, CO, NO_2, O_3, SO_2, PM_{10}, and $PM_{2.5}$ were within the good state as compared with WHO standards. There were no variations between the temperature of summer and winter seasons from 2022-2023, and this may be attributed to climatic changes towards hot weather (Table 1). The great cause of air pollution is human activities such as smoke from plants in various factories, road traffic congestion by vehicles, construction of roads, gaseous, and PM wastes excreted from landfills; most of these air contaminants are absorbed and biologically cleaned up by plant species. The exponential rise the vehicle numbers and rapid increase of factories, uncontrolled wildfire burning individually, as well as the industrial areas burning, cause great amounts of gaseous wastes that cause air pollution and climatic changes; thereby, destroying the ozone layer because of excess dangerous pollutants of greenhouse gasses[18]. Air quality in Zagazig City is generally acceptable and good for individuals. These results were lesser than that of Oyareme and Osaji study[1], except for O_3 and SO_2, which is due to differences between locations and areas. However, the obtained results were in agreement with acceptable levels of other studies belonging to other different sites in Africa and outside Africa[2,18-20].

Physicochemical characteristics of the soil samples of the studied areas

The soil temperature relies on the energy ratio absorbed to energy loss[21]. The soil temperature is a very essential factor as it indicates its impact on the physical,

Table 1: Air quality parameters concentrations at Zagazig City, Sharkia governorate, Egypt, during summer 2022 and winter 2023.

	Climatic Changes	
	Summer	Winter
Temperature (°C)	30.03±1.27[a]	29.00±1.30[a]
Wind (km/hour)	13.43±1.04[a]	12.87±0.90[a]
Humidity (%)	45.13±3.23[a]	66.67±2.87[b]
Pressure (mb)	1009.25±0.40[a]	1020.53±0.59[b]
Visibility (km)	12.34±0.37[a]	11.97±0.39[a]
$PM_{2.5}$ (µg/m^3)	11.47±0.65[a]	18.16±1.96[b]
NO_2 (µg/m^3)	3.44±0.47[a]	13.66±1.46[b]
O_3 (µg/m^3)	109.96±2.70[a]	57.18±3.75[b]
SO_2 (µg/m^3)	4.23±0.20[a]	17.85±2.04[b]
CO (µg/m^3)	115.28±2.37[a]	186.47±8.25[b]
PM_{10} (µg/m^3)	18.35±1.43[a]	26.41±2.81[b]

Means with different letters in the same row are significant differences at $P<0.05$, unpaired T-Test (n = 180). PM: particulate matter

chemical, and biological processes involved in plant growth. The soil temperature varies with daytime, local climatic changes, and seasons[21]. The present study indicated that there is no change in values of soil temperature in the various examined samples (Table 2). The soil temperature in the tested areas varies from 20.5±0.5°C in winter to 34.5±0.5°C in summer. Soil moisture is the amount of water present in the soil. Pore space and moisture are very essential characteristics of the soil. Soil absorption of the essential elements depends on the moisture content and texture of the soil[21]. A soil type is responsible for the amount of water remaining in drained soil to field capacity and the accessible amount of it. High moisture content is due to de-aeration, decreased action of microbes, and the oxygen content of soil[22]. The highest soil moisture in summer was in site II, while the highest soil moisture in winter was in site III (Table 2). The present observations confirmed our previous findings regarding the soil moisture of the urban sites of Zagazig City during the summer season, except for El-Ahrar site (site II); this may be attributed to the nearest location between Kafr El-Ashraf Village and University Site, time of collection, and also to type o the agricultural soils[23]. Other studies recorded higher contents of soil moisture in different countries “Nigeria and India”, which may be attributed to the de-aeration, which bumped atmosphere in the soils, reduction of microbial activity, the oxygen value of the soil, and difference between geographical areas[24,25]. The soil pore space is the space filled with water and air. The raising in organic matter or clay content (fine textured soils) will increase the pore space in soils[26]. This may explain the differences in the pore spaces among the three tested sites in the current study. The current investigations indicated that the pH values of all examined soil samples were always on the alkaline side (Table 2). This observation agreed with those found by Soni[27] in Abohar City (India). Soil pH (alkalinity and acidity) plays the best effect on the availability of plant nutrients and the creature types that occur in the soil[28]. The pH value also affects the solubility and availability of metals to plants. Kekane *et al*.[21] reported that the soil with a pH value of about 6 to 8.5 is normal, while that of more than 8.5 is considered to be alkaline soil.

Table 2: Seasonal soil physicochemical properties in the soil samples of Zagazig City from El-Henawy area (site I), El-Ahrar area (site II), and University area (site III) during summer 2022 and winter 2023 at Sharkia governorate.

