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LONGITUDINAL AND VERTICAL PROFILE OF ENVIRONMENTAL POLLUTION MONITORING OF THE POLOG VALLEY, SHAR MOUNTAIN AND MALI I THATË

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Abstract

Introduction: The Polog Valley, situated at 380–550m above sea level between the Sharr Mountains and Mali i Thatë, is a low-lying plain prone to thermal inversion during winter. This occurs when cold air becomes trapped beneath a layer of warmer air, preventing normal air circulation. As a result, pollutants such as PM0.6, PM2.5, and PM10 accumulate, posing serious health risks. The Sharr Mountains (2794m) and Mali i Thatë (2287m) geographically enclose the valley, worsening the inversion effect, particularly from December to February. This leads to increased respiratory, cardiovascular, and neurological illnesses, especially in the elderly, infants, and middle-aged individuals, with significant social and economic costs.
Aim of the Study: This study aims to monitor environmental pollution across the Polog Valley, Sharr Mountains, and Mali i Thatë during winter. It examines how thermal inversion affects human, plant, and animal health. Pollutant impact will be assessed using chicken and quail egg samples, with previous tests showing adverse effects on embryonic development.
Materials and Methods: Forty chicken and forty quail egg samples will be exposed to environmental pollutants in a controlled setting. Pollutants, prepared in 50ml vials, will be administered in 100µL doses for quail and 200µL for chicken eggs at various developmental stages. Samples will be incubated and analyzed using a magnifying glass, Nikon SMZ 1500 stereomicroscope, and Kozo FL 666 fluorescent microscope. The study will be conducted at the Scientific Research Laboratory of the Faculty of Forestry and the Ecological and Technological Institute University of Tetova.
Results: The research will provide data on environmental pollution in the vertical and longitudinal profiles of the study area. Findings will offer reliable indicators for ongoing environmental monitoring.
Conclusion: The study will highlight the extent of environmental pollution in the Polog Valley, Sharr Mountains, and Mali i Thatë. It will offer evidence-based recommendations for addressing pollution and mitigating its health and ecological impacts.

Keywords: longitudinal profile, vertical profile, pollutants, quail eggs (*Coturnix japonica*), chicken eggs (*Gallus domesticus*), embryonic development stages, health effect

1. Introduction

The Polog region is situated in the northwestern part of the Republic of North Macedonia, encompassing an area of 2,416 km², which represents 9.7% of the country's total territory. According to the altitude, the lowest point of the region is located in the village Raotince (municipality of Jegunovcë) 385m above sea level, with coordinates 42 ° 03`03 "ngw and 21 ° 08`21" egl, the highest point is the highest peak in the country, Korabi i Madh 2764 m with coordinates, 41 ° 47`25 "ngw 20 ° 32`48 "egl. The region consists of the following nine municipalities: Tetovë, Gostivar, Mavrovë and Rostushe, Zhelinë, Tearcë, Bogovinje, Vrapchisht, Jegunovcë and Brvenicë. It has 184 settlements, of which 182 are rural and 2 urban settlements (Tetovë and Gostivar). The presence of a mildly favorable bioclimatic setting, abundant water resources, diverse landforms, and a clean natural environment serves as a key factor in promoting rural tourism in the region. Geological geomorphologic (relief) motifs in the Polog region are manifested by the presence of Sharr Mountain, Mali i Thatë, Mavrovë plateau, mountain massif Bistra, Deshat and the valley of the river Radika, which are quite interesting and attractive from a tourist point of view. On the other hand, the hydrographic motifs are presented with a rich water fund of rivers and lakes. The most important rivers are: Vardar River, Radika, Pena, Mazdracha, Bogovinje River, Mavrovë. The average annual precipitation in Polog region is 780 mm on average per year in Tetovë, 1200 mm in Kodrën e Diellit, 890 mm in Gostivar, 920 mm in Mavrovë and 1020 mm in Lazaropole. Precipitation in the eastern portion of the region occurs primarily in the form of rain, and in the western higher lands in the winter months they are in the form of snow. What is very important for the eastern mountainous areas is that the atmosphere is quite clean, the presence of oxygen is great, and thus has an excellent convenience for health recreational tourism in this area (Ademi, Z., & Ibraimi, R., 2020).

