SPATIAL DISTRIBUTION OF PM_1 AND SINUS ARRHYTHMIAS IN ATHENS, GREECE

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ABSTRACT

The study of particulate matter with diameter less than 1 μm (PM_1) in Athens' atmosphere and their impacts on human health is the goal of this study. PM_1 concentrations were recorded by three detectors (light scattering method) at six vital points in high traffic peak roads, during the period 1/10/2006–30/9/2007. The collected PM_1 samples concern the same hour of the day, in absence of wind. The spatial distributions of the PM_1 concentrations for the warm (April to September) and the cold (October to March) period of the year were achieved by the use of Kriging method.

Further to, in order to find out the impacts of PM_1 concentrations on health, we analyzed daily admissions for non-fatal arrhythmias to emergency units of the Social Security Institute and a Regional Hospital of Athens. Results demonstrate a significant relationship of PM_1 with sinus arrhythmias, which confirms the assumption that PM_1 represent one of the main hazards in cardio respiratory syndromes in the most polluted cities of Europe, which confront high traffic problems, due to the enormous number of exhausts emissions.

KEYWORDS:
PM_1 concentrations, sinus arrhythmias, Athens, Greece.

INTRODUCTION

The particulate matter (PM) in the atmosphere is not an easy concept to understand and concerns a lot of researchers in different disciplines. PM is a mixture of particles that vary in size, morphology, chemical composition and concentration and derive from nature and human sources. Many atmospheric factors contribute in their expansion but mainly the wind conditions influence their dispersion in the air. The adverse effects of PM on public health seems to depend more on the number of particles inhaled and the duration of inhalation, than the particle dimension or the nature composition. Many researchers around the world are in close investigation with this fine irrespirable fraction of the thinnest particles, which are smaller than 1 μm, hence PM_1 [1]. Once they are inhaled, they are not filtered from the rhinofarynx, so they proceed and arrive in terminal alveoli where they are deposited [2]. In the process, they pass in to the blood stream. This easily irrespirable fraction of these thinnest PM continues to be the main hazard for the cardio respiratory pathological status of the population. PM_1 through endothelium emigrates with the blood vessels in several parts of the body reaching in fundamental organs where they are attached. [3-5]. PM1 start to be for good in close correlation with our health quality level [6]. It is already known that a great problem is emerged with the big mass of vehicles in the greater Athens area (GAA), creating serious health disorders (especially cardio respiratory syndromes) to the population, during the last twenty years [7].

The objective of this study is to contribute to the knowledge of the dispersion of PM_1, looking into the spatial distribution of PM_1 in the GAA and on the other hand to find out the PM_1 impacts on sinus arrhythmias. Moreover, the investigation of the physical and chemical processes as well as the discrimination between the various anthropogenic and natural sources is required to understand the factors that control PM_1 levels in the GAA.

DATA AND ANALYSIS

Athens is a megacity, which faces air pollution problems. The population suffers frequently from air pollution episodes even in summer and winter seasons, mainly due to vehicles, industries and central heating. The GAA extends in 450 km^2 and has a population of approximately 3,500,000 inhabitants (according to census of 2001). The city is connected to the seaside by three avenues with Southwest direction. These avenues are daily full of traffic due to people commuting towards the center of the city, most of them going to work. The total number of vehicles circulating in the city is 2,300,000 private cars (97% gasoline combustion), 15,000 taxis (84% diesel), 177,000 light trucks, 50,900 heavy trucks and 6,940 public buses, according to the Greek Environmental Ministry-Division of Air Pollution. The climate of Athens is of Mediterranean type with hot dry summers and wet winters. The mean air temperature varies from 9.3 ^oC (January) to 27.0 ^oC (July), while the relative humidity from 48% (July) to 73% (December). The annual rainfall is 376 mm.

