Innovative systems for the detection of air particles in the quarries of the Western Rif, Morocco

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ABSTRACT

In a world where climate change looms large the spotlight often shines on greenhouse gases, but the shadow of man-made aerosols should not be underestimated. These tiny particles play a pivotal role in disrupting Earth's radiative equilibrium, yet many mysteries surround their influence on various physical aspects of our planet. The root of these mysteries lies in the limited data we have on aerosol sources, formation processes, conversion dynamics, and collection methods. Aerosols, composed of particulate matter (PM), sulfates, and nitrates, hold significant sway across the hemisphere. Accurate measurement demands the refinement of in-situ, satellite, and ground-based techniques. As aerosols interact intricately with the environment, their full impact remains an enigma. Enter a groundbreaking study in Morocco that dared to compare an internet of thing (IoT) system with satellite-based atmospheric models, with a focus on fine particles below 10 and 2.5 micrometers in diameter. The initial results, particularly in regions abundant with extraction pits, shed light on the IoT system's potential to decode aerosols' role in the grand narrative of climate change. These findings inspire hope as we confront the formidable global challenge of climate change.

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1. INTRODUCTION

People started to dig the soil with basic tools, made out of wood, horn or bone for the soft soils, flint for the rock. To work soft rocks, the researchers used tools made from hard rock, while to work hard rocks, they have to await the development of metals, and powerful abrasives such as the diamond, then that of the explosives [1]. Rock extraction industries, usually situated out of the cities, significantly contributes to the particulate air contamination. These factories produce a lot of particles [2]. Particulates are fine particulate matter (PM), both solid and vapour, of a given substance or combination of chemicals, that are suspended in a gaseous medium. Originating from human or naturally derived sources, aerosols are also a globally and locally important contributor to air quality and allergic disease symptoms [3].

Terrestrial aerosol is an important element of the climate control program in that it has a major impact on the global atmosphere, including direct and indirect impacts on the physical and chemical properties of clouds, and consequently on their insulation properties and life cycle, as well as on the climate system. The latter include the direct and the indirect effects of radiation energy diffusion and adsorption, as well as indirect changes in the physics of the clouds, and thus in their insulation properties and life span [4], [5]. The biggest sectors contributing to fine particulate pollution remain the residential sector (45%) and industrial processing (26%). Wood for heating is responsible for the most noxious particulate emissions. Road transport also accounted for 18% of PM2.5 particulate pollution (a slight increase on PM10) [6], [7]. The toxicity of suspended dusts is dependent on their physical and chemical characteristics, their size and on their capacity to absorb other pollutants present in the ambient air [8]–[10]. The consequences of chronic exposure to high particulate concentrations can include respiratory complaints, an increase in the severity and frequency of asthma episodes in sensitive individuals, an augmentation of existing allergies or conditions, and a reduced life span ranging from a matter of several months to more than one year, depending on the intensity and duration of the exposure. Airborne dust has the capacity to absorb and scatter light, reducing its visibility [11], [12]. Undesirable impacts can also be seen on the environment, as fine particles can be absorbed by plants or settle on the soil, leading to decreased plant development. By settling on property, particles also help to degrade the appearance of buildings and buildings in urban areas [13], [14].

Wireless and internet of thing (IoT) technologies [15], [16] are converting cities into smart, or networked, cities. The term "IoT" covers all items that are connected to a network through wireless or wired means, whether Wi-Fi, wireless Bluetooth, low power wide area network (LPWAN) or cellular networks (3G, 4G, and 5G). More than 50 billion devices will be online by 2020, predicted Cisco [17], [18].

Particle size and form are regarded as crucial factors; in the study of the effect of particulates on human health and the the environment, small particles present a greater health threat than large ones [19]. As the industrialization progresses and the car park increases, the air pollution problem from gas spray and airborne matter has become more challenging with Morocco's economic progress in the past few years, and the problem is bound to increase in the future [20]. The objective of this project is to set up a satellite monitoring system centered on the Moroccan Western Rif, and to build a high resolution particle capturing system and other hybrid satellite model based conventional systems.