Figure 1. Macedonia geography map showing the major geographical features of Macedonia (Freeworldmaps.net, 2021)

In today's world, human society is facing problems of various natures. Among the pressing environmental issues confronting developing nations, air pollution remains a major concern in countries such as the Republic of North Macedonia. Data from several international sources, including a World Bank report, indicate that air pollution is responsible for around 1,350 deaths annually in the Republic of North Macedonia. The economic impact of this public health issue is significant, with losses estimated at approximately 3% of the nation's GDP. Furthermore, recurring reports from the European Environment Agency, including the latest editions, consistently list cities like Tetovë, Shkup, Kumanovë, and Bitol among the most polluted in the region. According to Pollution Index by City 2020 MidYear (URL.01) and WHO (URL.02) Tetovë is ranked in the first place in the world as the most polluted city with PM10 and PM2.5 particles. According to the WHO, these particles are classified in the first group of carcinogenic particles, namely particles with a strong carcinogenic action. If the level of PM10 and PM2.5 particles increases by 10 $\mu g/m^3$ above the Permitted limit values, carcinogenic diseases increase by 22% and 36%, respectively (Dimitrovski et al., 2017).


Figure 2. **Air pollution in Tetovo - North Macedonia** (North Macedonia's capital Skopje enveloped in thick fog and smog. Photo by EPA/Georgi Licovski)

In general, hazardous substances from both natural and man made sources pollute the air. Major contributors to air pollution include vehicle exhaust, industrial emissions from power plants and chemical manufacturers, waste incineration, and natural events like volcanic eruptions. These sources release harmful substances into the atmosphere such as sulfur dioxide, carbon monoxide, nitrogen oxides, heavy metals, ozone, biological agents, and tobacco smoke which are then inhaled by living organisms. When these pollutants are ingested, they disrupt the body's internal systems, leading to serious health conditions such as cancer, cardiovascular and reproductive disorders, prenatal and central nervous system complications, as well as respiratory issues. Tobacco smoke contains a range of toxic substances, including benzene, cadmium, arsenic, formaldehyde, and nicotine, all of which are linked to serious health problems. Exposure to these chemicals can lead to cancer, affecting not only active smokers but also non smokers who inhale secondhand smoke. Passive smoking can increase the risk of developing conditions such as asthma, bronchitis, throat infections, and eye irritation. Exposure to biological pollutants such as bacteria, viruses, dust mites, cockroaches, and pollen can lead to asthma, hay fever, and other allergic conditions. Meanwhile, volatile organic compounds (VOCs) are known to cause irritation of the eyes, nose, and throat, as well as headaches, nausea, and impaired coordination. Extended exposure can lead to damage in various parts of the body, with the liver being particularly vulnerable. Lead, in particular, can impair brain function and disrupt the digestive system, and under certain conditions, it may also contribute to the development of cancer. Ozone exposure can lead to eye irritation, a burning sensation, and may contribute to the development of respiratory issues such as asthma. It can also weaken the body's defenses against infections like colds and pneumonia. During winter, children are particularly vulnerable to respiratory problems caused by nitrogen oxide exposure. The health effects of these pollutants can vary in severity and duration, depending on the type and level of exposure. Short-term exposure can cause symptoms such as irritation of the eyes, skin, nose, and throat, along with coughing, headaches, nausea, and dizziness. In more severe cases, it may lead to conditions like asthma, bronchitis, and complications affecting the lungs and heart. Long term effects will be neurological, reproductive, respiratory, and cancer (Ghorani Azam A. et al., 2016).

Exposure to air pollution *in-utero* has long term implications for respiratory health. Exposure events during pregnancy can significantly influence foetal and postnatal development and maturation. Germ and foetal cells are particularly sensitive to external exposure events due to their faster rates of replication, faster differentiation and higher sensitivity to surrounding signals compared with mature cells. Prenatal exposure to environmental factors can disrupt organ development, potentially leading to long term health complications and diseases later in life (Perera F et al., 2011).

Nanoparticles (NPs) are ultrafine particles found in a wide array of materials. Despite their widespread presence, there remains limited understanding of their potential secondary effects on both living organisms and the environment. Increasing scientific interest has been directed toward assessing the health impacts of environmental NP exposure in humans. While most studies have focused on adult populations or animal models, embryonic stages are considered more vulnerable to environmental pollutants. As a result, recent research has increasingly emphasized the effects of NPs on embryogenesis. Among experimental models, chicken embryos hold a prominent position in developmental and toxicological studies due to their rapid development, ease of access, and suitability for direct observation and manipulation. These features have established them as a preferred vertebrate model for over two millennia, contributing significantly to research in genetics, virology, immunology, cell biology, and oncology. The early stages of chicken embryogenesis, marked by rapid cellular and organ development, provide a sensitive platform for evaluating NP induced toxicity, including effects on organogenesis, body weight, and oxidative stress (Kron, 2018), (*Ghimire, S et al., 2022*).

Sources of Nanoparticles in Air Pollution:

1. Combustion processes (e.g., car engines, industrial emissions, power plants)
2. Wildfires and biomass burning
3. Secondary particle formation in the atmosphere (from chemical reactions)
4. Nanomaterials released during manufacturing or disposal of nanotechnology based products (Sharma, K. et al., 2023).

