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Review article

THE IMPACT OF AIR POLLUTION ON PUBLIC HEALTH IN SOME REGIONS OF KOSOVO

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Abstract

Background: Air pollution is a major environmental and public-health concern in Kosovo, particularly in urban areas during winter. Fine particulate matter (PM_{10} and $PM_{2.5}$) poses significant health risks due to its ability to penetrate deep into the respiratory system. **Methods:** Daily PM_{10} and $PM_{2.5}$ measurements for 2024 were analyzed for Pristina, Peja, and Gjilan using data from the Kosovo Hydro-Meteorological Institute. Annual and seasonal averages were compared with WHO and EU air-quality standards. Pearson correlation analysis was used to assess the relationship between PM_{10} and $PM_{2.5}$ levels. **Results:** All regions exceeded WHO annual limits for PM_{10} (15 µg/m³) and $PM_{2.5}$ (5 µg/m³), while remaining within EU limits. Pristina recorded the highest annual concentrations (PM_{10}: 28.3 µg/m³; $PM_{2.5}$: 18.21 µg/m³). Winter pollution levels were more than twice as high as summer values, especially in Gjilan. A strong correlation between PM_{10} and $PM_{2.5}$ (r = 0.98**) indicates common emission sources such as traffic, construction dust, and solid-fuel heating. Health data from Kosovo show rising rates of respiratory, cardiovascular, and cancer cases associated with chronic particulate exposure. **Conclusion:** Urban areas in Kosovo experience persistent air pollution that exceeds WHO recommendations, particularly during winter. The observed seasonal and regional patterns underscore the urgent need for improved air-quality monitoring, stricter emission controls, and targeted public-health measures.

Keywords: Air pollution, $PM_{2.5}$, PM_{10}, public health, Locality , Kosovo, exposure assessment

Introduction

One of the biggest problems for the environment and human health worldwide is air pollution. High levels of pollutants in the atmosphere are a result of increased urbanization, heavy transportation, industry, and the combustion of fossil fuels. The World Health Organization (WHO., 2006) estimates that exposure to contaminated air causes over 7 million deaths annually. Human health is linked with the built environment and air pollution through opportunities of physical activities for good health and air pollution inhalation leading to poor health. The most hazardous air pollutants, PM2.5 and PM10, are small particles that enter the lungs deeply. Nitrogen dioxide (NO_2) is mostly produced by automobiles, sulphur dioxide (SO_2) is produced by coal and industry, Tropospheric Ozone (O_3) is created by atmospheric chemical processes. Carbon monoxide (CO) with polycyclic aromatic hydrocarbons (Manisalidis *et al.,* 2020). The origins of air pollution, the primary categories of contaminants, and their effects on public health are reviewed in this essay. Air pollution and climate change are closely related. Climate is the other side of the same coin that reduces the quality of our Earth (44). Pollutants such as black carbon, methane, tropospheric ozone, and aerosols affect the amount of incoming sunlight (Gennaro *et al*., 2016). The ongoing phenomena of human migration from rural to urban areas began in the 18th century with the emergence of the industrial period. The worldwide urban population surpassed the rural population in 2008, marking a turning point in the urban-rural demographic balance. By 2050, it is expected to account for more than 70% of the world's population (UNFPA.,2007). Urbanization has greatly enhanced human comfort and quality of life, but it has also brought about some unforeseen issues. Among these are urban heat islands (UHI) and air pollution. Mass vehicle use is a relatively new source of urban air