2. THE PROPOSED METHOD

All liquid and solid particles suspended in the air, including dust, pollen, soot, smoke, and droplets are harmful. Simply put, fine particles are dust. In the case of air pollution, this is often the result of less than full combustion. They generate what are known as unburnt particles. When you see smoke coming out of a chimney or exhaust pipe, or when you cough up cigarette smoke, it's because there are many particles of varying sizes [21], [22]. Particles are of both anthropogenic (human) and natural origin. Particles of natural origin come mainly from volcanic eruptions and natural wind erosion, or from the advance of deserts (which are sometimes of anthropogenic origin), fires and vegetation fires. Human activities, such as heating (particularly wood-burning), the combustion of fossil fuels in cars, thermal power stations and many industrial processes, also produce considerable quantities of CO_2. These emissions have been rising for two centuries.

One of the benefits of fine particles is their deep penetration into the pulmonary system. They can encourage inflammation and make people with heart and lung problems sicker. Currently, suspended PM and ozone pose a serious health risk in many cities in both developing and industrialized countries. It is now possible to establish a quantitative relationship between the level of pollution and certain health criteria (increased mortality or morbidity) [23]. This gives invaluable indications of the health gains that can be anticipated from a reduction in air pollution.

PM10 sampling and measurements were carried out using the reference technique described in EN 12,341 (1999) [24]: "air quality for the determination of the PM10 portion of suspended PM using the reference technique and an in-situ test process to demonstrate the equivalence of the method of measurement". Sampling and measurement of PM2.5 were carried out using the standard technique described in EN 14907 (2005) [25]: "the mass fraction of suspended PM2.5 is determined using a gravimetric measuring technique as a reference". We are designing and deploying a new artificial intelligent (AI)-based system for weather and climate monitoring. For particle and air parameter monitoring, the proposed system will use the connections of the IoT with sensors for weather. The project will develop a programmable board for the survival program and as a command center and control system [12]–[14]. Then, the devices and the sensors used can be directly or secondarily connected to networks. Connected sensors are used to collect data on air quality and meteorology. The measured data are transferred to a card for immediate processing. After straightforward processing, the map will send the processed readings to the database computer. The database can be accessed remotely via the website. When an adverse value is found, an email notification is dispatched to the end-user.

A basic description of the suggested system is given in Figure 1. There are some well-proven methods for the measurement of solid matter at high definition, such as the vibrating taper element microbalance. The gravitation principle is a quantitative method of mass-based particle analysis. These high-precision measuring devices, which have long been familiar, are all enormous, fixed and costly, and are not therefore often used.

Smart city applications based on IoT can also be employed to help monitor environmental metrics. For instance, to monitor air quality, sensors collect data on the quantity of microscopic PM2.5 and PM10 particles, sulfur dioxide, ozone and the nitrogen content, and transmit the data to a platform that reviews and displays the sensor readings, so that users can visualize air quality and be alerted when the air pollution is critical [16]–[18]. Smart city solutions based on the IoT also enable waste collection schedules to be optimized by monitoring waste levels. When the waste management system approaches a given threshold, it receives a recording from the sensor, interprets it and then notifies the carrier's mobile app, instructing it to dump the full container rather than the half-empty ones [18].

The technology is based on AI and can be used to detect aerosols. We are currently proposing an intelligent air pollution (PM) or particles detection method, which will offer an affordable space/time surveillance solution. The method we are proposing for finer particulate measurements is the synchronized hybrid ambient real-time particulates (SHARP) method, which allows the mass of particles to be identified in real time using a beta counter for combined mitigation (14C) and a short-term scattering response counter. The digital filters are used in the system to continually calibrate the photo-meter on the basis of the pooled beta attenuation data. It uses moisture reduction with intelligence (IMR) in conjunction with a regular filter for sample changes to reduce moisture interference and the loss of volatile components. Based on the use of commercial off-the-shelf (COTS) sensors [18]–[20].