The explanation of thermal inversion has already noted that mixing between two air layers of different densities caused by temperature differences is not possible. Therefore, it can be concluded that one of the primary consequences of this thermal imbalance is the entrapment of pollutants, preventing their proper dispersion into the atmosphere. In fact, the warmer air layer acts as a lid over the cooler air near the ground, where pollutants tend to accumulate. This creates smog, often referred to as a 'pollution beret,' which can be seen from several kilometers away and is typically accompanied by a drop in air quality levels. This phenomenon has direct implications for human health, leading to a rise in medical visits due to respiratory and cardiovascular issues, particularly among vulnerable populations such as children, the elderly, and individuals with pre-existing conditions. A study by Rendón, A. M. et al., (2015) in Hanoi highlighted this cause and effect relationship, showing that levels of NO_2, SO_2, PM_{10}, and $PM_{2.5}$ increased during thermal inversion episodes, which coincided with a notable rise in hospital admissions among those under 15 and over 60 years of age (Rendón, A. M. et al., 2015).

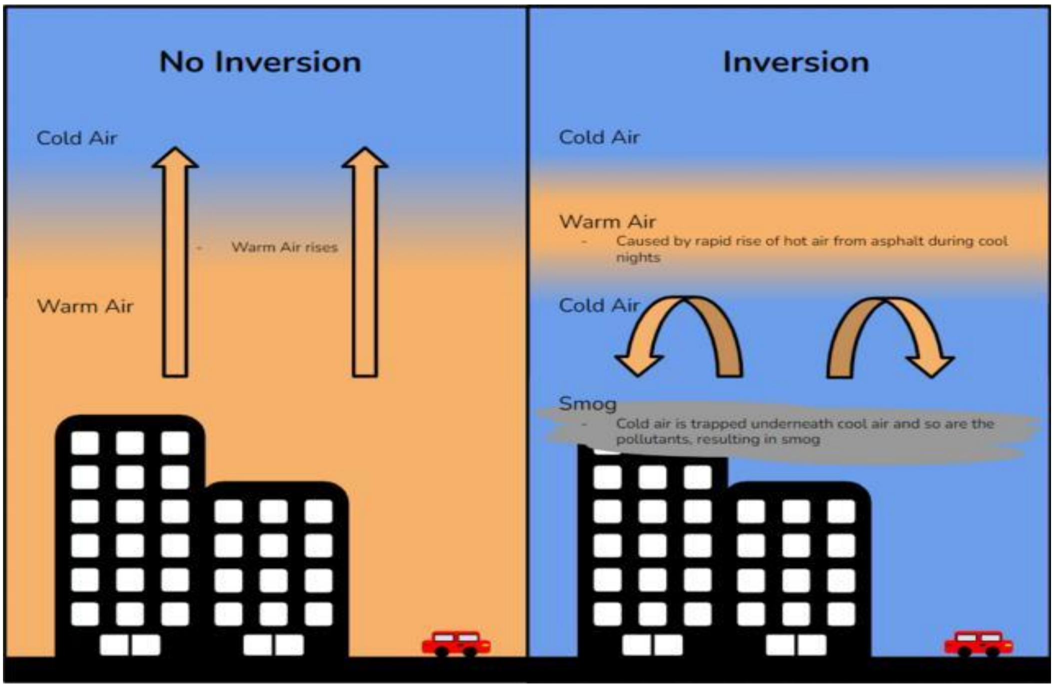


Figure 3. **Thermal inversion and the impact of pollution in the Polog basin** (thedailyECO, 2025)

2. Material And Methods

The research was carried out within the framework of the Scientific Laboratory of the Ecological and Technological Institute of UT and the Scientific Research Laboratory of Medicine of UT in the period 2024/25. The experiment was carried out according to the method modified by the authors Beadini et al., 2024 at the LHSHM (Scientific Medical Research Laboratory) of UT.

In the study were taken 20 fertilized country chicken eggs (from local farmers, Tetovë) and incubated in the incubator for 21 days and 35 quail eggs (from local farmers, Tetovë) incubated in the incubator for 14 days.

Figure 4. Quail and chicken eggs during incubation in the incubator

Both of the eggs were treated with air pollutant at certain stages of embryonic development. Using the stereomicroscope with macroscopic and microscopic method were analyzed ontogenetic changes in certain stages of embryonic development. The injection method used for this study was injection in the air sack of the egg.

Figure 5. Sampling and dosing during the experimental phase

On different days of incubation the development of embryos from all groups was studied after each egg was hatched. Size and embryo weight, organ development, formation of head, beak, eyes, limbs, feathers were monitored.
The injection method used for this study was injection in the air chamber at the bottom of the egg, where hole was punched with a needle, then different doses of air pollutant extract was injected.