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pollution. It results from the normalization of sprawl or suburban living (Piracha *et al.,* 2022). The problem of air pollution is complicated. It is a mixture of several gases and particles. Particulate matter, volatile organic compounds, ozone, carbon monoxide, sulphur oxide, and nitrogen oxide are examples of air pollution (Anenberg *et al.,* 2010). The effects of air pollution are made worse by UHI (Ulpiani G., 2021). Higher energy and water usage (Arnfield A., 2003), declining air quality (Weng and Yang., 2006), increased CO emissions (Roxon *et al.,* 2020), and major consequences for human health are among the proven negative effects of UHI. Particulate Matter (PM) is airborne pollution (dust, soot, smoke) classified by size (PM10, PM2.5, ultrafine), originating from sources like vehicle exhaust, industry, fires, cooking, and even natural events, plus secondary formation from gases like SO_2 and NOx in the air. Measured by filters and pumps, PM is dangerous because fine particles penetrate deep into lungs and bloodstream, causing heart/lung disease, cancer, asthma, stroke, and premature death, with no safe exposure level recognized. Air pollutants show these effects by causing direct cellular injury or by inducing intracellular signalling pathways and transcription factors that are known to be sensitive to the oxidative stress (Baulig *et al.,* 2003). The quality of life in Kosovo has deteriorated due to environmental degradation, industrial pollutants, a weak waste management system, extensive use of fertile land for construction, and neglect and misuse of natural resources. Many cities in Kosovo experience inadequate air quality, with ambient concentrations of particulate matter measuring 2.5 micrometres in diameter or smaller (PM2.5) significantly surpassing both national and European Union (EU) standards, as well as the global air quality guidelines for PM2.5 established by the World Health Organization (WHO.,2006). Air pollution in the capital, Pristina, is on par with that of major cities such as Beijing, Mumbai, and New Delhi. In particular, during winter months, urban areas experience severe episodes of smog and haze, primarily due to the increased demand for heating in the residential and commercial sectors, which largely relies on the burning of solid fuels. The current levels of air pollution pose significant risks to Kosovo's population of 1.9 million, resulting in detrimental health effects (World bank., 2019). Exposure to fine PM2.5 poses significant dangers to human health, as these particles can penetrate deep into the lungs and enter the bloodstream, leading to various illnesses and even fatalities. As a consequence, they can lead to serious health issues, including lower respiratory tract infections, cancer affecting the trachea, bronchi, and lungs, ischemic heart disease (IHD), heart attacks, and chronic obstructive pulmonary disease (COPD). The strongest causal links are seen between PM2.5 pollution and cardiovascular and pulmonary diseases. Many people in Kosovo are exposed to ambient concentrations of fine particulate matter (PM) 2.5 micrometres in diameter or less (PM2.5) that are higher than the European Union's (EU) less strict limit value of 25 $\mu g/m^3$ and the World Health Organization's (WHO) air quality guideline value of 10 $\mu g/m^3$ .Lung cancer, ischemic heart disease (IHD), heart attacks, chronic obstructive pulmonary disease (COPD), and respiratory disorders are all linked to PM2.5, which has well-documented negative health impacts and is one of the world's leading causes of sickness and death (WHO.,2016). Due to unfavourable weather conditions that restrict atmospheric dispersion and increased emissions, particularly from the burning of solid fuels for heating homes and other structures, Kosovo's wintertime PM concentrations are noticeably higher (WHO., 2006). Smaller particles reach the lower respiratory tract and thus have a greater potential to cause lung and heart disease. According to the Landrigan *et al.* 2017, PM2.5 air pollution is associated with several risk factors for cardiovascular disease, including hypertension, increased serum lipid concentrations, accelerated progression of atherosclerosis, increased prevalence of cardiac arrhythmias, increased emergency department visits for cardiac disease, increased risk of acute myocardial infarction, and increased mortality from cardiovascular disease and heart attack. Premature deaths and illnesses brought on by air pollution not only inflict suffering, but they also raise health care expenditures and reduce productivity at work. Because acidic and nitrogenous substances in the air can be deposited in

