

## Case Study: Pollution of Air with PM Particles in the City of Bitola, Macedonia

Nikola V. Dimitrov<sup>1</sup>, Mite Ristov<sup>2</sup>

Gordana Boshkovska<sup>3</sup>, Daniela Ristova<sup>4</sup>, Aneta Pechipaykovska<sup>5</sup>, Metodija Boskovski<sup>6</sup>

<sup>1</sup>(Faculty of tourism and business logistics/ University Goce Delcev, Stip, Macedonia)

<sup>2</sup>(High school / Josip Bros Tito, Bitola, Macedonia)

<sup>3</sup>(Primary school/ Gorgi Sugarev, Bitola, Macedonia)

<sup>4</sup>(Primary school/ Todor Angelevski, Bitola, Macedonia)

<sup>5</sup>(Primary school/ Kole Kaninski, Bitola, Macedonia)

<sup>6</sup>(Primary school/ Dame Grujev, Bitola, Macedonia)

**Abstract:** The paper is the result of a research project that was conducted to assess the impact of urban air pollution from PM particles and raise people's awareness. The goal of the project was to identify air pollutants and to propose measures to overcome the problem. The research was attended by professors, young people and citizens supported by the local community. The monitoring values of PM10 at the measuring points show that the ambient air of the city of Bitola is permanently exacerbated with a negative impact on human health. Exposure to people with polluted air has shown significant changes in health status. These changes can be an indicator of environmental stress caused by uncontrolled urban air pollution. The survey ends with a draft measures to reduce air pollution in the city.

**Keywords:** PM particles, polluted air, environmental stress, Bitola, Macedonia

### I. INTRODUCTION

The problem of pollution with PM particles is present in most urban settlements in the world. Air pollution causes great concern globally due to the mission of a variety of human activities, and to the detriment of its health and the condition of the wildlife as a whole. Air pollution in urban areas is mainly due to emissions of industrial gases and traffic-related particles, combustion from households' fires and other pollutants. (1), (2), (3), (4), (5).

Currently, in Macedonia, air pollution is widespread in urban areas, where apart from industry and thermal power plants, major air polluters are vehicles and households.

Motor vehicles powered by petrol and diesel engines release a wide range of pollutants, carbon monoxide, organic compounds, nitrogen oxides, sculpture dioxide, and suspended particles of ultra fine primary particles, smoke, metals (Cd, Co, Cu, Pb, итн) and internal dust, etc. (1), (2).

### II. MATERIALS AND METHODS

#### Data for the area of the city

This study arose from the realized research and educational project: "Snap, post, alert" at the regional geographical association "Geosfera" from the city of Bitola, located in the southwestern part of the Republic of Macedonia.

Bitola, is located at 41 ° 01'55 " N north latitude and 21 ° 20'05"E eastern latitude and 620 meters mean altitude (MSL), with a total area of the urban zone of the city of 25km<sup>2</sup>, and of the city area of 422.38 km<sup>2</sup>. The total population in the city is 74,550 inhabitants, and the area of 105,644 inhabitants (census 2002). (Map 1.) The city of Bitola is the seat of the municipality and the Pelagonia statistical region. Climatic classification of the Köppen Climate is Cfb mild wet continental climate with hot and dry summers and cold and snowy winters. and winds from the northern and southern quadrants.

Map 1. Geographic location of Macedonia and Bitola

### **Preparations and steps in the research**

The research educational project: "Take pictures, post, alert" is aimed at acquainting citizens with air pollution with PM particles, then raising citizens' awareness of the harmful effects of air pollution, human health, identifying the causes and the consequences of polluters in the immediate environment, to alert the competent institutions and to define draft measures for reducing pollution. Realization of project activities took place through several steps. First step, a workshop with professors - mentor members of the RGD "Geosfera" and introduction to the application "Notecam lite - photo with notes" needed for determining the geographical coordinates using a smartphone for all air pollutants. Second step, educational lecture "PM particles in the air - continuous killer of all of us" in front of students and citizens (October 25, 2017). Presented general aspects of air pollution with PM particles in Macedonia and the world.

Third step: realization of 10 educative lectures of educators - mentors and students in 9 schools in the city. Fourth step: Start of the research (November 3, 2017). Fifth step: Presentation of the project to the local authorities and signing a memorandum of cooperation with the Municipality of Bitola (November 24, 2017), to alert the relevant research institutions to take measures for improving the air quality. Step 6: Presentation of the results of the research and educational project (February 24, 2018).