*Figure 6***.** The injection method used for this study was injection in the air sack of the egg done by students at LHSHM

The injection area was then disinfected and sealed with tape. Control and experiment eggs were kept in the same incubator (the same environment, temperature and conditions).
The air pollutant extract was collected in the mornings from the doorposts, threshold and entranceway of houses in different regions of North Macedonia.

The air pollutant samples were taken in different orientations in nature. In the longitudinal and vertical profile of environmental pollution in the Polog Plain, Sharr Mountain and Mali i Thatë.

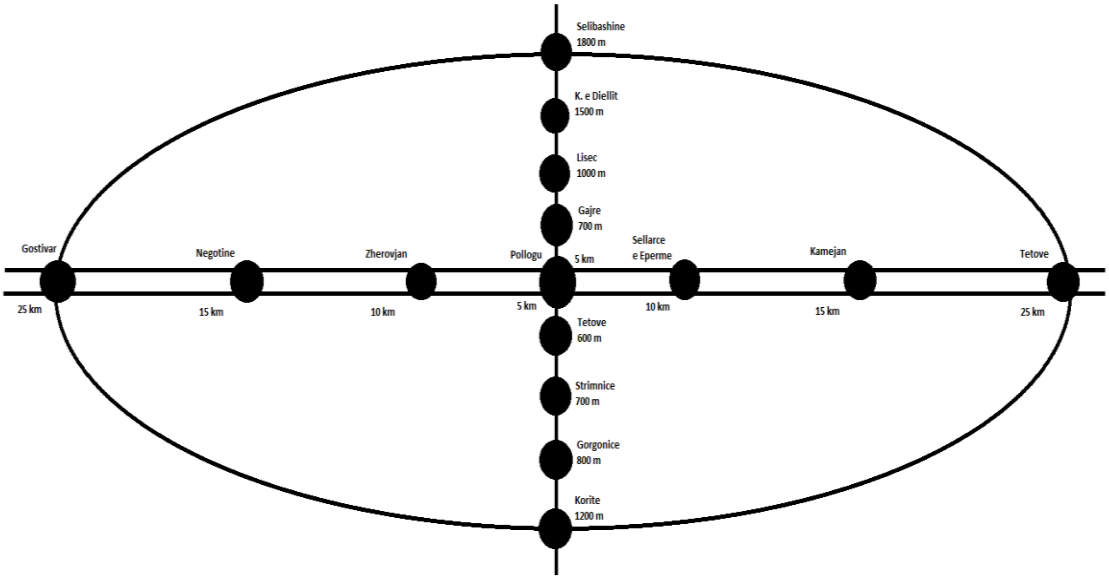
*Figure 7***.** Comparative levels of pollutants according to location and geographical position of the village of Polog, Sharr Mountain and Dry Mountain

In the vertical profile, the pollutant samples were taken from the following locations:

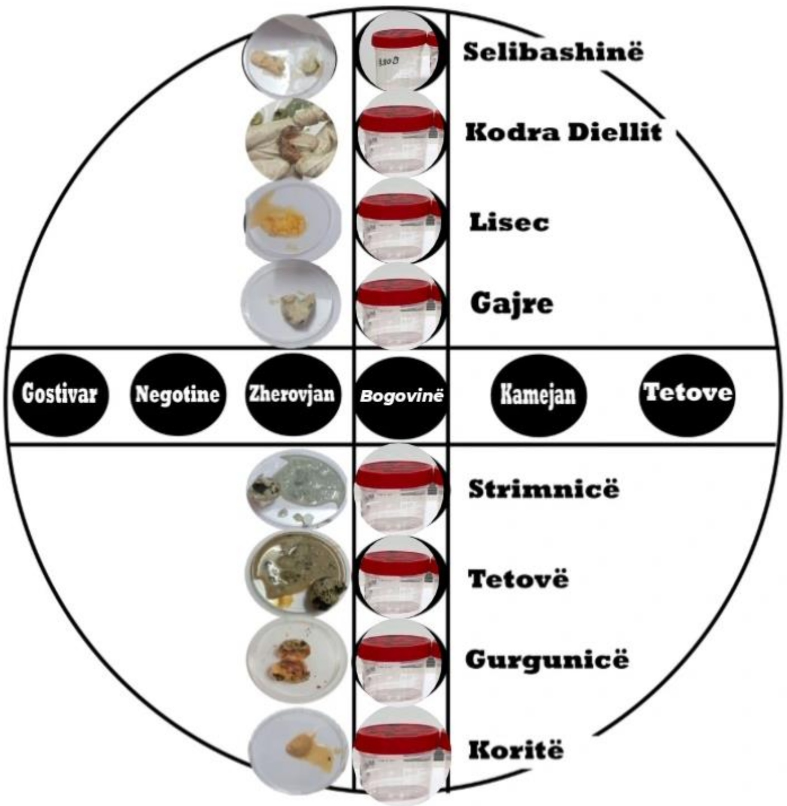
- Selibashinë,
- Kodra e Diellit,
- Lisec,
- Gajre,
- Tetovë,
- Strimnicë,
- Gorgonicë and
- Koritë.