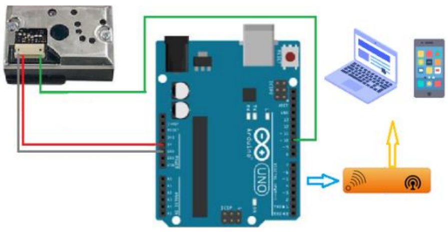

Figure 1. Architecture of designed system using

3. MATERIELS AND METHODS

3.1. Classic system and sites study

The area studied is located in Southern Morocco. More particularly, in a part of the Rif mountain range in North-West Morocco (see Figure 2). The organic geosyncline of the Rif range is characterized by repeated and orogenic occurrences, as well as late magma phases and teletectonic occurrences [17]. The former zones comprise the inner Rif domain or the so-called North Rif chain. The study area is surrounded by the Mediterranean Sea to the east and north, and the plains that separate it extend from Middle Atlas to the south and Atlantic to the west. The topography is very marked (high mountains) and the climate is mild, with heavy rainfall in winter. The main cities in the Western Rif are Tangier, Tetouan, and Chefchaouen [9], [10]. In this article, we work on the area with the following grid coordinates (Figure 2): -5.6679, 35.0852, -5.2943, and 35.9531.

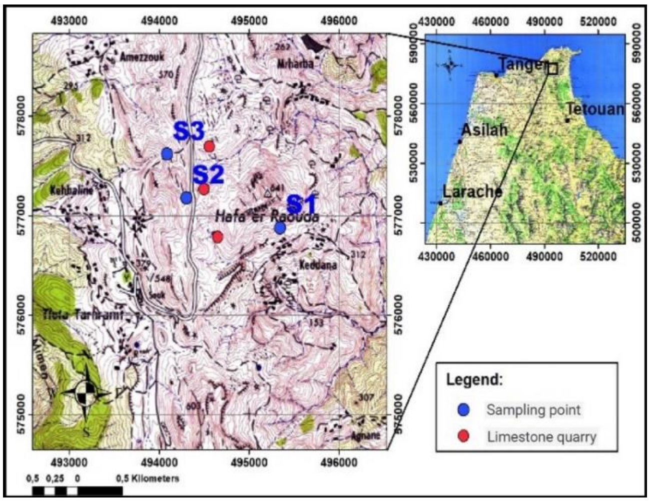

Figure 2. Area of study and site coordinates

The ambient PM satellite investigations were also based on a novel spatio-temporal model developed to forecast PM1.0 as well as PM2.5. They made use of the moderate resolution imaging spectroradiometer (MODIS) on the Terra and Aqua spacecraft. By employing this NASA Goddard earth observing system (GEOS) model and modern era post-mortem for use in surveys and graduate school (MERRA-2) is a reanalysis of NASA's satellite era utilizing the GEOS version 5 with its atmospheric development system (ADAS) model, version 5.12.4. MERRA's effort concentrates on archival meteorological or climate analysis for a wide variety of time scales over time, by presenting NASA's EOS recordings in a climatological setting [9], [10].

3.2. Suspended particle sensor

In Figure 3, Honeywell's particulate matter (HPM) series mobile PM monitor (sensor 1) equipped with universal input/output analog (UART) enables customers to explore the product in more depth and at a lesser cost to effectively monitor or track particulate contaminants in the environment. These HPM series sensors are specifically designed for PM2.5 and use a particle capture method based on laser diffusion. The sensor GP2Y1026AU0F (sensor 2) is a high-level detector with an integrated computer and a signal-based output for temperature control UART. The GP2Y1030AU0F transducer features an integral digital PC and a unique digital waveform output UART [12].