### **Sampling and selection of research methods**

Course of the research. The current concentrations of PM particles were measured on 03.11.2017 between 19:00 and 21:00 on 14 measuring units from Bitola to Novaci (Ciflik, Brusnichka, Dovlezhik, Black Bridge, Gymnasium, Bitola 2, Bela Cesma, Winx, Bitola 1, River Dragor, Open space, Logovardi, Open space, Novaci), with weather conditions of 7 ° C, increased concentrations of particles in the central city area Bitola 2 with 280 mg / m<sup>3</sup> and Bitola 1 with 250 mg / m<sup>3</sup>, and reduced concentrations in the western higher parts of the city from 60 to 180 mg / m<sup>3</sup>.

On 10.11.2017, in the period between 13:00 and 15:00 hours, the 14 measurement units, with the weather conditions of 11° C, measured the current concentrations of PM particles in the central city area Bitola 1 with 350 mg / m<sup>3</sup> and Bitola 2 with 260 mg / m<sup>3</sup>, and decreased concentrations in the western higher parts of the city from 60 to 190 mg / m<sup>3</sup>.

On 06.12.2017, between 22 and 23 hours of the 14 units of measurement, with the weather conditions of 8° C, the current concentrations of PM particles were measured, increasing concentrations of PM particles in the central city area Bitola 1 with 400 mg / m<sup>3</sup> and Bitola 2 with 390 mg / m<sup>3</sup>, and decreased concentrations in the western higher parts of the city from 40 to 100 mg / m<sup>3</sup>.

On 25.12.2017, in the period between 14.00 and 15.00 hours, on 14 measuring units, with weather conditions of 8° C, increased concentrations of PM particles were recorded in the central city area Bitola 1 with 240 mg / m<sup>3</sup> and Bitola 2 with 360 mg / m<sup>3</sup>, and decreased concentrations in the western higher parts of the city from 50 to 110 mg / m<sup>3</sup>.

On 26.12.2017, between 19:00 and 20:00 hours on 14 measuring units, with weather conditions of 2° C, increased concentrations of PM particles in the central city area Bitola 2 with 700 mg / m<sup>3</sup> (14 times higher values than the maximum allowed concentrations (MPC, 50 mg / m<sup>3</sup>) and Bitola 1 with 400 mg / m<sup>3</sup>, and decreased concentrations in the western higher parts of the city from 100 to 350 mg / m<sup>3</sup>.

On January 10, 2018, between 19:00 and 20:00 hours, on the 14 units of measurement, with a 3° C timing, the current concentrations of PM particles from the Bitola to Novaci region were measured, and concentrations of particles were recorded in the central city area of Bitola 2 with 350 mg / m<sup>3</sup> and Bitola 1 with 300 mg / m<sup>3</sup>, and reduced concentrations in the western upper parts of the city from 60 to 100 mg / m<sup>3</sup>.

## **III. RESULTS AND DISCUSSION**

The research shows that the most polluted air with a high concentration of PM particles is in the central area of the city due to the high traffic density, the density of individual housing houses using wood for heating, poor air circulation and a small green area.

From field surveying and registration of polluters, photographing objects that pollute the air and their mapping, 16 industrial and energy facilities were registered, 98 individual and collective homes emitters of large pollution, 7 public polluters, 22 burned waste, 10 hotels and bakeries polluted, 5 construction sites, all located in 2 alarm regions of the city.

Participants in the research through the Facebook group of 240 pupils and 1314 other members from Bitola, 315 posts were posted, 2085 likes and emoticons and 192 comments. The Facebook group has initiated activities for 12 field inspection supervisors with no penalties for polluters to the competent authorities.

The results of the research on the maximum concentration of PM 10 particles for the days 10.11.2017 and 26.12.2017 is presented in Figures 1 and 2.

**Figures 1. Maximum concentration of particles PM 10 for 10.11.2017**

**Figures 2. Maximum concentration of particles PM 10 for 26.12.2017**

The pollution level with PM 10 particles per month for 11.2017, 12.2017 and 01.2018 is presented in Figures 3,4 and 5.

**Figures 3. PM 10 pollution level in the month of 11.2017**

**Figures 4. PM 10 pollution level in the month of 12.2017**

**Figures 5. PM 10 pollution level in the month of 01.2018**

The results showed increased air pollution in the city of Bitola in the three months and this exceeds the average - allowed level of pollution, which has a negative impact on the health of the citizens.