While in the longitudinal profile, the pollutant samples were taken from the following locations:

- Gostivar,
- Negotinë,
- Zherovjan,
- Polog Plain,
- Sellarce e Epërme,
- Kamejan etc.



Schematic presentation 1: Longitudinal and vertical profile of environmental pollution in the Polog basin, Mali i Thatë and Sharr Mountain



Schematic presentation 2: Comparability between the pollutant sample and embryonic development at certain stages of ontogenetic development

The samples taken from environmental pollutants are transformed into special 50ml vials and given to chicken eggs and quail eggs during the ontogenetic development stage in amounts of 100μL for quail eggs and 200μL for chicken eggs, at different time stages of embryonic development.

Incubation, injection and processing of the data for this experiment was done in the period from November 2024 to February 2025.

3. Results

In the following tables, the data of the experiment are presented, specifically the weight, temperature, and humidity of the quail and chicken eggs injected with air pollutants.

During the incubation of the eggs, the weight was measured at different stages of embryonal growth **(Tab.1)** and **(Tab.2).**

Normal weight loss can be observed in the first week and then its gradual increase in the following stages of embryonic growth.

Table 1. Determination of weight (gr), day of hatching and status of embryonal growth of 20 chicken eggs.

Nr	Egg	Weight before incubation	Weight on 3rd day (gr)	Weight on 6th day (gr)	Weight on 9th day (gr)	Weight On 12th day (gr)	Hatching of eggs	Temp.	Humidity	Status
1	1K	64.9 gr	63.1 gr	62.1 gr	61 gr	60.2 gr	Yes	37.5 C	88%	**Successfully hatched**
2	2K	63.1 gr	61.5 gr	60 gr	58.4 gr	57.2 gr	Yes	37.5 C	88%	Organogenesis
3	3K	67 gr	65.3 gr	64.2 gr	62.8 gr	62.4 gr	No	37.5 C	88%	Organogenesis
4	4K	74 gr	70.7 gr	69.5 gr	66.9 gr	66 gr	Yes	37.5 C	88%	Blastomere
5	5K	58.4 gr	56.8 gr	55.8 gr	53.2 gr	53.1 gr	Yes	37.5 C	88%	Blastomere
6	6E	58 gr	56.4 gr	54.3 gr	54.1 gr	53 gr	Yes	37.5 C	88%	Blastomere
7	7E	69.5 gr	67.8 gr	64.2 gr	62.2 gr	60.8 gr	No	37.5 C	88%	Organogenesis
8	8E	59.6 gr	58.2 gr	53.8 gr	50.2 gr	48.9 gr	No	37.5 C	88%	Blastomere
9	9E	61.4 gr	59.4 gr	51.7 gr	50.8 gr	50.1 gr	Yes	37.5 C	88%	**Successfully hatched**
10	10E	69.7 gr	66.1 gr	64.2 gr	63.8 gr	62.8 gr	No	37.5 C	88%	Organogenesis
11	11E	63.8 gr	62.1 gr	60.9 gr	59.7 gr	x	X	37.5 C	x	x
12	12E	64.3 gr	63.2 gr	60.8 gr	60.2 gr	x	x	37.5 C	X	x
13	13E	63.3 gr	61.8 gr	58.4 gr	57.4 gr	54.5 gr	Yes	37.5 C	88%	**Successfully hatched**
14	14E	63.5 gr	54.8 gr	52.7 gr	50.6 gr	49.9 gr	No	37.5 C	88%	Organogenesis
15	15E	62.8 gr	54.8 gr	59.1 gr	57.4 gr	55.7 gr	Yes	37.5 C	88%	Organogenesis
16	16E	71.3 gr	61.6 gr	57.9 gr	55.9 gr	55.2 gr	Yes	37.5 C	88%	Organogenesis
17	17E	58.8 gr	61.6 gr	60.1 gr	58.4 gr	63.9 gr	No	37.5 C	88%	Organogenesis
18	18E	58.5 gr	69.7 gr	68.5 gr	67.2 gr	65.2 gr	No	37.5 C	88%	Blastomere
19	19E	60.6 gr	57.1 gr	55.5 gr	55.4 gr	57.9 gr	Yes	37.5 C	88%	Blastomere
20	20E	68.6 gr	56.9 gr	55.4 gr	52.6 gr	51.1 gr	Yes	37.5 C	88%	Blastomere

Experiment eggs were hatched and then embryonic development in different groups was observed.

Table 2. Determination of weight (gr), day of hatching and status of embryonal growth of 35 quail eggs.