	Site I		Site II		Site III	
	Summer	Winter	Summer	Winter	Summer	Winter
Temperature (°C)	34.5±0.5^{ac}	20.5±0.5^{bc}	34.5±0.5^{ac}	20.5±0.5^{bc}	34.5±0.5^{ac}	20.5±0.5^{bc}
Moisture (%)	3.62±0.02^{ac}	2.04±0.04^{bc}	12.02±0.02^{ad}	2.42±0.22^{bc}	3.05±0.05^{ae}	12.75±0.25^{bd}
Pore space (%)	84.3±0.3^{ac}	93.1±0.1^{bc}	24.4±0.4^{ad}	91.2±0.2^{bd}	85.4±0.4^{ae}	40.7±0.2^{be}
pH-value	7.9±0.1^{ac}	7.8±0.1^{bc}	9.1±0.1^{ad}	8.1±0.1^{bd}	7.9±0.1^{ac}	8.4±0.1^{be}
Chloride content (%)	0.16±0.01^{ac}	0.92±0.01^{bc}	0.04±0.00^{ad}	1.8±0.03^{bd}	0.10±0.00^{ae}	0.83±0.01^{be}
Bicarbonate (%)	0.11±0.00^{ac}	0.09±0.00^{bc}	0.10±0.003^{ad}	0.11±0.00^{bd}	0.07±0.00^{ae}	0.08±0.00^{be}
Carbonate (%)	ND^{ac}	ND^{ac}	0.02±0.00^{ab}	ND^{ac}	ND^{ac}	ND^{ac}

a, b: The comparison between summer and winter in each site; c, d, e: the comparison between summer or winter in all sites; ND: not detected. Means with different letters in the same row are significant differences at $P<0.05$, One-Way ANOVA (n = 48).

Chlorine is found in soil in the form of soluble chlorides and is strongly combined with organic matter or minerals. It is present in soluble form in a soil solution and tends to accumulate in saline salts as compound with calcium, sodium, or magnesium. The chloride availability to plants is affected by organic matter, aeration, and soil acidity[29]. High levels of chloride ions cause increased concentrations in its absorption by plants leading to poisonous problems in crops and yield reduction, yet chlorine is an essential cofactor for photosynthesis[30]. The discovered concentrations of the chloride ions in the soil samples of the current study are higher than those recorded previously by us[23], which may be attributed to the agricultural state of Kafr El-Ashraf Village than the urban state of the current study sites due to continuous irrigation in villages than urban areas. Alkalinity (carbonate and bicarbonate) is the measure of salt or saline-impacted soil with a pH value greater than 7. These soils are present commonly in the aired climates. The alkalinity of the present investigations was reported in the ranges from 0.07-0.11%, which was lower than that observed previously by us[23]; this may be attributed to the agricultural state of Kafr El-Ashraf Village than the urban state of the current study sites due to continuous addition and spray of fertilizers and pesticides in villages than urban areas in Zagazig City (Egypt).

Heavy metals concentration in the fine dust, soil, and brains of cattle egrets of the studied areas

Heavy metals concentration mostly achieved the highest concentrations (*P*=0.01, paired T-test) in the fine dust (3.7±0.7) than the soil (2.4±0.5) at Zagazig City (Tables 3 and 4). Heavy metals concentration mostly showed higher concentrations in El-Henawy area (site I) than in University area (site III), and El-Ahrar (site II) areas in fine dust samples only (Table 3). The heavy metals concentrations were mostly in the following order in fine dust and soil of the tested areas**:** As > Se > Pb > Hg > Cd > Cr. The data found in Table "5" indicated notable (*P*<0.05) seasonal variations in heavy metals concentration in the brain samples in Hg and Pb only. In the brain, the metal concentration decreased in the following order: Se > As > Pb or Hg> Cd > Cr. The average concentrations of As in the fine dust and soil of the present study at the three investigated sites were above the permission levels (5 µg/g)[31]. Our results were above those obtained by da Silvia *et al*.[32] in Brazilian watershed. The present observations showed that the average concentrations of Hg in the fine dust and soil samples of three study areas were within the permissible limits (0.03-2.00 µg/g)[33]. Concerning the mean concentrations of Se in the present study, they were within the permissible limits (5.63 µg/g)[34] at the fine dust and soil samples, except for the fine dust of El-Henawy area (site I). The average concentrations of Cd and Pb in the fine dust and soil samples were lower in the three observed areas than those previously found in Orabi farms, El Obour City, Qalyubia governorate, Egypt (0.5 and 25 µg/g, respectively)[35]. The Cr is the most environmentally toxic pollutant in the world, its content in fine dust and soil samples at all the tested sites was below the average world in soils of densely populated areas (50.9 µg/g)[36].

Table 3: Seasonal heavy metals concentration in the fine dust samples of Zagazig City from El-Henawy area (site I), El-Ahrar area (site II), and University area (site III) during summer 2022 and winter 2023 at Sharkia governorate.