The PM_1 concentrations were recorded at six different sites of GAA (Table 1), in the morning (07:30–8:45 LT, LT=UTC+2 hrs) with high peak traffic, during the period 1/10/2006–30/9/2007. The recordings were carried out mainly during no windy days, because of the strong dispersion of PM_1 during windy days. The instant counts were achieved in a four meters distance from the road and two meters above the ground. Three detectors (based on light scattering method) of two different models (Aerocet 531; Met One instruments US and Dustrack; TSI Co) were used [8]. All detectors were calibrated weekly and flow rate test and zero test were carried out according to the factory instructions. Regarding the epidemiological data, with respect to sinus arrhythmias, they were acquired from the emergency units of the Social Security Institute and a Regional Hospital of Athens on daily basis during the examined period. Arrhythmias, (Greek word, meaning no rhythm) are disorders of the regular rhythmic beating of the heart. Arrhythmias can occur in a healthy heart and be of minimal consequence. They also may indicate a serious problem and lead to heart disease, stroke or sudden cardiac death. Sinus arrhythmia is the simple type of arrhythmia that refer to cyclic changes in the heart rate and it is common in children and often found in adults and is not fatal for the patients. In order to find out the influence of PM_1 concentrations on sinus arrhythmias we evaluated the mean PM_1 concentrations of the sampling sites: Syntagma, Syngrou and Faliro, because the emergency units used were in close distance from these sites.

The possible correlation between the frequency of sinus arrhythmias and the examined PM_1 concentrations was examined by the application of Generalized Linear Models (GLM) with Poisson distribution [9], a method of analysis which has been performed satisfactory in previous studies [10, 11]. Poisson models with log links are often called log-

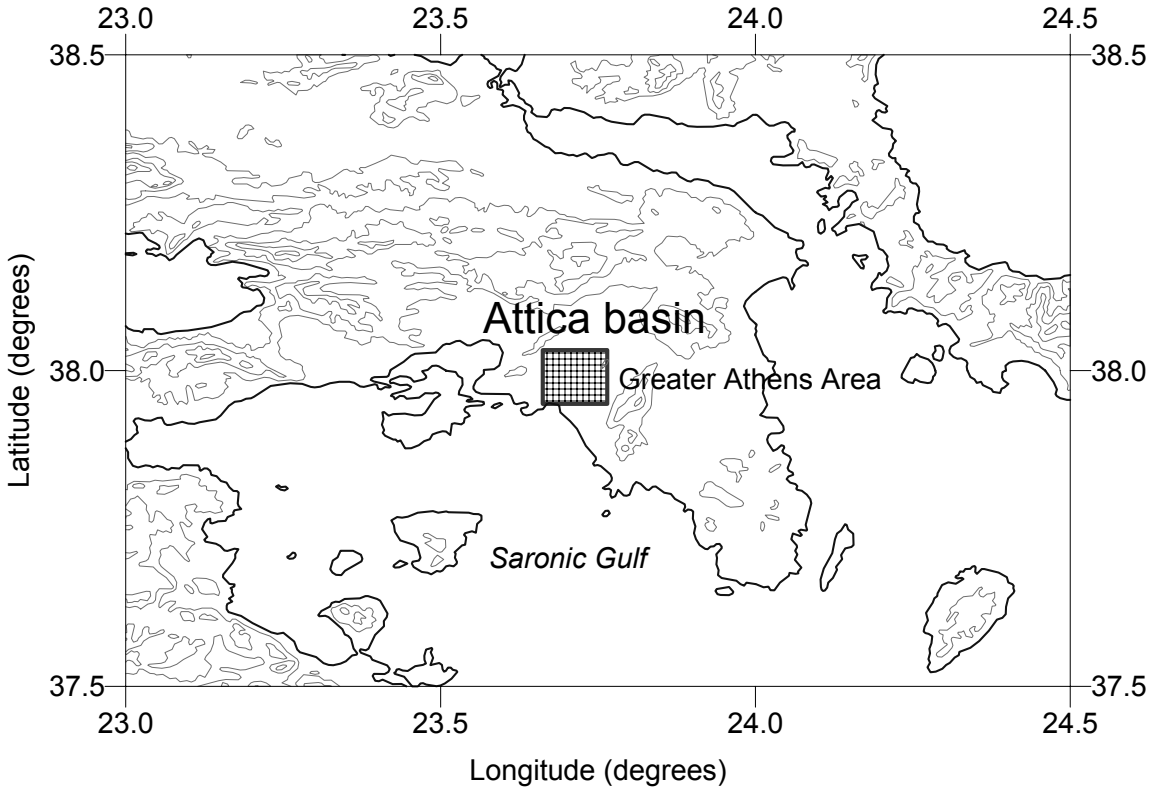


FIGURE 1 - Sampling region in the greater Athens area within the Attica basin.