Nr	Egg	Weight before incubation	Weight on 3rd day (gr)	Weight on 6th day (gr)	Weight on 9th day (gr)	Weight on 12th day (gr)	Weight on 14th day (gr)	Hatching of eggs	Temp.	Humidity	Status
1	1K	13.3 gr	12.6 gr	12.3 gr	12.1 gr	11.9 gr	11.5 gr	No	37.5 C	88%	Blastomere
2	2K	13.4 gr	12.6 gr	12.1 gr	11.9 gr	11.5 gr	11.2 gr	No	37.5 C	88%	Blastomere
3	3K	12.5 gr	12.4 gr	12.3 gr	12.1 gr	11.5 gr	11.2 gr	No	37.5 C	88%	Blastomere
4	4E	12.8 gr	12.6 gr	12.4 gr	12.2 gr	12 gr	11.8 gr	No	37.5 C	88%	Blastomere
5	5E	12.8 gr	12.4 gr	12.3 gr	12.2 gr	12.1 gr	11.9 gr	Yes	37.5 C	88%	Blastomere
6	6E	12.7 gr	12.9 gr	12.5 gr	12.2 gr	12.1 gr	11.8 gr	Yes	37.5 C	88%	Organogenesis
7	7E	12.5 gr	12.4 gr	12.3 gr	12.1 gr	11.9 gr	11.5 gr	No	37.5 C	88%	Blastomere
8	8E	12.4 gr	12.1 gr	11.9 gr	11.5 gr	11.7 gr	11.5 gr	Yes	37.5 C	88%	Blastomere
9	9E	11.8 gr	11 gr	10.9 gr	10.7 gr	9.9 gr	9.8 gr	Yes	37.5 C	88%	Organogenesis
10	10E	12.2 gr	11.6 gr	11.5 gr	11.4 gr	11.3 gr	11.1 gr	No	37.5 C	88%	Blastomere
11	11E	13 gr	12.9 gr	12.9 gr	11.9 gr	11.7 gr	4 gr	Yes	37.5 C	88%	Blastomere
12	12E	12.5 gr	12.5 gr	11.8 gr	11.5 gr	11.1 gr	8 gr	Yes	37.5 C	88%	Blastomere
13	13E	13.4 gr	13 gr	12.5 gr	12.2 gr	12.3 gr	11 gr	Yes	37.5 C	88%	Blastomere
14	14E	14.9 gr	14.7 gr	14.3 gr	14.1 gr	14 gr	13.8 gr	No	37.5 C	88%	Blastomere
15	15E	13.3 gr	13.2 gr	7.5 gr	5.1 gr	4.1 gr	3.2 gr	Yes	37.5 C	88%	**Successfully hatched**
16	16E	13.8 gr	13.7 gr	13.3 gr	13 gr	5.7 gr	5 gr	Yes	37.5 C	88%	Blastomere
17	17E	14.8 gr	12.8 gr	12.5 gr	12.2 gr	7.9 gr	7.6 gr	Yes	37.5 C	88%	Organogenesis
18	18E	13.6 gr	13.2 gr	13 gr	12.5 gr	12 gr	11.1 gr	Yes	37.5 C	88%	**Successfully hatched**
19	19E	15.3 gr	15.2 gr	15.2 gr	14.9 gr	14.7 gr	13.2 gr	Yes	37.5 C	88%	**Successfully hatched**
20	20E	13.6 gr	13.3 gr	13.2 gr	12.9 gr	12.7 gr	11.4 gr	Yes	37.5 C	88%	Organogenesis
21	21E	15 gr	14.8 gr	14.5 gr	14.3 gr	13.9 gr	13.2 gr	No	37.5 C	88%	Organogenesis
22	22E	13.9 gr	13.8 gr	13.5 gr	13.3 gr	13.1 gr	12.7 gr	Yes	37.5 C	88%	Blastomere
23	23E	14.8 gr	14.6 gr	14.4 gr	14.1 gr	13.9 gr	13.5 gr	No	37.5 C	88%	Blastomere
24	24E	14.5 gr	14.3 gr	13.9 gr	13.7 gr	13.4 gr	13.1 gr	No	37.5 C	88%	Blastomere
25	25E	12.9 gr	12.7 gr	12 gr	10.8 gr	10.7 gr	10.2 gr	Yes	37.5 C	88%	Organogenesis
26	26E	14.7 gr	14.6 gr	14.4 gr	14.1 gr	14 gr	13.8 gr	No	37.5 C	88%	Organogenesis
27	27E	12.8 gr	12.2 gr	12.1 gr	11.9 gr	11.4 gr	11 gr	Yes	37.5 C	88%	Blastomere
28	28E	11.7 gr	11.5 gr	11.6 gr	11.3 gr	11.1 gr	10.5 gr	Yes	37.5 C	88%	Blastomere
29	29E	13.3 gr	13.2 gr	12.8 gr	12.6 gr	12.5 gr	10 gr	Yes	37.5 C	88%	Blastomere
30	30E	18.5 gr	14.3 gr	14.2 gr	12.1 gr	12.1 gr	11.9 gr	No	37.5 C	88%	Blastomere
31	31E	12.3 gr	12.2 gr	12.1 gr	12 gr	11.8 gr	11.5 gr	No	37.5 C	88%	Organogenesis
32	32E	11.9 gr	11.7 gr	11.4 gr	11.2 gr	3.7 gr	3.6 gr	No	37.5 C	88%	Organogenesis
33	33E	14 gr	13.9 gr	13.7 gr	13.4 gr	13.9 gr	13.5 gr	No	37.5 C	88%	Organogenesis
34	34E	13.5 gr	13.4 gr	13 gr	12.8 gr	7.3 gr	7.2 gr	Yes	37.5 C	88%	Organogenesis
35	35E	14.4	14.3 gr	14.1 gr	13.8 gr	13.6 gr	13 gr	No	37.5 C	88%	Organogenesis