Parameter (µg/g fine dust)	Site I		Site II		Site III	
	Summer	Winter	Summer	Winter	Summer	Winter
Mercury	2.00±0.03^{ac}	1.96±0.00^{bc}	0.91±0.01^{ad}	0.86±0.01^{ad}	1.19±0.03^{ae}	0.95±0.29^{ad}
Lead	7.6±1.0^{ac}	3.6±0.3^{bc}	1.2±0.2^{ad}	1.3±0.4^{ad}	1.2±0.2^{ad}	1.5±0.3^{ad}
Cadmium	0.35±0.01^{ac}	0.27±0.00^{bc}	0.13±0.02^{ad}	0.08±0.00^{bd}	0.21±0.02^{ae}	0.13±0.01^{be}
Arsenic	15.6±0.7^{ac}	11.7±0.6^{bc}	7.8±0.3^{ad}	7.4±0.2^{ad}	7.4±0.0^{ad}	7.3±0.2^{ad}
Selenium	11.5±0.1^{ac}	11.3±0.1^{ac}	3.2±0.3^{ad}	3.1±0.2^{ad}	5.6±0.7^{ae}	5.4±0.6^{ae}
Chromium	ND^{ac}	0.03±0.00^{ac}	ND^{ac}	ND^{ad}	0.01±0.00^{ad}	0.01±0.00^{ad}

a, b: The comparison between summer and winter in each site; c, d, e: the comparison between summer or winter in all sites; ND: not detected. Means with different letters in the same row are significant differences at *P*<0.05, One-Way ANOVA (n = 48).

Concerning As levels in the brains of cattle egrets, they were above the safe levels (0.01-0.2 µg/g) as in excreta of *Passer domesticus* in rural areas of Ludhiana, India[37]. Regarding Hg levels in the present species, they were above the international permissible levels (0.05 µg/g) and the highest levels (0.14 µg/g) found in tissues of *Bubulcus ibis* collected from different areas in Pakistan[38]. For many species of aquatic avians, the limit of Se "like selenomethionine" in the egg over 3 ppm per wet weight causes embryo deformation and decreases hatchability[39]. The obtained average concentrations of Se in the brain tissues of the cattle egrets (4.52-4.60 µg/g) in the present investigation during summer and winter seasons were higher than the recorded levels (3 µg/g) by Spallholz and Hoffman[39]. This revealed alarm pollution and may be attributed to various anthropogenic activities, painting trades, gun-bluing chemicals, and chemical processes for selenium recovery.

Table 4: Seasonal heavy metals concentration in the soil samples of Zagazig City from El-Henawy area (site I), El-Ahrar area (site II), and University area (site III) during summer 2022 and winter 2023 at Sharkia governorate.

Parameter (µg/g soil)	Site I		Site II		Site III	
	Summer	Winter	Summer	Winter	Summer	Winter
Mercury	0.89 ± 0.04^{ac}	0.84 ± 0.02^{ac}	1.41 ± 0.00^{ad}	0.81 ± 0.04^{bc}	1.11 ± 0.28^{ad}	0.97 ± 0.00^{ac}
Lead	1.57 ± 0.35^{ac}	1.63 ± 0.33^{ac}	0.96 ± 0.16^{ac}	2.30 ± 0.95^{ac}	0.84 ± 0.01^{ac}	0.99 ± 0.08^{ac}
Cadmium	0.12 ± 0.01^{ac}	0.09 ± 0.00^{ac}	0.16 ± 0.01^{ac}	0.12 ± 0.00^{bd}	0.20 ± 0.01^{ae}	0.12 ± 0.01^{bd}
Arsenic	5.1 ± 0.1^{ac}	9.1 ± 0.4^{bc}	8.0 ± 0.2^{ad}	8.9 ± 0.7^{bc}	9.0 ± 0.2^{ad}	6.6 ± 0.1^{bd}
Selenium	3.3 ± 0.6^{ac}	3.4 ± 0.5^{ac}	4.5 ± 1.1^{ac}	4.7 ± 1.1^{ac}	5.2 ± 0.4^{ac}	5.1 ± 0.4^{ac}
Chromium	0.02 ± 0.01^{ac}	0.01 ± 0.01^{ac}	0.03 ± 0.01^{ac}	0.02 ± 0.01^{ac}	0.02 ± 0.01^{ac}	0.01 ± 0.00^{ac}

a, b: The comparison between summer and winter in each site; c, d, e: the comparison between summer or winter in all sites; ND: not detected. Means with different letters in the same row are significant differences at $P<0.05$, One-Way ANOVA (n = 48).

Table 5: Seasonal heavy metals concentration in the brain samples of the cattle egrets from Zagazig City during summer 2022 and winter 2023 at Sharkia governorate.

Parameter (µg/g tissue)	Brain samples	
	Summer	Winter
Mercury	0.30 ± 0.01^{a}	ND^{b}
Lead	0.09 ± 0.07^{a}	1.03 ± 0.05^{b}
Cadmium	0.08 ± 0.02^{a}	0.05 ± 0.01^{a}
Arsenic	4.02 ± 0.49^{a}	3.57 ± 0.30^{a}
Selenium	4.60 ± 1.00^{a}	4.52 ± 0.97^{a}
Chromium	ND^{a}	ND^{a}

ND: not detected. Means with different letters in the same row are significant differences at $P<0.05$, unpaired T-Test (n = 45).