TABLE 1 - Geographical characteristics of the sampling sites.

Code number	Sampling sites	Longitude (degrees)	Latitude (degrees)	Altitude (m)	Distance from sea (m)
1	**Aristotelous**	23.7285	37.9892	80	7,500
2	**Omonoia**	23.7288	37.9840	100	7,200
3	**Syntagma**	23.7347	37.9773	70	6,000
4	**Syngrou**	23.7160	37.9570	60	3,000
5	**Faliro**	23.7047	37.9277	40	1,500
6	**Piraeus**	23.6438	37.9458	3	0

linear models and are used for frequency data. In the models fitting procedure we used as dependent variable the daily number of sinus arrhythmias in the emergency ambulatories, while as independent covariates the PM_1 concentrations.

Further to, Logistic Regression Analysis was applied to the datasets, in order to estimate odds ratios for the independent variable in the constructed model. This analysis is useful for situations, in which you want to be able to predict the presence or absence of a characteristic or outcome based on values of a set of predictor variables.

RESULTS AND DISCUSSION

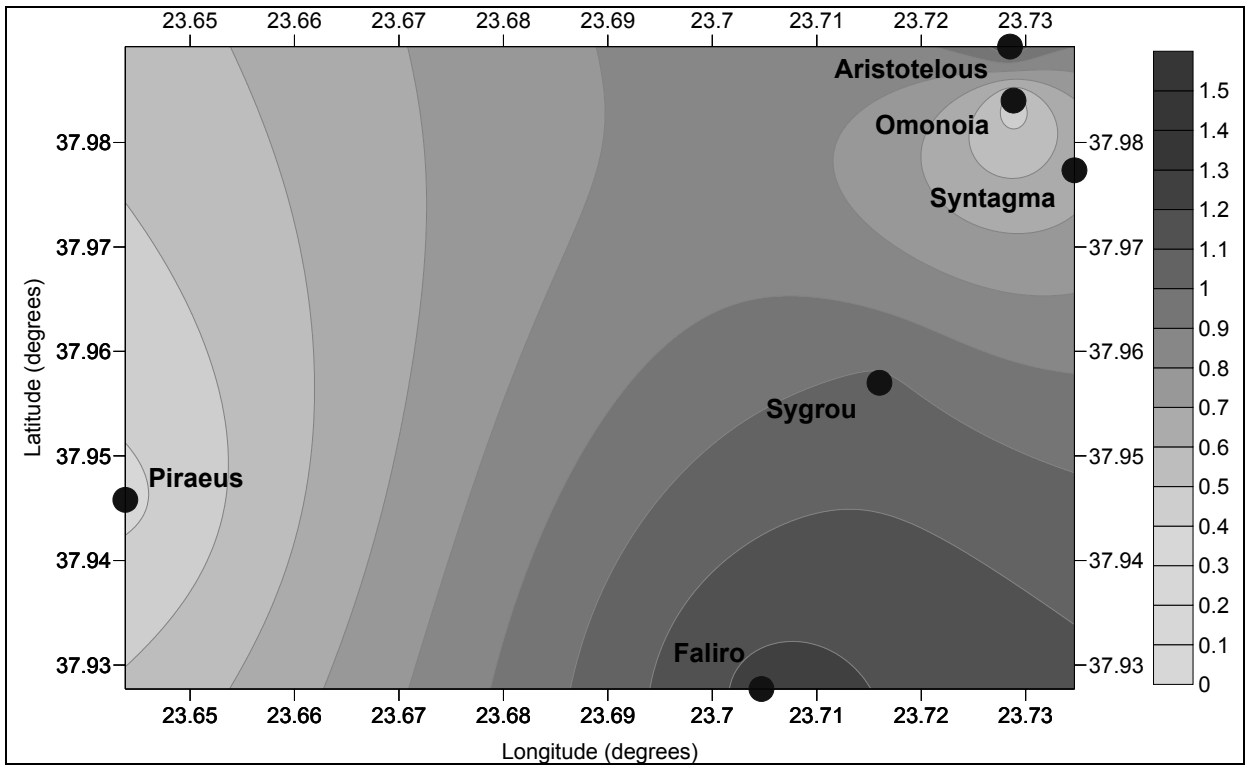
The spatial distribution of the PM_1 concentrations is depicted in Figure 2. During the warm period of the year (April-September) the PM_1 concentrations are lower than the cold period of the year (October-March) and ranges from 0.44 $\mu g \cdot m^{-3}$ (Omonoia) to 1.24 $\mu g \cdot m^{-3}$ (Faliro). Within the cold period of the year, higher concentrations of PM_1 appear all over the examined area and variate from 0.53 $\mu g \cdot m^{-3}$ (Piraeus) to 3.19 $\mu g \cdot m^{-3}$ (Faliro). A possible explanation of this finding is that except the factor of traffic, another important factor, the central heating, is aggregated to the sources that produce particulate matter. Furthermore, due to summer vacations, lower concentrations of PM_1 are recorded. In both examined periods, the sampling sites in Faliro and secondary in Aristotelous indicate the highest figures. Approximate calculations in Faliro revealed that a load of 3,800 vehicles within an hour was registered. This is expected because both locations are in heavy traffic every morning (working time).