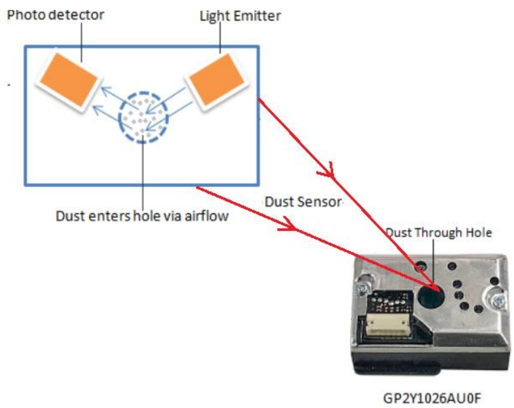

Figure 3. Sensors for capturing airborne particles

4. RESULTS AND DISCUSSION

4.1. Monitoring of particulate matter by conventional system

The operational density of airborne materials is a major output of particle aerosol modelling, and is the level of shielding provided by the airborne substance to the passage of optical energy by means of scattering or light absorption. It is the extent to which light transmissibility is impaired by airborne aerosols due to light emitted, scattered or absorption of the light suspended in the air. The aerosol operational particle depth (AOD) or opal width (τ) is the measure of the extent of the integrated extinction per unit through a vertically stacked area. The quench factor is the unit of partial light reduction per unit track (particularly in relation to radar frequencies, also known as attenuation). The vertical optical height is also referred to as the vertical standard elevation. The total particles' optical depth is measured at 550 nm by the MODIS (reasonably resolved spectral imager), at 866 and 870 nm by the wide field view sensor (WiFS) for the sea large eyehot detector, at 444, 556, 670, and 866 nm by the multi angle spectroradiometer imager (MISR), and by the Aura ozone instrumentation at a frequency from 343 to 500 nm ozone monitoring instrument (OMI) [12].

The information is collected in the precise form of a small solid fragment, referred to as dust, which is frequently used as the starting point for further calculations. Dust is typically between 1 and 100 µm in diameter. It can be aerosolized into the air or ground onto the soil surface. Because dust sources are so plentiful, they are made up of many differing species, both types inorganic and organic (disc.gsfc.nasa.gov/). Over the space of a year, the temporal, and spatial variability of PM in the Western Rif area was observed.

In fact, the obtained results provide a complete view of the modified AOT 550 nm-PM1.0 for different time periods as shown in Figure 4. The four figures show that from June to September, there are more fine particles in this image than in the others. From January to March, Figure 4(a) shows a modified AOT 550 nm-PM1.0; its PM1.0 range varies between 1.255*e-1 and 1.752*e-1, and we can observe that the PM cluster level. Cluster level in Figure 4(b) is higher than the one in Figure 4(a), fluctuating between (1.655 to 1.815)*e-1 for the months of March to June. In the months from June to September, on the other hand, we observe that the area of search for AOT 550 nm-PM1.0 extinguished by dust spots varies between (2.139*e-1) and (3.380*e-1) Figure 4(c). In the case of Figure 4(d), we see that the variety of PM1.0 extinction decreases on a scale from 1.514*e-1 to 1.709*e-1.

Over the whole module period, from January to March, the variations in PM 2.5 in Figure 5 ranged from 1.98*e-1 to 2.489*e-1, and we have a variance above or below this order of (2.498 to 2.845)*e-1. The fluctuations shown in Figure 6, Figures 6(a), (b), and (d) are meme concentration values, but Figure 6(c) shows a greater change in the atmospheric attenuation of dust AOT 550 nm-PM2.5 from June to September, and the same can be said for PM1.0, which has a higher degree of intensity than the rest of its predecessors.