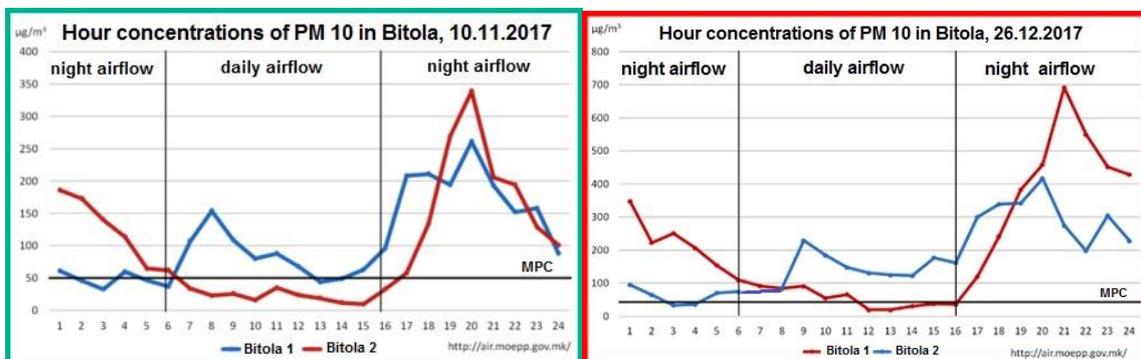
**DISCUSSION**

Air quality is one of the basic indicators of overall environmental quality. In Macedonia, urban pollution is the result of emissions from many sources, mainly stationary, industrial and domestic combustion of fossil fuels, emissions of motor vehicles and inefficient environmental regulations. Bitola due to increased urban pollution, the use of many personal vehicles, the flow of traffic in the city is a serious problem, the increased pollution from collective and individual combustion of fossil fuels, all this becoming an alarming environmental problem, especially for people's health, and a problem for plants. The research showed that the ambient air in the city in the winter months is polluted. The polluted air causes a major problem for the health of people and plants.

**IV. FIGURES AND TABLES**

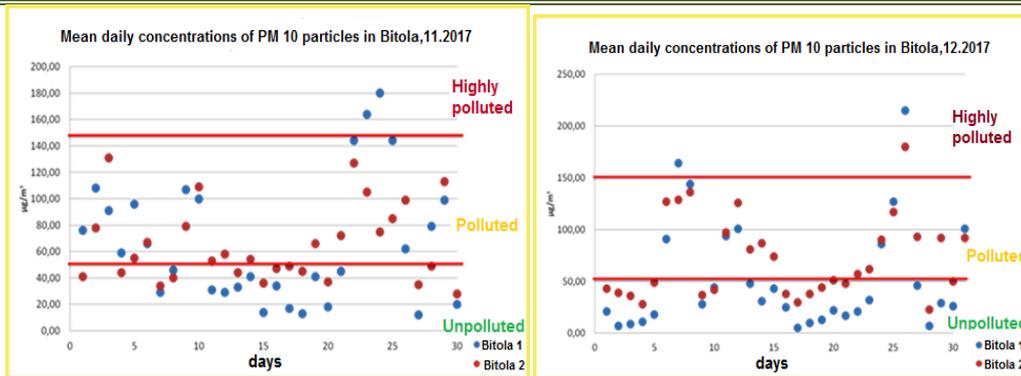


Map 1. Geographic location of Macedonia and Bitola



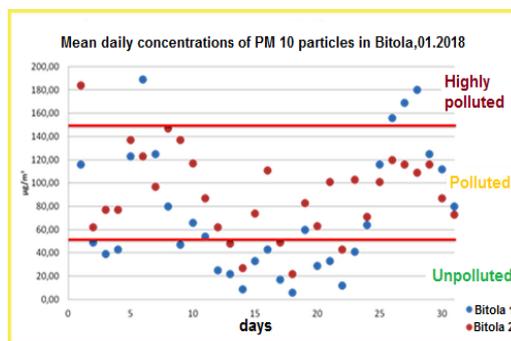
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Figures 2. Maximum concentration of particles PM 10 for 26.12.2017



Figures 3. PM 10 pollution level in the month of 11.2017

Figures 4. PM 10 pollution level in the month of 12.2017



Figures 5. PM 10 pollution level in the month of 01.2018

## V. CONCLUSION

This study shows that the research and educational project has played an important role for change and raising the awareness of citizens, local authorities and competent authorities on the problem of air pollution is PM particles in the city of Bitola. These changes can be considered as important indicators for serious control of all pollutants by citizens and institutions.

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