Regarding the impacts of PM_1 on health, we found out that PM_1 are related with sinus arrhythmias more in warm period than the cold period of the year. Figure 3 depicts the correlation between PM_1 and sinus arrhythmias during the warm period ($r=0.7$, $p=0.0000$) and the cold period ($r=0.5$, $p=0.0085$). An explanation of this finding is that people prefer to stay indoors during the cold period because of low air temperature and windy days, so the impact of PM_1 is diminished due to the inhalation dose is insufficient. On the contrary, warm period favors exacerbation of arrhythmias due to PM_1, because people remain outdoors many hours of the day.

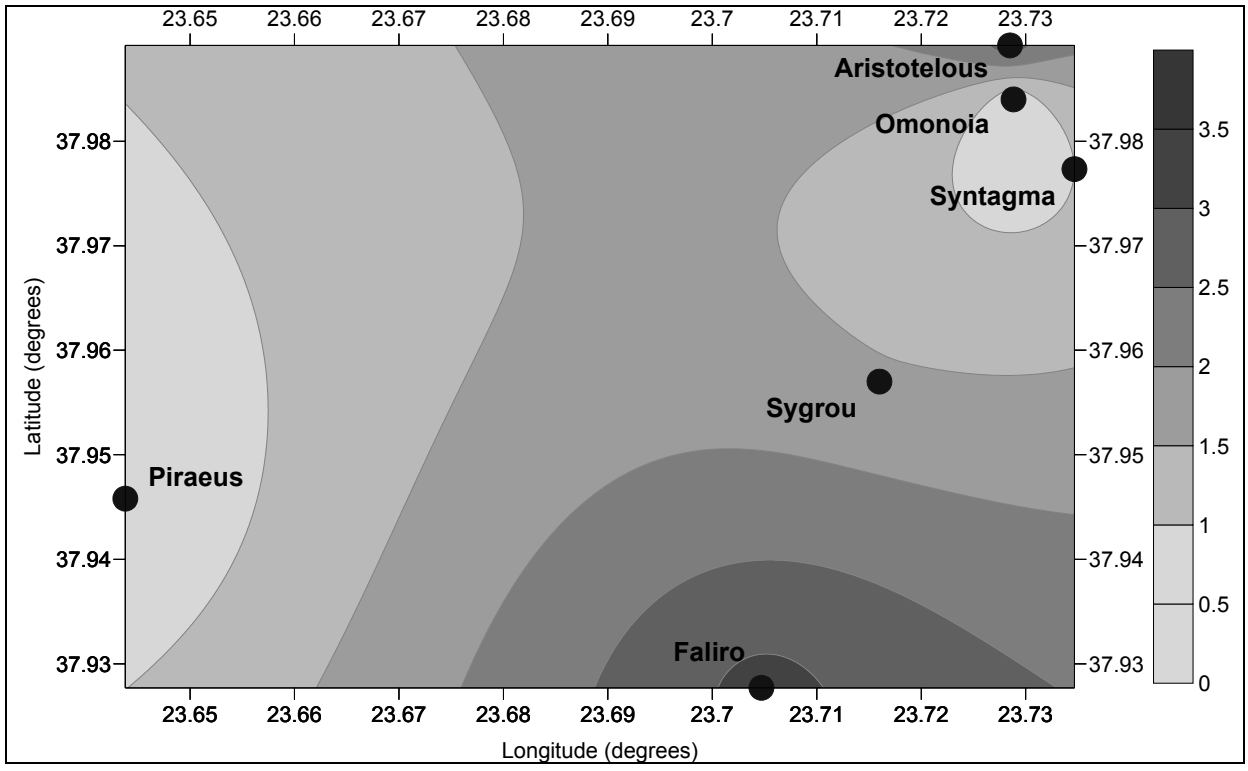
The females (60%) are more vulnerable than males (40%). Besides, 65% of the females are 50 years old and 35% are over 70 years old, while the critical age threshold for males is 55 years old. It is important to remark that there were only few smokers within the examined sample of patients, coming to the emergency health units for the studied period. Besides, no one of them has any coronary or ischemic disturbance in his medical record, in the past. Atherosclerotic cardiovascular diseases (ASCVD) have occupied all medical doctors in industrialized Europe. The pathological-physiology explanation is still under ulterior and accurate investigation. A characteristic propriety of ultra fines PM is the rapid passage from lungs (localization-deposition) in to the blood circulation (diffusion). The next step is the short or long immigration in periphery of the body with an attachment in various organs with all the possible consequences for the human health.

