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Survey Paper on Various Methods of Automating the Water System using Dust Sensor to Suppress the Dust in Mining

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***Abstract*—This paper describes different methods of automating the water sprinklers based on the dust level in the environment. Different types of Dust monitor system are discussed which is based on the different dust level sensors used. Several types of dust level monitor module are deigned, constructed and tested. In this survey paper, here we describe and compare many types of Dust monitor modules which are designed in different techniques which monitors the density of the dust particles which are contained in airborne particulate and accordingly dust monitor module will actuate the sprinkling operation in order to maintain the dust level.**

Keywords*—Dust monitoring system, density of dust particles, water sprinklers, dust sensor.

I. INTRODUCTION

The procedure or industry of getting coal or other minerals from a mine is described as Mining. The average mine worker is exposed to the harsh underground environment in mining field which leads to incur an injury or it may cause death. Coarse particles, PM10, (usually found in windblown dust) and fine particles, PM2.5, (found in smoke and haze) can causes the greatest problems because they can get deep into the lungs. Scientific studies have proved that exposure to particle in the dusty environment causes development of chronic bronchitis, increased respiratory symptoms, etc. Therefore, the dust density in the environment needs to be continuously monitored in open cast mines. Water sprinklers of 28000 liters & 70000 liters are used to suppress the dust in the open cast mines which are manufactured in BEML. These conventional water sprinklers consist of four types of sprinkling and the operator need to select and actuate any one type of sprinkling which is suitable to suppress the dust. The conventional water sprinkler is manually operated by the operator based on the dust seen by him. This method does not completely suppress the dust and it is not accurate. And also, water is wasted if the dust density is as per the directions given by central pollution control board. Based on the above background, we thought it is necessary to implement the automated water sprinkling system which measures the dust density contained in airborne particulate matter in the mine and accordingly module will automatically actuate the sprinkling in order to suppress the dust in the environment. And also, this technology is compatible to CAN or inbuild display for continuous monitoring of dust concentration, the system is capable to drive electrical load, the system has the non-volatile memory for store the data of dust concentration once it cross the set value with date and time stamp & the system will have both auto/manual operation. Once the dust concentration crosses the permissible value automatically system should actuate solenoid driver in order to start the sprinkling operation. In case of failure or malfunctioning of auto operation system should provide alternate option to actuate solenoid driver. Therefore, this dust monitor module is used to implement an automatic system, using advanced technology to monitor the density of fine dust particles in the mining environment & accordingly actuate the sprinkling operation with minimal human intervention.

II. LITERATURE SURVEY

[1] Proposed a new method to extract the mining explosions related information and process the same to alert the people who are working in the place of the mine. The workers inside the mine sometimes doesn't have any idea about some explosions taking place in the proximity of mines. For this cause, a system is designed with the use of a robotic machine incorporated with the raspberry pi3 version. The main and primary objective of this proposed work is to build a rescue robot that may be managed via a web page. The proposed system consists of two modules that is transmitter and receiver module. Transmitter module contains digital camera to capture photographs of internal situations of coal mine. This camera is connected to USB port of raspberry pi3 which is powered by 5V, 2A electricity adapter. The display is connected to HDMI port. Temperature sensor (LM35) is connected to one of the pins of raspberry pi module which is used to measure the temperature. Gas sensor is also likewise connected to one of the GPIO pin of raspberry pi module which is used to identify the presence of poisonous toxic gas levels like CH4, CO, CO2. To identify any fireside conditions, fire place sensors are used. MCP3008 IC is used to transform analog data in digital form. Servo motors are used to make movements in robot. To reduce the temperature in coal mines, cooling fans are used & DC motors are used to deliver oxygen and water. All output devices are linked through relay. Receiver module consists of a PC which is used to display the information received from the robot in the controller room. A web page is also used. For motion of robot, commands are given through web page. In

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the primary stage, the raspberry pi3 board is made ready to start. It works on OS. Python is used to write the source code and this code is compiled and debugged onto the Raspberry pi system. Subsequently, a buzzer is employed to provoke the precautionary actions. At last, they conclude that using this system the user can monitor the work place from the control room. Since, wi-fi is used in the system, the data can be easily sent from one point another point.