soil and water, decreasing their quality and impacting ecosystems, air pollution also affects agriculture. This has an impact on food quality and commercial uses of the area, such as tourism. Furthermore, air pollutants that contribute to climate change include black carbon (BC), which is a part of PM2.5. Particle pollution exposure has been linked in numerous scientific studies to a number of issues, such as: increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing; nonfatal heart attacks; irregular heartbeat; aggravated asthma; reduced lung function; and premature death in individuals with heart or lung disease. Particle pollution exposure is most likely to affect those with heart or lung problems, children, older persons, minority populations, and low socioeconomic status groups, either because they are more susceptible or may have higher exposures. (U.S. Environmental Protection Agency; 2025). Smoke emissions can travel hundreds of kilometers downwind of fire areas, exposing people to a complex mixture of fine particles, ozone precursors, and other harmful compounds (Dennekamp M, Abramson MJ., 2011). According to a recent global estimate, smoke from landscape fires may be responsible for 339,000 deaths annually.13 Hospital admissions for respiratory and cardiovascular conditions, as well as ER visits, are strongly correlated with PM levels (Gennaro *et al.,* 2016). The main goal in our study were to determine the extent to which exposure to $PM_{2.5}$ and PM_{10} contributes to health problems in the population of selected municipalities in Kosovo.

Materials and Methods

Study Area

The study was conducted in selected regions of Kosovo, including urban where official air-quality monitoring stations are located (Prishtina, Gjilan and Peja). These regions were chosen based on population density, availability of air-quality data, and reported health concerns.
Description of Regions
Prishtina is located in the north-eastern part of Kosovo, with geographic coordinates **42.66° N, 21.16° E.** It lies in a hilly–plain area, with an average elevation of approximately **652 meters above sea level.** The climate is **continental with Mediterranean influences,** featuring cold winters with occasional snowfall and hot, dry summers. The average annual temperatures range between **10–12°C.** Winter temperature inversions contribute significantly to the accumulation of air pollutants (KHMI). Rapid urbanization has led to several consequences, including infrastructure expansion, increased air pollution, and the reduction of green spaces in central urban areas. Peja is located in the **western part of Kosovo,** at the foothills of the Bjeshkët **e Nemuna**. It is one of the most important geographical, cultural, and economic centres of the region. **Geographical Coordinates:** approximately **42.66° N, 20.29° E. Elevation:** around **500 meters above sea level** in the city centre; higher altitudes extend toward Rugova Canyon. Peja has a continental–mountain climate, characterized by: Cold winters with moderate snowfall, Warm to hot summers, Average annual temperature: roughly 11–12°C.Gjilan is located in the **southeaster part of Kosovo,** near the borders with North Macedonia and Serbia. It serves as an important regional centre for trade, agriculture, and administration. Geographical Coordinates**:** approximately 42.46° N, 21.47° E. Elevation**:** around 460–520 meters above sea level, depending on the part of the city. Gjilan has a continental climate, characterized by Cold winters with occasional snowfall, Hot and dry summers.

Materials / Data Sources

In our study the data sources were daily air-quality measurements of $PM_{2.5}$ (fine particulate matter), PM_{10} (coarse particulate matter). Particulate matter (PM) pollution includes particles with diameters of 10 micrometres (μm) or smaller, called PM, and extremely fine particles with diameters that are generally 2.5 micrometres (μm) and smaller Willson WE 1997. All data information for year 2024 on air quality (AQ) are which was include in our study are taken from Kosovo Hydro Meteorological Institute This data was generated with Complementary Sensor Networks (KHMI).

Statistical Analysis

The data used in this study were obtained from the **Kosovo Hydro Meteorological Institute and** include official air-quality measurements for the year **2024.** The analysis was conducted for three selected regions: **Prishtina, Peja, and Gjilani,** chosen based on their demographic importance, level of urbanization, and availability of continuous monitoring data. To evaluate climatic influences and potential pollution sources, the dataset was divided into two seasons: **Winter (November–March)** Characterized by increased use of solid fuels for heating, thermal inversions, and generally higher particulate concentrations. **Summer (June–September)** Characterized by higher temperatures, greater atmospheric mixing, and typically lower $PM_{2.5}$ and PM_{10} levels. The comparison was made with the Determination of exceedances of WHO and EU air quality standards. Pearson Correlation Analysis (PCA) was conducted to assess the relationship between: seasons Winter (November –March) and Summer (June-September). While the Chi square (χ^2) test and ANOVA for LSD 5 and 1% was calculated by the statistical program MINITAB 18.