In the process, GLM analysis is applied to the examined datasets, taking into consideration that dependent variable is the daily number of sinus arrhythmias, while independent covariate is the PM_1 concentrations. The results of the analysis are presented in Table 2. With respect to the warm period of the year, a statistically significant relationship ($p<0.01$) between arrhythmias and the PM_1 concentrations was revealed on the same day; namely an increase of 1 $\mu g \cdot m^{-3}$ in mean PM_1 concentrations, was associated with an increase 34% in the probability of having arrhythmias. Furthermore, a statistically significant lag effect of 3 days between the increase in arrhythmias and the peak in the PM_1 concentrations exist. An increase of 1 $\mu g \cdot m^{-3}$ in lagged mean PM_1 concentrations links to an increase 5% in the probability of having arrhythmias. There is not any statistically significant ($p<0.01$) relationship between mean PM_1 concentrations and arrhythmias on the same day or lagged days, within the cold period of the year.

Additionally, Logistic Regression Analysis was applied in order to estimate odds ratios for the independent variable (PM_1) in the constructed model. PM_1 concentrations greater than 4 $\mu g/m^3$ in the warm period of the year seems to approximately 8folds the risk (odds ratio=7.833, 95% C.I.: 0.469–130.748, significant level=0.152) of observing the daily number of patients with sinus arrhythmias in the upper 90^o percentile (i.e. >3 cases with sinus arrhythmias per day) compared to the lower 10^o percentile (i.e. 0 cases per day).



Warm period



Cold period

FIGURE 2 - Spatial distribution of PM_1 concentrations in Athens, during the warm period (upper panel) and the cold period (lower panel).