Experiment eggs were hatched and then embryonic development in different groups was observed.

Figure 8. Schematic representation of the different stages of embryonic development of chicken eggs injected with pollutants in different periods of time from day 1 - 21.

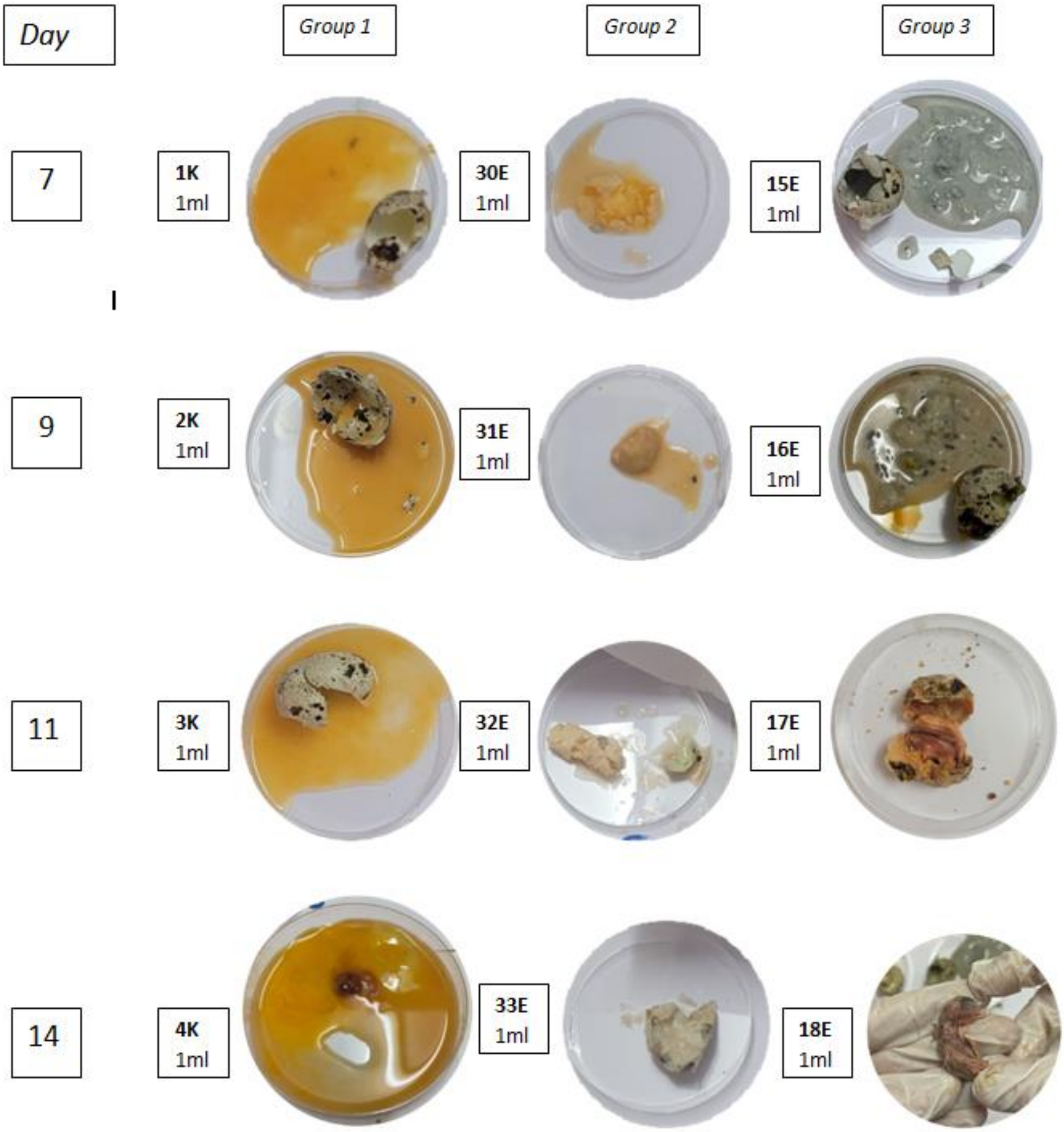


Figure 9. Schematic representation of the different stages of embryonic development of quail eggs injected with pollutants in different periods of time from day 1 - 14.