Concerning Pb level in the birds' brains, it was within the safe levels (0.1 µg/g) as in excreta of *Passer domesticus* in rural areas of Ludhiana, India[37]. Regarding Cd levels in the studied cattle egrets, they were higher than the acceptable international limit (0.02 µg/g) as in excreta of *Passer domesticus* in rural areas of Ludhiana, India[37], and they were comparable with that recorded by Adegbe *et al*.[40] in *Bubulcus ibis* from Lagos State Metropolis, Nigeria. In this study, no bioaccumulation of Cr was seen in the brain tissues of the cattle egrets; this could be attributed to the lack of heavy industry in the studied sites. It was reported higher concentrations of Cr in the tissues of avian species than in our study, and this was linked to food[41].

Ultrastructure of the cattle egret's brain

The electron microscopic studies showed the risk impacts of metal pollution on the brain (cerebellum and cerebrum) of the examined cattle egrets (Figures 2 and 3, respectively) in Zagazig City. The riskiness of ultrastructure alterations in the brain tissues exposed to heavy metals was increased in the cattle egrets of the summer season compared to those of the winter season. This could be due to mercury toxicity, where its concentration was higher in the brain tissues in the summer season than in the winter season. The ultrastructural investigations indicated acute damage in the brain tissues of the examined cattle egret birds (Figures 2 and 3). The obtained brain damage can be related to a potential decrease in protein synthesis action attributed to the endoplasmic reticulum and mitochondrial destruction forming a reduction in the energetic capacity transport. This may be also related to the high concentrations of arsenic in the soil and fine dust deposited from the air, breathing of heavy metals directly from the air and passing throughout the blood to the brain, drinking of polluted water, and polluted food. In addition, Nassar and Khater[42] found the same results in the kidney tissues of the cattle egrets collected from Kafr El-Ashraf Village and Qanayat City from Sharkia governorate, Egypt, feeding from garbage in the city or agricultural soil in a village. However, the present investigation was the first to direct insight into heavy metal pollution, which has hazard effects on the birds' nervous system in Zagazig City.

In conclusion, the exposure of cattle egret birds for a long time to the heavy metals found in the studied areas caused health hazards to their brains tissues. So, these useful birds for farmers and agriculture are at a high hazard of extinction because of arsenic contamination of air and soil, and most studied heavy metals pollution, which may be related to breathing, drinking and its food. The ultrastructure of the cattle egrets' brains formed major deformation and aberrations attributed to trace elements accumulation; a hypothesis that was confirmed by measuring heavy metal pollution levels in the air, soil, and birds' brain. Finally, the maintenance of air and soil qualities and the animals' health is possible if protected against the extensive heavy metals usage, possibly by reducing heavy metal wastes and using machines and vehicles that are friendly to the environment.

ACKNOWLEDGEMENTS

The authors gratefully thank Prof. Dr. Abdel-Monem Khalil, Professor of Environmental Pollution, Zoology Department, Faculty of Science, Zagazig University, Egypt, for providing valuable feedback and help on this study. I greatly thank Prof. Dr. Nabil Abbas, and Prof. Dr. Anwar El-Agamy, Professors of Animal Physiology and Fish Biology, Zoology Department, Faculty of Science, Zagazig University, Egypt, for their beneficial comments.

ETHICAL APPROVAL

The current work was accepted by The Institutional Animal Care and Use Committee at Zagazig University (Approval number: ZU-IACUC/1/F/32/2024).

FUNDING SOURCE DISCLOSURE

There is no funding for the present study.