Results and Discussion

Urban air pollution is an environmental concern of many cities throughout the world and now recognized as an important health problem, both nationally and worldwide. The air quality measurements (AQM) for the three municipalities (Prishtina, Peja, and Gjilan) that we investigated were compared to WHO and EU criterion norms. The results highlight important public health issues and show large regional variations in pollution levels. The WHO yearly recommendation of 15 $\mu g/m^3$ is exceeded by all three localities, suggesting that coarse particle pollution is a year-round problem. All regions are still inside the 40 μg/m yearly EU limit, though. Prishtina exhibits the highest yearly average (28.3 $\mu g/m^3$), suggesting ongoing exposure to higher PM10, perhaps as a result of winter heating, building dust, and heavy traffic. In 2017, 3.5 million premature deaths from respiratory infections, diabetes, cardiovascular disease, lung infections, obstructions, and cancer were caused by transportation-related air pollution (Anenberg *et al.,* 2015). The effects of exposure to pollutants in the indoor environment can be acute and chronic and vary from person to person, which can be considered a major public health concern. Some results from Kosovo Agency of Statistics (KAS) 2024 reports that the number of cancer cases has significantly increased from 3110 in 2022 to 4165 in 2023.

Table.1. The Annual average of pollution in three regions in Kosova

Pollution	Regions	Prishtine	Peja	Gjilan	WHO Standard(µg/m³)	EU (µg/m³)
PM10	annual average	28.3	19.46	20.92	15	40
	Max	43.61	35.39	41.88		
	Min	17.04	8.46	8.39		
PM2.5	annual average	18.21	13.82	16.84	5	25
	Max	34.22	29.66	37.75		
	Min	9.69	6.64	5.86		
	SD	12.53	11.60	14.94		

The lower averages in Gjilan (20.92 µg/m³) and Peja (19.46 µg/m³) indicate either better natural ventilation or fewer emission sources. Pollution in Prishtina and Gjilan are significantly greater, probably as a result of severe winter pollution occurrences. Peja exhibits a lower and more stable peak, probably as a result of improved air circulation. Prishtina exhibits high minimum levels, indicating that pollution is present all year round. There are times when the air is noticeably cleaner in Peja and Gjilan. While all municipalities satisfy the EU standard for PM10, none of them meet the WHO standard. Please refer to Figure 1 and Table 1. The Table 1 showed that the Prishtina locality's maximum PM10 values were 43.61 µg/m³, while the lowest values were 17.04 µg/m³. The difference between these values was 26.57 µg/m³, while the differences for PM2.5 were 24.53 µg/m³, which can be regarded as highly significant differences on high variation and can be considered the area with the highest health risk.