4. Discussions

Some studies have shown that fertilized chicken eggs have been a great model for laboratory experiments. The use of pollutants in fertilized chicken eggs is not the only time research has focused on different pollutants for embryonic growth, organ formation, external size of the embryo, formation of the head, beak, eyes, feathers, limbs etc. Chicken embryo has been used as a development model for over 200 years, (Vergara M. N. et al., 2022) which allows direct observation and manipulation of developing embryo.

Furthermore, the chicken embryo functions as a closed system, enabling relatively precise exposure to toxicants without maternal influence. In this study, the chicken embryo model was used to evaluate the potential developmental toxic effects caused by PM2.5 exposure. PM2.5 was exposed to the chicken embryos via air cell injection, by which the PM2.5 was injected onto the air cell membrane without direct penetration into the egg. This method has been demonstrated to elicit comparable results to real-world exposure to environmental contaminants (Hoffman D. J. et al., 1996).

Animals are exposed to environmental pollutants just as much as humans, and in some cases even more so. Although the sensitivity of animals to individual pollutants is not the same in all species, almost all pollutants can result in death of the animal, preceded by more or less noticeable changes in behavior, a decline in production, increased susceptibility to stressors and diseases, reduced reproductive success, damage to the respiratory system, neurological problems, etc. Changes in common behavior are the first sign that the animal is uncomfortable in the environment it is in and it should not be ignored. In environments where both people and animals are present, a change in animal behavior may indicate that these conditions are not suitable for people, either (Relić et al., 2023).

Behavioral changes may also occur as a result of exposure of the organism to pollutants. A pollutant may be a chemical substance such as toxic metals, radionuclides, organophosphorus compounds, gases, and others or a group of substances that, when introduced into the environment, can cause adverse effects on ecosystems and human health or geochemical substance (dust, sediment), a biological organism or product (bacteria, viruses, etc.), or a physical substance (heat, radiation, sound waves) that is intentionally or accidentally released by humans into the environment and has actual or potential harmful, unpleasant, or nuisance effects. Environmental pollution can be classified as air pollution, water pollution, land pollution, noise pollution, radioactive pollution, light pollution, thermal pollution, and so on. Pollutants are environmental stressors (Jacquin L. et al., 2020).

The results of our research correlate with the data of different world authors regarding this negative phenomenon for the living environment.

5. Conclusions

- The experimental results provide important insights into the biological effects of environmental pollution in the Polog field region in longitudinal and vertical profile, particularly on embryonic development in avian species. Both **chicken and quail eggs** were used to evaluate the developmental toxicity of pollution extracts. The findings demonstrated a range of adverse outcomes, including mild growth retardation (e.g., reduced embryo weight and size), more pronounced developmental abnormalities (such as malformed beaks and underdeveloped feathering), and, in severe cases, complete arrest of embryonic growth. These effects were dose dependent, with higher concentrations of pollutants leading to lethal outcomes and total developmental failure in both species.
- Notably, the study raises concerns about the potential of airborne pollutants to disrupt key physiological systems. The possibility of negative impacts on the nervous, cardiovascular, respiratory, and endocrine systems especially during early developmental stages highlights the need for further targeted research in this area.
- While the health effects of air pollution on human populations are widely acknowledged, its influence on embryonic development and reproductive biology in both wildlife and model organisms such as birds remains insufficiently explored. The broader implication is clear: contamination of ecosystems by chemical, physical, and

biological pollutants can lead to serious ecological imbalances, threatening both human health and the integrity of natural life systems worldwide.

- In conclusion, the air in the villages along the longitudinal profile near Mali i Thatë turns out to be more polluted, while in the vertical direction, near the villages of Sharr Mountain, the pollution is lower. This indicates an uneven distribution of pollution in the region, where the Polog basin, due to its geographical position, lack of sufficient air circulation and concentration of human activities, especially in urban and industrial areas, represents an area with high potential for the accumulation of air pollutants.
- Such a situation could have fatal consequences for the population of Pollog valley, Sharr Mountain and Mali i Thatë but could also have a negative impact on the plant and animal world.
- It is recommended that state institutions should take measures to reduce air pollution, as it directly affects human health, damages plant and animal biodiversity, disrupting the natural balance and worsening the quality of life.

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