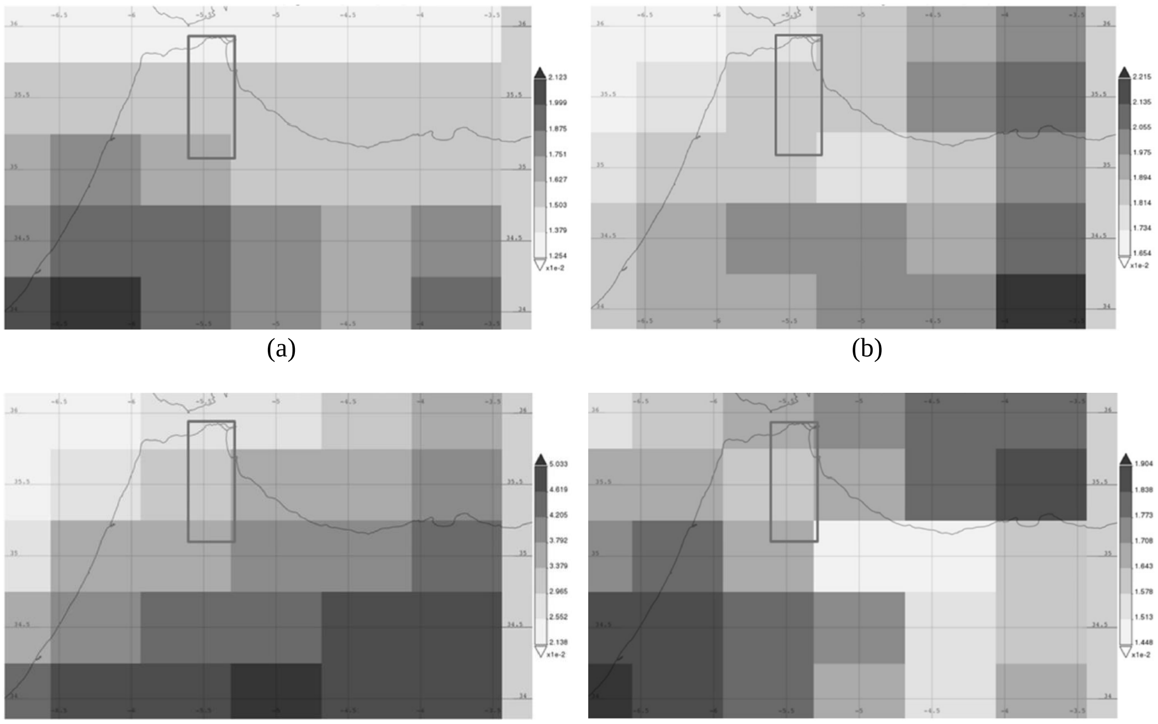

Figure 4. Extinction map of the mean AOT 550 nm-PM1.0 um dust periodically 0.5×0.625 degrees (a) over 2018-Jan - 2018-Mar, (b) over 2018-Mar - 2018-Jun, (c) over 2018-Jun - 2018-Sep, and (d) over 2018-Sep - 2018-Dec