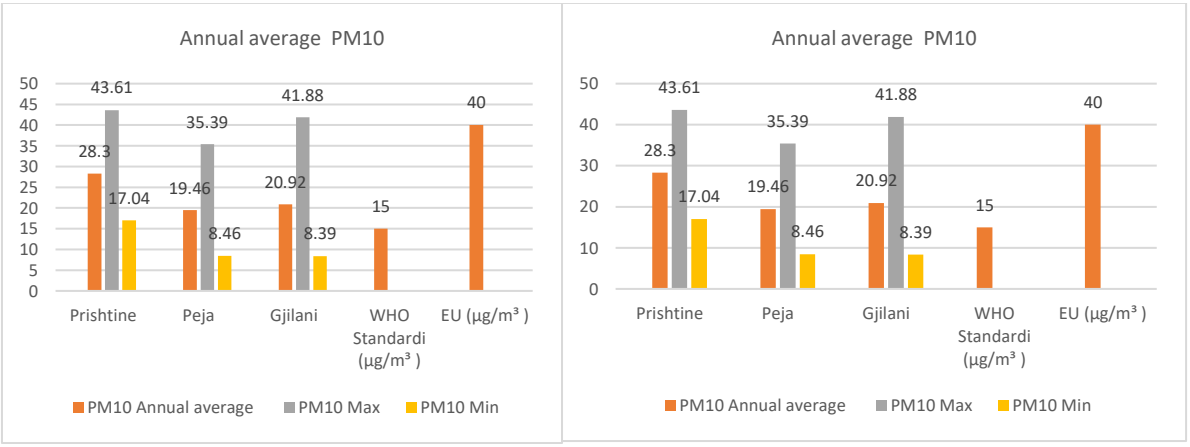


Figure 1. Comparison the annual average pollution with WHO and EU Standards

The PM2.5 is the most dangerous pollutant because it penetrates deep into the lungs and bloodstream. From our results for PM2.5 the results showed different results in three localities. In Region of Prishtina the annual average for PM2.5 were 18.21 µg/m³ and compared with WHO standards (5µg/m³) was Very high exceedance (3.6× above) while with EU standards are within the lim**it (25µg/m³).** While region Peja's extreme values (Max and Min) for PM10 and PM2.5 were 26.93 µg/m³ and 23.02 µg/m³, respectively, moderate spread has the best levels but still above WHO. Additionally, the highest values for PM10 and PM2.5 in the region of Gjilan were 33.49 and 31.89 µg/m³, respectively. This indicates days with exceptionally high pollution levels and is a very high variability characterised on unstable pollution. According to Table 1's findings, there was a very substantial connection (r=0.98**) between Pm10 and Pm2.5 particles**.** **Results are presented in Table 1 and figure 2.** Some results which was done by Shabani *et al.,* 2022 for the pollution in Prishtina, reported that 15,141 respiratory visits (11,344 with

diagnostic "J" , 3797 with diagnosis "U07") and 6440 cardiovascular visits were recorded during the observation period. The temperature varied from -8.6 to 28.3 ◦C (mean: 10.8 ◦C) and the particulate matter (PM2.5) concentration ranged from 2.4 to 120.3 µg/m3 (arithmetic mean: 21.8). A time trend line with 25 and 23 nodes, respectively, worked well for respiratory and cardiovascular cases. Many studies by different authors Jerrett *et al.,* 2009; Epton *et al.,* 2008 related to air pollution suggest that exceeding the standard limits can cause diseases such as negative impact on lung development in children and adolescents. Most studies have suggested negative effects of air pollution on lung function and respiratory symptoms in children. According to Menace of Air Pollution in the 21st Century, pollution is an unwanted alteration in the physical, chemical, or biological properties of soil, water, and air that may have an impact on life or pose a risk to any living thing and it is determined that respiratory allergies (asthma, rhinitis) are a threat posed by air pollution (Kumar R., 2018). Children who are exposed to pollution may experience immune system impairment, respiratory disorders, nasopharyngeal carcinoma, and leukaemia (UNICEF., 2016).

Table 2. The mean pollution levels in Prishtina throughout the winter and summer

Prishtina/months	PM10 Winter	PM2.5 Winter	PM10 Summer	PM2.5 Summer
1	43.61	34.22	17.04	9.69
2	35.21	23.74	23.3	11.42
3	26.47	16.83	22.91	12.09
4	35.22	27.25	23.24	12.48
5	37.7	28.8	21.54	12.02
Average	*35.64µg/m³*	*26.16µg/m³*	*21.60µg/m³*	*11.54µg/m³*
CV%	*17.30*	*24.62*	*12.26*	*9.54*
Chi square (χ^2)	*18.55*		*44.43*	
P-value	*0.007*	*0.008*	*0.001*	*0.000*

Notes: Months for winter seasons are included: 1-January W, 1-May S, 2-February W, 2-June S,