[2] This article portrays air and water splashing frameworks, planned at the KOMAG Institute of Mining Technology, utilized in long wall shearers, in road headers, at move purposes of transports and in roadways. The straightforward and lightweight structure of this air and water spraying system guarantees that the arrangements can be utilized anyplace that residue happens noticeable all round. The utilization of air and water spraying systems can decrease the concentration of dust by up to 80% and they add to a huge decrease of concentration of dust noticeable all around. A few results of tests concerning the viability of air and water spraying gadgets are introduced in this paper, also discussed the check trial of the author's solution for spraying spots. This system is proposed for regions in mine with noteworthy dust generation., where there is a requirement for clean air. The two medium spraying nozzles require only a little volume of water (somewhere in the range of 0.1 and 0.4 dm3/min) and a little volume of air (somewhere in the range of 50 and 150 dm3/min). During the longwall shearer activity, the convergence of absolute dust was decreased by 42%, and the centralization of respirable portion was decreased by 93%. The VIRGA and Bryza-1200 spraying gadgets, planned and designed for belt moving points, are additionally successful in dust control, surpassing over 70% of decrease in dust concentration. The BRYZA roadway dust defensive obstruction decreases concentration of dust by about half in the whole roadway cross section. The after effects of coal dust control meet the full desires of the mines. Adaptability and flexibility of the solutions discussed in this paper for dust control permits utilizing them in different regions, where a comparative issue of airborne dust may exist.

[3] In this paper they have briefly discussed about an air-microfluidic miniaturized wearable respirable dust monitor (WEARDM) and presented a plan, fabrication and experimental evaluation of each components used in WEARDM. WEARDM directly measures the respirable mass fraction of the dust in underground coal mines. To maintain or preserve uniform collection efficiency over the respirable particle dispersion, device uses a dual resonator gravimetric sensing approach. WEARDM is optimized for low flow rate which equalizes low power utilization and little form factor. The main components used in this system are (1) An elutriator used as an inlet to avoid large size particles entering and blocking the small channels, (2) A Virtual impactor also called as respirable fractionator is used for selecting the respirable fraction based on ISO convection, (3) RH preconditioner or dryer is utilized to eliminate water droplets and moisture so that to manage the effect of the environmental conditions, (4) Dual resonator mass sensor is used here for real time mass measurements, where larger particles or settled on a QCM (quartz crystal microbalance) using inertial impactor, and smaller particles are settled on MSR (mass sensor resonator) using thermophoresis force, and (5) a pump which is used to pull the air through the device. All the components mentioned were experimentally evaluated and the results showed that the device successfully operated as expected such as removing the large particles, separating respirable fraction, drying, and measuring the PM4 mass concentration very accurately. They also conclude that the device is suitable for personal PM exposure monitoring other than coal mine application because of the low flow rate of the WEARDM monitor which has many advantages like smaller size, low power requirements, and a long period battery life.

[4] Presented a new system to measure and monitor the fine dust particles (PM2.5) in indoor environment using IOT technology. Also, in this system they have implemented a new feature of transmitting the collected dust data to the smartphone using the app of the smartphone. It is an embedded system of an IOT devices (i.e., fine dust sensors) and microcontroller are configured in hardware to accurately measure and collect data on fine dust particles also they have used a wireless transceiver device such as Wi-fi to transmit the collected data of fine dust particles to the smartphone. Here, the protocols mainly used for IOT are MQTT (Message Queue Telemetry Transport) and CoAP (Constrained Application Protocol). The MQTT protocol was applied to this system for monitoring the fine dust components. In this paper they have mainly discussed about the IOT, protocol used for data transmission and the design of fine dust monitoring system using IOT. To design this system, IOT technology is utilized wirelessly therefore they have used wi-fi telecommunication as its transmission speed is faster it can achieve speed up to 600 Mbps and also it is more secured. Here, they have only discussed about two protocols which are currently used here in IOT that is MQTT & CoAP. The designed system consists of hardware structure and in particular it consists of PM2.5 fine dust sensor (GP2Y1012AU0F), Arduino microcontroller and wi-fi module (ESP8622) along with resistor of 150 ohm and capacitor of 220 μF. Overview of IOT monitoring system can be of subdivided into 4 steps that is sensor, IOT platform, network & monitoring device. The sensor used here is GP2Y1012AU0F which can measure fine dust of PM2.5 concentration which produces an analog output and this converted to digital value in the IOT platform and this data is transmitted to the user smartphone through a wi-fi network module ESP8266. Hence, the reliable data is transmitted to a smart phone and since they are using the MQTT protocol data loss is minimized here.