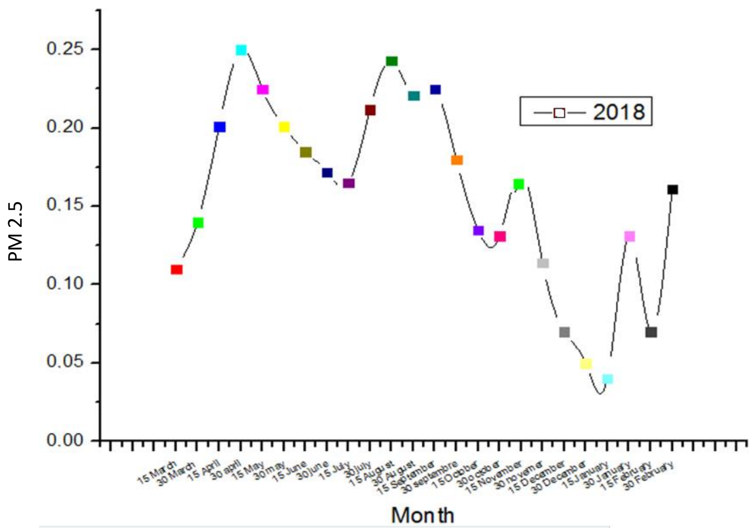

Figure 5. Particle evaluation as a function of time

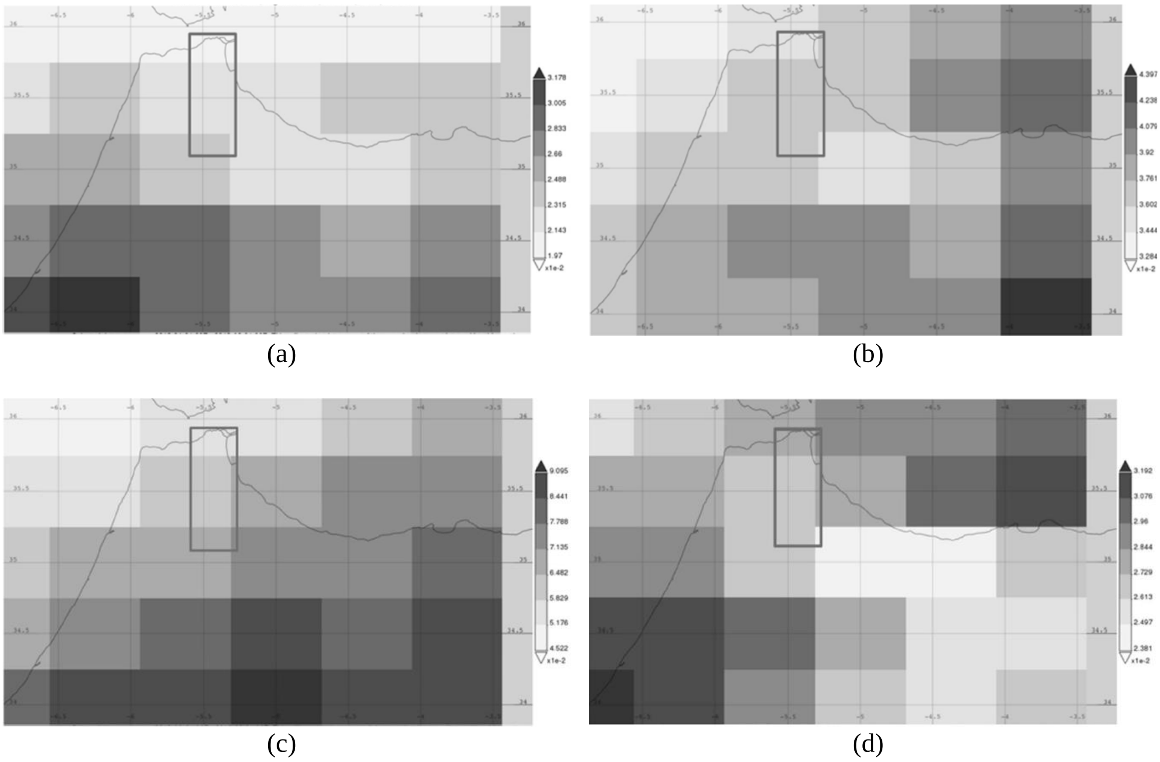

Figure 6. Extinction map of the mean AOT 550 nm-PM2.5 um dust periodically 0.5×0.625 degrees (a) over 2018-Jan - 2018-Mar, (b) over 2018-Mar - 2018-Jun, (c) over 2018-Jun - 2018-Sep, and (d) over 2018-Sep - 2018-Dec