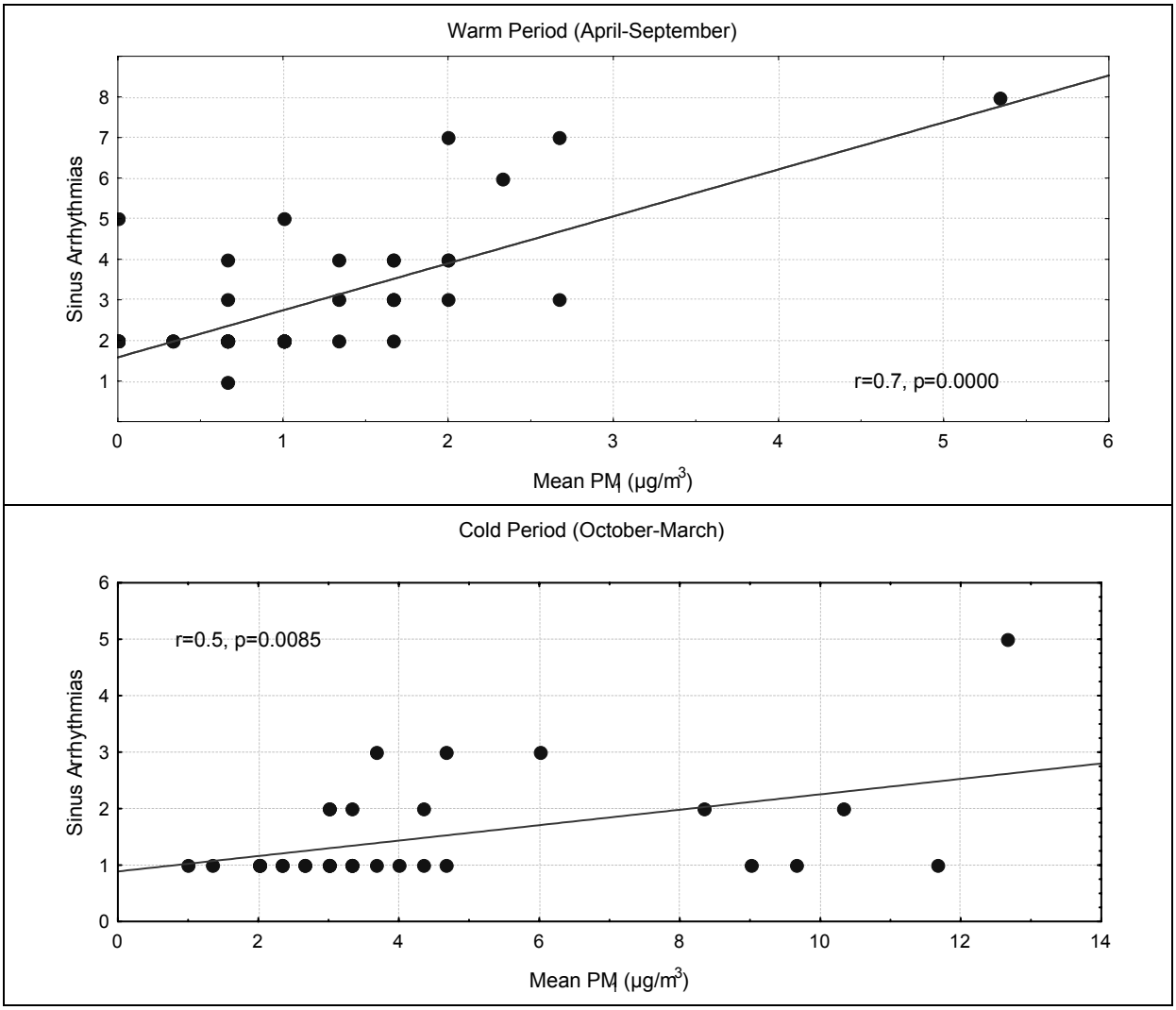


FIGURE 3 - Scatter plots between sinus arrhythmias and mean PM_1 concentrations in Athens, during the warm period (upper panel) and the cold period (lower panel).

TABLE 2 - Results of the application of Generalized Linear Models (GLM) with Poisson distribution, (dependent variable the daily counts of sinus arrhythmias, while independent covariates the PM_1 concentrations), for the warm period of the year.

	Sinus Arrhythmias	
	β-coefficient ± S.E.	p
PM_1 (μg/m^3)	+0.2944 ± 0.0666	0.00001
Lag 3 Days PM_1 (μg·m^{-3})	+0.0500 ± 0.0200	0.01235

CONCLUSIONS

The performed analysis showed that the ultra fine particulate matter with diameter less than 1 μm (PM_1) is in close relation with sinus arrhythmias registered in the emergency units of the hospitals in Athens. This relationship appears in the warm period of the year and not in the cold one. Further investigation is needed in order to define safety thresholds for PM_1 for public health, because these particles are able to pass easily in the blood and thereafter to cause damages in essential organs of the human body. Our scientific team has defined the PM_1 impacts on health as PM symptomatology, which consist of tachycardia, arrhythmias, dryness of rhinopharynx, dispnea, dry cough, dacryrrea, headache, fatigue, vertigo and general cataptosis of the organism. We work on this discipline to find out the consequences of the exposure to PM_1.

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