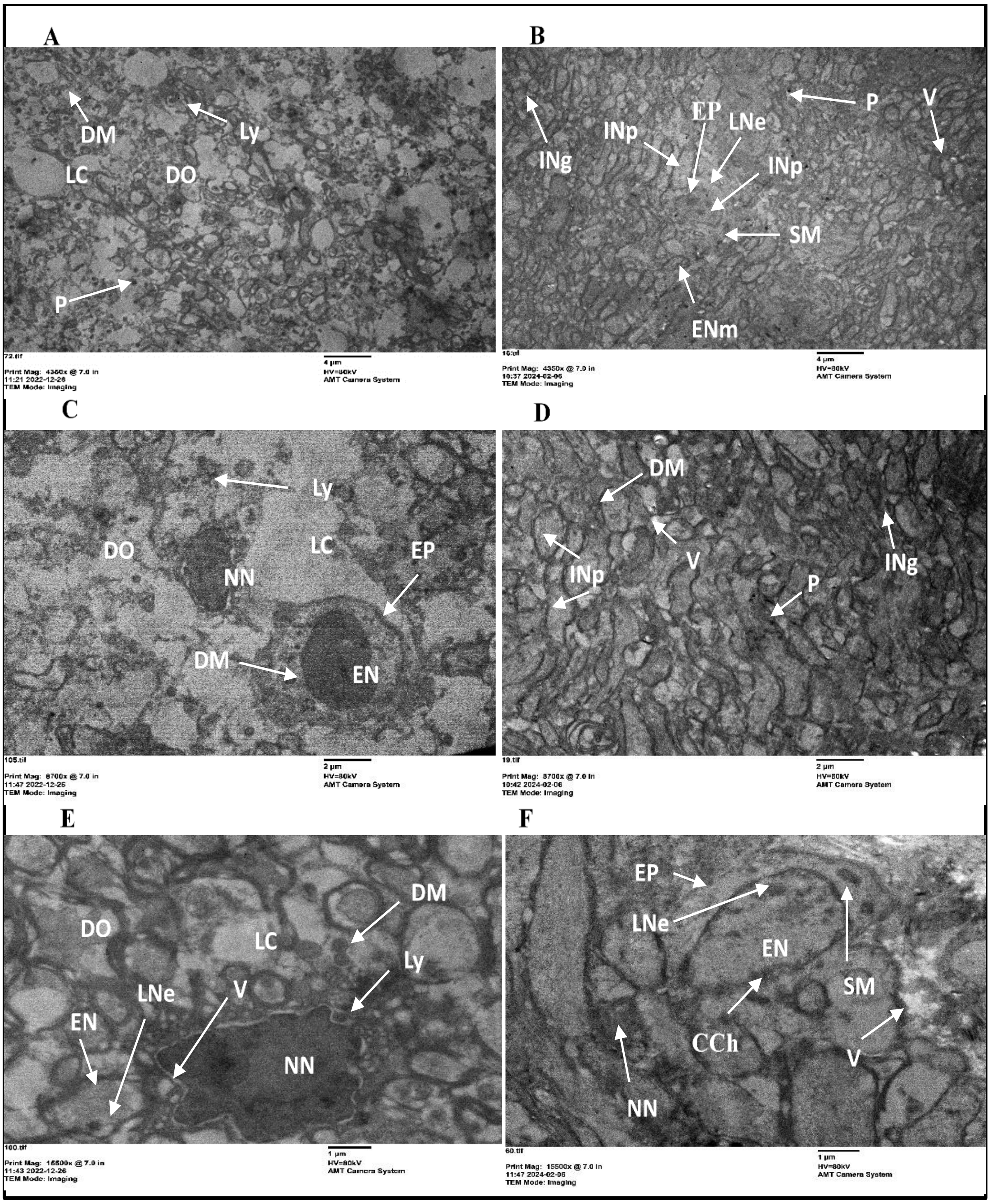

Figure 2: Transmission electron micrographs of a cerebellum from an illness cattle egret during summer 2022 and winter 2023 showing enlarged Purkinje cell (EP) with enlarged nucleus (EN), large nucleolus (LNe), condensed chromatin (CCh), and degenerated mitochondria (DM), other Purkinje cell and ganglia cell with irregular nuclei (INp and INg respectively), migrating cell with enlarged nucleus (ENm), some neuronal cells with necrotic nuclei (NN) and the others with elongated nucleus (EN), large nucleolus (LNe), great number of lysosomes (Ly), swollen mitochondria (SM), vacuolation of the cytoplasm (V), degeneration of cytoplasmic organelles (DO), lytic cytoplasmic organelles (LC) and pigments (P). **(a, b)** ×4350; **(c, d)** ×8700; **(e, f)** ×15500; **(A, C, E)** for summer birds; **(B, D, F)** for winter birds.