4.2. Monitoring of particulate matter by our system

To assess our system and to evaluate the response, 2 units of sensors were tested for 5 working days at a laboratory research station. The sensor intercomparison showed for PM2.5 (sensor 1) an R2 between 0.98 and 0.99, and for PM2.5 (sensor 2) an R2 comprised between 0.99 and 1. In conclusion, the PM2.5 signal had a greater sensitivity. To determine sensor repeatability, the name was calculated. Better responsiveness for PM2.5 (sensor 1) (9-24%) than for PM2.5 (sensor 2) (10-37%). Using the correlation results as a guide, the reproducibility analysis shows the best result for the PM2.5 signals presented in Figure 7 about the laboratory. In addition, a comparison of the conventional method and the IoT sensor concentration (averaged over a day) shows an R2 between 0.91 and 0.95 for PM2.5, indicating a good trend for both methods. HR values >95% affect sensor results.

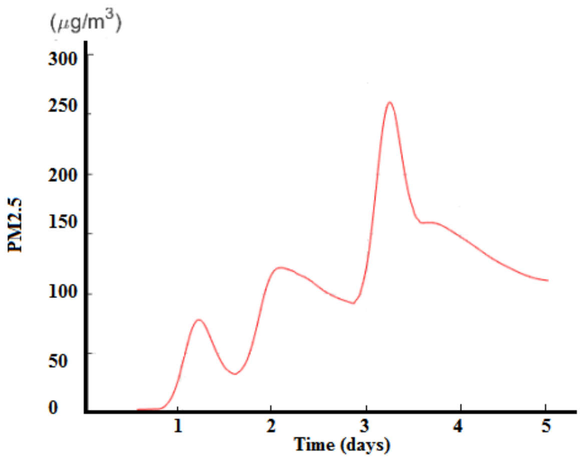

Figure 7. Variation of PM2.5 measurement over time

All these projects enable the development and testing of low-cost, easy-to-build transducers with outstanding temporal accuracy. Easy to deploy and with outstanding temporal resolution, some preliminary work is still required to ensure that the data collected by the collectors is of the best quality. For instance, in South Morocco in 2018, a project to chemically qualify particles was conducted with the help of regionally-based particles specialists. The chosen monitoring strategies are in line with changing global patterns in particulate suspension. Experimental surveillance using sensors. The use of low-cost sensors for tracking and monitoring went smoothly; after being subjected to elevated levels of contamination, they did not present any problems for their measurement, and it was also made possible to find out about concentration levels in a certain number of subway metropolitan areas without the need for official permission. It has been made possible to establish concentration limits in urban areas where no official monitoring stations are present. It was also made possible to identify the diurnal trends for each site.

5. CONCLUSION

The most dangerous type of particles for health are the very fine particulates (PM2.5 through PM0.1). They reach the narrower bronchial branches and can penetrate the pulmonary alveoli. The tiniest particles can travel even through the cell membranes, causing damage to the cardio-vascular function. The finest possible detail that can be seen in an individual image is known as spatial definition. It is also generally defined as the size of the individual image pixel. In an picture, the objects which can be identified will depend on the sensor's spatial address. In principle, as resolution is raised, the area visible to the imager decreases: a high resolution picture will cover a less dense area than a moderate image. In the world of remote detection, the variable used to describe the pixels is called reflectance. The reflectance reflects the way a surface reacts when it is illuminated by direct sunlight. Their time resolution and temporal accuracy can occasionally be missed due to the single duration of the overviews. Suggesting a system of IoT based sensors that is easy to use and gather information from is of interest for providing air quality warning and monitoring air at a distance. This project is focusing on the detection of PM1.0 and PM2.5 particulate air pollutants, which are the smallest particles of average particle size. In this first phase, which is the analysis of remote sensing images, the surveillance sites are located in northern morocco, and represent one of the main and most intense sources of emissions. The images mask the reality that the air in this area is highly polluted.

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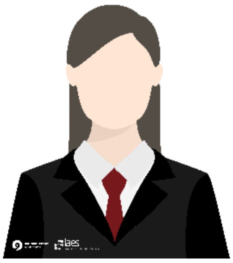

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