3-March W, 3-July S, 4-November W, 4-August S, 5-December W, 5-September S

The average winter concentration of PM10 is 35.64 µg/m³, while the average summer concentration is 21.16 µg/m³. This shows that PM10 levels in winter are approximately 65% higher than in summer. The winter values range from 26.47 to 43.61 µg/m³, indicating significant variability influenced by weather, heating intensity, and atmospheric conditions. Summer values are much lower and more stable, ranging from 17.04 to 23.30 µg/m³, reflecting better air dispersion and lower emissions. The average winter concentration of PM2.5 is 26.16µg/m³, compared to 11.54 µg/m³ in summer. PM2.5 levels in winter are more than double the summer values (approximately 126% higher). Winter values range from 16.83 to 34.22 µg/m³, consistently exceeding WHO recommended limits. Summer values remain low, between 9.69 and 12.48 µg/m³, indicating significantly cleaner air during warmer months. The ratio PM2.5/PM10 from our results is: **Winter seasons:** 26.16 / 35.64= **0.73** which indicates pollution dominated by fine particles and for **Summer seasons:** 11.54 / 21.60 = **0.53 which** suggests a higher share of coarse dust in summer. Table 2. According to the **Kosovo Environmental Strategy 2013–2022,** the main contributors to air pollution are power plants, industrial facilities (metallurgy, mines, and cement factories), households, the transport sector, small combustion plants, agricultural activities, and waste burning. The exposure to heat-related health concerns in metropolitan areas and larger urban centres has increased proportionately with the world's growing urban population (Tong *et al.,* 2021).

Table 3. The mean pollution levels in Peja throughout the winter and summer

Peja/months	PM10 Winter(W)	PM2.5 Winter(W	PM10 Summer (S)	PM2.5 Summer(S)
1	35.39	29.66	11.62	6.64
2	33.42	22.018	14.09	6.87
3	18.91	12.33	17.35	7.1
4	25.27	21.85	10.81	6.78
5	29.29	26.2	8.46	8.46
Average	*28.456 µg/m³,*	*22.4116 µg/m³,*	*12.466 µg/m³,*	*7.17 µg/m³,*
CV%	*23.22*	*29.0*	*27.20*	*10.32*
Chi square (χ^2)	*11.62*		*28.64*	
P-value	*0.0006*	*0.0015*	*0.0012*	*0.000*

Notes: Months for winter seasons are included: 1-January W, 1-May S, 2-February W, 2-June S,

3-March W, 3-July S, 4-November W, 4-August S, 5-December W, 5-September S

The PM10 levels in regions of Peja decreased by 56%, from an average of 28.46 µg/m³ in the winter to 12.47 µg/m³ in the summer. In contrast, PM2.5 drops by 68% from 22.41 µg/m³ in winter to 7.17 µg/m³ in summer. In Peja, PM2.5 also makes up a sizable portion of PM10, however the Winter ratio was: 22.41 divided by 28.46 equals 0.79 shows that fine particles from combustion (wood, coal, transportation, etc.) are the main source of winter pollution. The summer ratio, which is 7.17/12.47 = 0.57, indicates a little greater contribution from coarse particles (dust resuspension). All winter values are higher than WHO limits, with some exceeding WHO limits by more than twice (PM2.5=29.66 µg/m³, for example). Summer averages are likewise higher than WHO norms. The WHO yearly limit of 5 µg/m³ is still exceeded by only one summer PM2.5 point (8.46 µg/m³), which is above the PM2.5 summer pattern. This shows that although levels are much lower than in the winter, Peja still does not satisfy WHO standards in the summer. Table 3.

Table 4. The mean pollution levels in Gjilan throughout the winter and summer

Gjilan/months	PM10 Winter(W)	PM2.5 Winter(W)	PM10 Summer (S)	PM2.5 Summer(S)
1	41.81	37.75	8.39	5.86
2	41.88	34.35	11.85	7.1
3	21.66	17.27	12.4	8.37
4	30.6	25.89	12.84	9.37
5	30.04	27.69	11.08	7.7
Average	*33.198* µg/m³.	*28.59* µg/m³.	*11.312* µg/m³.	*7.68* µg/m³.
CV%	*26.06*	*27.83*	*15.56*	*17.20*
Chi square (χ^2)	*4.08*		*8.94*	
P-Value	*0.0010*	*0.0013*	*0.0001*	*0.0002*