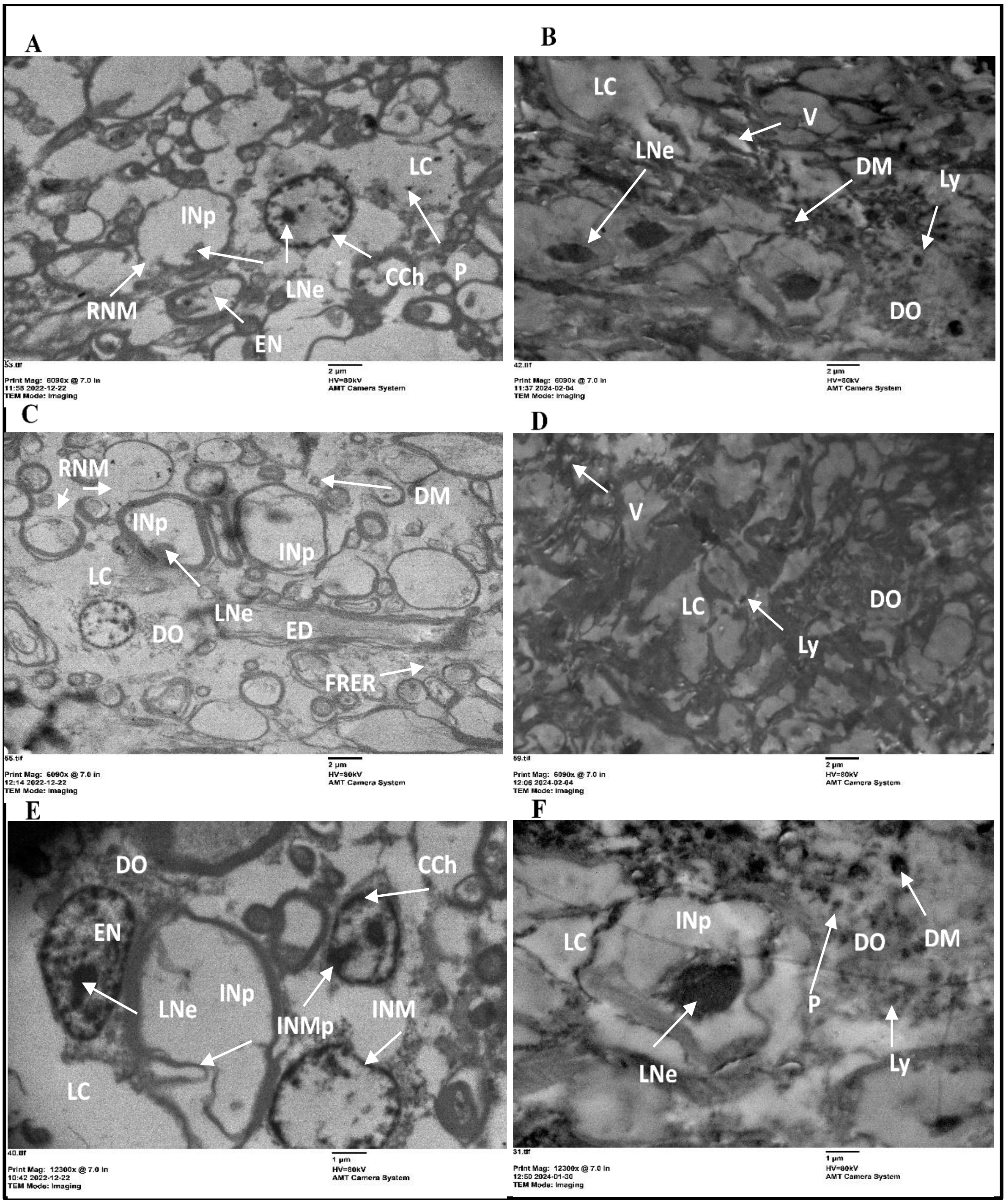

Figure 3: Transmission electron micrographs of a cerebral cortex from an illness cattle egret during summer 2022 and winter 2023 showing neuronal soma cell with enlarged nucleus (EN), large nucleolus (LNe), and condensed chromatin (CCh), enlarged pyramidal cells with enlarged dendrite (ED), enlarged nucleus (EN), irregular nucleus (INp), and large nucleolus (LNe), condensed chromatin (CCh), invagination of nuclear membrane (INMp), irregular nuclear membrane (INM), rupture nuclear membrane (RNM), and stellate cells with elongated nucleus (EN), and large nucleolus (LNe), great number of lysosomes (Ly), degenerated mitochondria (DM), fragmented rough endoplasmic reticulum (FRER), vacuolation of the cytoplasm (V), degeneration of cytoplasmic organelles (DO), lytic cytoplasmic organelles (LC) and pigments (p). **(a, b)** ×6090; **(c, d)** ×6090; **(e, f)** ×12300; **(A, C, E)** for summer birds; **(B, D, F)** for winter birds.

CONFLICT OF INTEREST

There is no conflict of interest for the present study.

AUTHORS' CONTRIBUTIONS

The research article was studied and provided the field survey by ZZK and SEN. Data analysis and the investigations were estimated and determined by ZZK and SEN. Manuscript was written by ZZK. The reviewing and editing were finished by ZZK and SEN. The last version revision of the manuscript was carried out by ZZK. The authors have reviewed and accepted the published version of this research article.

REFERENCES

[1] Oyareme, V. and Osaji, E. I. O. (2022). Environmental air quality parameters monitory information assessments and its health implications on biotic factors in Banjul Metropolis, The Gambia. OALIB, 9(3): e8428 (DOI: 10.4236/ oalib.1108428).

[2] Chen, P. (2019). Visualization of real-time monitoring datagraphic of urban environmental quality. EURASIP J Image Video Proc, 2019: 42 (DOI: 10.1186/s13640-019-0443-6).

[3] Albayrak, T. and Mor, F. (2011). Comparative tissue distribution of heavy metals in house sparrow (*Passer domesticus*, Aves) in polluted and reference sites in Turkey. Bull Environ Contam Toxicol, 87: 457-462.

[4] Kekkonen, J.; Hanski, I. K.; Väisänen, R. A. *et al.* (2012). Levels of heavy metals in house sparrows (*Passer domesticus*) from urban and rural habitats of southern Finland. Ornis Fenn, 89(2): 91-98.

[5] Adout, A.; Hawlena, D.; Maman, R. *et al*. (2007). Determination of trace elements in pigeon and raven feathers by ICPMS. Int J Mass Spectrom, 267(1-3): 109-116.

[6] Koivula, M. J.; Kanerva, M.; Salminen, J.-P. *et al.* (2011). Metal pollution indirectly increases oxidative stress in great tit (*Parus major*) nestlings. Environ Res, 111(3): 362-370.

[7] Isaksson, C. (2010). Pollution and its impact on wild animals: a metanalysis on oxidative stress. Ecohealth, 7(3): 342-350.

[8] Aloupi, M.; Karagianni, A.; Kazantzidis, S. *et al*. (2017). Heavy metals in liver and brain of waterfowl from the Evros delta, Greece. Arch Environ Contam Toxicol, 72(2): 215-234.

[9] Elarabany, N. F. and El-Batrawy, O. A. (2019). Physiological changes in the cattle Egret, *Bubulcus ibis*, as a Bioindicator of air pollution in New Damietta City, Egypt. Afr J Biol Sci, 15: 13-31.

[10] Shahbaz, M.; Hashmi, M. Z.; Malik, R. N. *et al*. (2013). Relationship between heavy metals concentrations in egret species, their environment and food chain differences from two headworks of Pakistan. Chemosphere, 93(2): 274-282.

[11] Malik, R. N.; Moeckel, C.; Jones, K. C. *et al*. (2011). Polybrominated diphenyl ethers (PBDEs) in feathers of colonial water-bird species from Pakistan. Environ Pollut, 159 (10): 3044-3050.

[12] Boncompagni, E.; Muhammad, A.; Jabeen, R. *et al*. (2003). Egrets as monitors of trace-metal contamination in wetlands of Pakistan. Arch Environ Contam Toxicol, 45(3): 399-406.

[13] Rowell, D. L. (1994). Soil Sciences: Methods and Applications. Routledge, London, UK.

[14] Gupta, P. K. (2000). Methods in Environmental Analysis: Water, Soil and Air. Agrobios, Jodhpur, India.

[15] Hegazy, H. M. R.; Haleem, H. H. and Fakhry, F. M. (2003). Cattle ergets as pesticides biomarker of environmental pollution in Kafr El-Sheikh gove-rnorate. Kafr El-Sheikh Vet Med J, 1(2): 1-14.

[16] Sultan, R.; Aslam, A.; Tipu, M. Y. *et al*. (2022). Pathology and molecular characterization of *Eimeria tenella* isolated from clinically infected broiler chickens in district Lahore, Pakistan. Pakistan J Zool, 54: 47-55.
[17] Ismaeil, S. A. A. and Emam, H. (2022). Morphological, histological and histochemical comparative investigations of the liver in young homing pigeon (*Columba livia domestica*) and cattle egret (*Bubulcus Ibis*). Adv Anim Vet Sci, 10(3): 607-620.
[18] Euphrasie-Clotilde, L.; Plocoste, T. and Brute, F.-N. (2021). Particle size analysis of African dust haze over the last 20 years: a focus on the extreme event of June 2020. Atmosphere, 12(4): 502 (DOI: 10.3390/atmos12040502).
[19] World Health Statistics (2014). WHO (https://reliefweb.int/report/world/world-health-statistics-2014).
[20] Adams, A. M.; Prospero, J. M. and Zhang, C. (2012). CALIPSO-derived three-dimensional structure of aerosol over the Atlantic basin and adjacent continents. JCLI, 25, 6862-6879.
[21] Kekane, S. S.; Chavan, R. P.; Shinde, D. N. *et al*. (2015). A review on physico-chemical properties of soil. Int J Chem Stud, 3(4): 29-32.
[22] Osuji, L. C. and Nwoye, I. (2007). An appraisal of the impact of petroleum hydrocarbons on soil fertility: the Owaza experience. Afr J Agri Res, 2(7): 318-324.
[23] Nasr, E. E.; Khater, Z. Z.; Zelenakova, M. *et al*. (2020). Soil physicochemical properties, metal deposition, and ultrastructural midgut changes in ground beetles, *Calosoma chlorostictum*, under agricultural pollution. Sustainability, 12(12): 4805 (DOI: 10.3390/su12124805).
[24] Edori, O. S. and Iyama, W. A. (2017). Assessment of physico-chemical parameters of soils from selected abattoirs in Port Harcourt, Rivers State, Nigeria. J Environ Anal Chem, 4(2): 194 (DOI:10.41722380-2391.1000194).
[25] Borkar, A. D. (2015). Studies on some physicochemical parameters of soil samples in Katol Taluka District Nagpur (MS), India. Res. J. Agriculture and Forestry Sci, 3: 16-18.
[26] Abdulkadir, M. O. (2016): Fundamentals of Soil Science. The Lemon Productions, Mogadishu, Somalia.
[27] Soni, M. (2016). Analysis of soil samples for its physico-chemical parameters from Abohar City. Pharma Innovation, 5(11): 37-39.
[28] Arias, M. E.; Gonzalez-Perez, J. A.; Gonzalez-Villa, F. J. *et al*. (2005). Soil health – a new challenge for microbiologist and chemists. Int Microbiol, 8: 13-21.
[29] Schulte, E. E. (1999). Understanding Plant Nutrients: Soil and Applied Chlorine. University of Wisconsin System Board of Reagents and University of Wisconsin-Extension, Cooperative Extension, Madison, Wisconsin, USA.
[30] Chukwu, U. J. and Anuchi, S. O. (2016). Impact of abattoir wastes on the physicochemical properties of soils within Port Harcourt Metropolis. IJES, 5(6): 17-21.
[31] Kabata-Pendias, A. and Mukherjee, A. B. (2007). Trace Elements from Soil to Human. Springer Berlin Heidelberg, Berlin, Germany.
[32] da Silva, Y. J. A. B.; Cantalice, J. R. B.; Singh, V. P. *et al*. (2019). Heavy metal concentrations and ecological risk assessment of the suspended sediments of a multi-contaminated Brazilian watershed. Acta Sci Agron, 41: e42620 (DOI: 10.4025/actasciagron.v41i1.42620).
[33] Morgan, H.; De Búrca, R.; Martin, I. *et al*. (2009). Soil Guideline Values for Mercury in Soil. Science Report SC050021 / Mercury SGV. Environment Agency, Bristol, UK.