Notes: Months for winter seasons are included: 1-January W, 1-May S, 2-February W, 2-June S,

3-March W, 3-July S, 4-November W, 4-August S, 5-December W, 5-September S

Results for PM10 and PM2.5 measurements for winter (W) and summer (S) are shown in the Table 4. . The PM10 and PM2.5 pollution levels are much greater in the winter than in the

summer. PM10 levels in the winter range from 21.66 to 41.88 μg/m³. While February had the highest number (41.88 μg/m³), with January coming in second (41.81 μg/m³). March had the lowest winter PM10 (21.66 μg/m³). The WHO's recommended annual threshold of 15 μg/m³ is exceeded by the average winter PM10 (33.198 μg/m³), indicating significant pollution. PM2.5 levels in the winter range from 17.27 to 37.75 μg/m³. The highest winter PM2.5 is at January (37.75 μg/m³). While the average winter PM2.5 (28.59 μg/m³) is nearly 4 times higher than WHO's recommended annual guideline of 5 μg/m³, and this indicates significant health risk during winter, as PM2.5 penetrates deeply into the lungs. PM10 levels in the summer range from 8.39 to 12.84 μg/m³, with Point 4 having the highest value (12.84 μg/m³). The average summer PM10 (11.312 μg/m³) is significantly lower than winter levels and falls within safe bounds. In contrast, PM2.5 ranges from 5.86 to 9.37 μg/m³. Point 4 has the highest summertime PM2.5 (9.37 μg/m³). The average (7.68 μg/m³) is far lower than winter levels, yet it is marginally more than the WHO's suggested limit of 5 μg/m³. The PM10 results for winter (33.198 μg/m³) are almost three times greater than those for summer (11.312 μg/m³). Additionally, PM2.5 levels in the winter (28.59 μg/m³) are nearly four times greater than those in the summer (7.68 μg/m³).

Conclusions and Recommendation

Based on the data available from our results for the three regions, the following main conclusions are; Annual concentrations of **PM2.5** and **PM10** frequently surpass WHO and EU limits. The Prishtina among the regions are with a significantly elevated risk of long-term health impacts. Epidemiological studies in Kosovo show a clear link between rising PM levels and higher incidence of asthma, chronic bronchitis, acute respiratory infections. Scientific evidence indicates that long-term exposure to PM2.5 raises the risk of: hypertension, ischemic heart disease, myocardial infarction (heart attack), peripheral circulation disorders. The risk increases by **10–20% for every 10 μg/m³ increase in PM2.5.** According to WHO and World Bank estimates: approximately **700–900 deaths annually in Kosovo** are attributable to air pollution exposure, a considerable portion originates from major urban areas, including Prishtina.
Based on the results for these three locations, we can recommend that**;**

- Continuous air quality monitoring should be expanded, especially in Prishtina and Gjilan, where variability and maximum pollution concentrations are higher. Specific monitoring programs should be established, especially during the winter season when pollution is highest.
- To Implement strong measures of control emissions during winter seasons since particulate matter concentrations are 60-120% higher, municipalities should implement temporary winter measures, such as restrictions on the use of low-quality fuel, subsidize cleaner heating systems.
- High PM levels throughout the year in Pristina indicate that some of them come from vehicle emissions. The strategies such as improved public transport and reduced vehicle use are recommended, where is possible.
- To develop targeted public health interventions, given the strong PM10–PM2.5 correlations ($r = 0.98$) and documented increases in respiratory and cardiovascular cases, health institutions should implement early warning systems, improve emergency during pollution days, and increase public awareness.
- Encouraging environmentally friendly urban infrastructure Particularly in densely populated regions, increasing urban green spaces with vegetation can aid in lowering particulate matter concentrations.

- Increasing public education and communication, awareness campaigns on the risks of pollution and behaviour during high pollution are essential for reducing exposure and improving responses at the community level.

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