[34] Hamilton, S. J. and Buhl, K. J. (2004). Selenium in water, sediment, plants, invertebrates and fish in the blackfoot river drainage. Water, Air, and Soil Pollu, 159: 3–34.

[35] Salman, S. A.; Zeid, S. A. M.; Seleem, E. M. *et al*. (2019). Soil characterization and heavy metal pollution assessment in Orabi farms, El Obour, Egypt. Bull Natl Res Cent, 43: 42 (DOI: 10.1186/s42269-019-0082-1).

[36] Chen, S.; Wu, C.; Hong, S. *et al*. (2020) Assessment, distribution and regional geochemical baseline of heavy metals in soils of densely populated area: a case study. Int J Environ Res Public Health, 17(7): 2269 (DOI: 10.3390/ijerph17072269).

[37] Pannu, K. K. and Kler, T. K. (2018). Heavy metal contamination in excreta of house sparrow (*Passer domesticus)* from rural areas of Ludhiana. JEZS, 6(1): 77-81.

[38] Yasmeen, R.; Muhammad, H. A.; Bokhari, S. S. *et al*. (2019). Assessment of heavy metals in different organs of cattle egrets (*Bubulcus ibis*) from a rural and urban environment in Pakistan. Environ Sci Pollut Res, 26: 13095-13102.

[39] Spallholz, J. E. and Hoffman, D. J. (2002). Selenium toxicity: cause and effects in aquatic birds. Aquat Toxicol, 57(1-2): 27-37.

[40] Adegbe, E. A.; Babajide, O. O.; Maina, L. R. *et al*. (2021). Heavy metal levels in cattle egrets (*Bubulcus ibis*) foraging in some abattoirs in Lagos State metropolis. Bull Natl Res Cent, 45: 71 (DOI: 0.1186/s42269-021-00529-7).

[41] El-Shabrawy, N. M.; Goda, A. S.; Donia, G. R. *et al*. (2021). Impact of heavy metals pollution on the biochemical parameters and the histo-pathological picture of two resident wild birds at EL-Salam Canal area, North Sinai, Egypt. SCVMJ, 26(2): 303-320.

[42] Nassar, S. E. and Khater, Z. Z. (2024). Physiological and ultra-structural changes in the cattle egret (*Bubulicus ibis*), as bio-indicators of soil heavy metal pollution in Sharkia province, Egypt. Egypt J Zool (EJZ), 81: 30-43.

التغييرات الدماغية لأبو قردان (*Bubulcus ibis*) الناتجة عن تلوث الهواء والتربة في محافظة الشرقية، مصر

زينب زهرى خاطر، صفاء عزت نصار

قسم علم الحيوان، كلية العلوم، جامعة الزقازيق، الشرقية، جمهورية مصر العربية

تعتبر جودة الهواء هي إحدى المشاكل الصحية الرئيسة التي واجهتها المناطق الحضرية مؤخرًا. وهدفت هذه الدراسة إلى تقييم جودة الهواء والتربة في مدينة الزقازيق، محافظة الشرقية بمصر، وقياس تأثيراتها على الحالة العصبية لدماغ طائر أبو قردان (*Bubulcus ibis*). تم تنفيذ المراقبة المستمرة لملوثات الهواء الفيزيائية والكيميائية (CO، NO، NO_2، O_3، SO_2، NH_3، والجسيمات الدقيقة "$PM_{2.5}$ وPM_{10}") في مدينة الزقازيق بمساعدة برنامج "Google Earth" لجودة الهواء في المناطق الحضرية خلال صيف 2022 وشتاء 2023. تم جمع عينات من الغبار الناعم والتربة وأدمغة طائر أبو قردان من ثلاث مناطق بمدينة الزقازيق (الحناوي، الأحرار، والجامعة) لقياس تركيزات المعادن الثقيلة (الزئبق، الرصاص، الزرنيخ، الكادميوم، السيلينيوم، و الكروم). ووفقًا للنتائج التي تم الحصول عليها، كانت معايير جودة الهواء في حالة جيدة بالمقارنة مع معايير منظمة الصحة العالمية. وكانت الخواص الفيزيائية والكيميائية لعينات التربة ضمن الحدود الآمنة التي أوصت بها الدلائل الإرشادية الدولية. وحققت عينات التربة وأدمغة طيور أبو قردان بمنطقة الحناوي أعلى تركيز للمعادن الثقيلة. وأشارت الفحوصات المتعلقة بالمعادن الثقيلة إلى مخاطر صحية في التراكيب الدقيقة لأنسجة أدمغة طيور أبو قردان مرتبطة بتلوث الهواء والتربة. وخلصت الدراسة إلى أنه يمكن تجنب التأثيرات الضارة المحتملة على أنسجة أدمغة طيور أبو قردان إذا تمت معالجة التربة والهواء بشكل مناسب وتقليل استخدام المعادن الثقيلة قدر الإمكان.