[5] Examined the plausibility of combining radio frequency wireless power transmission (RF WPT) method using TX91501 power transmitter made by power cast co. with open air dust monitoring system. For viable dust monitoring, both indoor and outdoor measurements are fundamental. Power consumption in indoor measurement isn't an enormous issue, but open-air measurement requires persistent control supply and low power operation hence this application is designed and developed. In this paper, power cast's TX91501 power transmitter is examined for its use in outdoor dust monitoring system. Here, they have briefly

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discussed about the outdoor dust monitoring system, RF WPT, Battery charging and overall operation. Firstly, the outdoor dust monitoring system is constructed using dust sensor, an Arduino board, and a Bluetooth communication module. For this system, they have selected Shinyei model PPD42NS dust sensor and utilized since it has a heating resistor and accurate measurement for outdoor system is conceivable. In case of Arduino board, they have opted universal Arduino uno board and in case of Bluetooth communication module, HC-06 module is utilized. Arduino board standby power is around 0.4W, PPD42NS dust sensor power consumption is around 0.4W and standby power of HC-06 Bluetooth communication module is around 0.02W and when communication is performed, about 0.1W is utilized. Hence, the peak power consumption of outdoor dust monitoring system is around 0.9W with communication. TX91501 power transmitter is used which operates at 915 MHz. To run the dust monitoring system battery needs to be charged. They have used full river's 100 mAh lithium ion battery for fast charging which is charged using RF signal. When the system is fully charged by RF WPT method, the two batteries which are serially connected are used for dust monitoring. Power transmitted by TX91501 is received by two antennas and the received RF powers are DC power and these two receivers are used to charge the batteries. Two serially connected batteries can produce 7.6V, which is able to operate the outdoor dust monitoring system. The entire outdoor dust monitoring system is operated using sketch program. The measured dust sensor results are transmitted to the smartphone via Bluetooth module only when the smartphone gives 'on' signal to Bluetooth module for low power operation. Hence by using RF WPT method, the system can be operated for a period of 8 minutes and the feasibility of this system is confirmed as a way to solve the problem of power supply which is very important issue while constructing a large number of outdoor dust monitoring system.

[6] In this paper they have successfully tested Fiber optic-based sensors for measuring dust concentration in variety of applications. This type of sensors has huge potential and it can be used in mining operations for measuring dust concentration if it is further developed. This paper presents an overview of using fiber optic-based sensors for measuring dust concentration and they say that in hazardous environment and also in presence of explosives within coal mines fiber optic-based sensors are more valuable in sensing dust particles. The sensing mechanism of fiber optic-based sensor depends on solid particle volume fraction, optical properties and size of dust particles & the performance of these sensors depends on sensor geometry. These sensors have many advantages like being non-intrusive, easy to use, cost effective, intrinsically safe, reliable and real time compared to other sensing devices. Fiber-optic based sensors are mainly categorized into reflection and transmission sensors. In reflection type sensors, the reflections are recorded when the light is travelled through the dust particles: whereas, in transmission type sensors, sensing response is calculated as it is a function of the intensity of light travelled through the dust particles. In this paper they have discussed that fiber optic sensors can be designed many types like single optical fiber, two optical fibers and a bundle of optical fibers. (1) Sensors with single optical fiber - In this type, the sensors response is proportional to the optical fiber diameter. Here they have briefed about testing of single optical fiber which was tested by Herbert et al. (2) Sensors with two optical fibers - In this type, two optical fiber are used one for emitting light and the other is used for receiving the signal. In this type, sensor response is proportional to the spacing and angle of the two optical fibers. Here, they discussed about the new design proposed by a Rundqvist et al which offers a high measuring volume and a near-linear sensitivity. (3) Sensors with bundle of optical fibers - In this type, the central optical fiber is used for emitting light and the two layers of surrounding zeniths of optical fibers are used for receiving signals. Here the principle of dust measurement is based on the intensity of backscattered light being a function of solid volume fraction of suspension, scattering characteristics of dust particles and geometrical properties of the sensor.

[7] Proposed an effectively accessible and cost proficient dust monitoring system that recovers fine dust levels within a prescribed location. An Arduino based IoT gadget is associated with a fine residue or dust sensor and gives dust level information to a versatile application progressively. This system offers new versatile assistance opportunities such as sending quick alerts to the administration supporters who live close by. Here mainly they have used the fine dust sensor that is sharp GP2Y1010AU0F, Arduino and Raspberry pi model 3. The Arduino is associated with dust sensor through circuit & also it is moreover associated with raspberry pi by means of USB. The Raspberry pi at that point sends fine dust concentration information to the android versatile application. Here the general operating succession of the designed system is described in 3 steps that is (1) Gather fine dust concentration crude information from the fine dust sensor. (2) Replace the information with processed information in Arduino and store the information into the raspberry pi. (3) Transmit the fine dust information through the system attachment when an android application demands fine dust data from the Raspberry pi. In this paper, they have led two sorts of analysis. The primary trial evaluated the exactness and proficiency of dust monitoring system. The subsequent tests investigated the changes in the concentrations of fine dust over time in various areas and the results were discussed. The indoor estimation results demonstrated that the sensor was able to react to changes in fine dust densities as planned. After some time, the concentration level of dust decreases when smoke is not delivered anymore, which clearly involves that the dust sensor is equipped for responding or reacting right away. Assessments of the usefulness of the Android application demonstrated that the TCP connected between the application and the server fills in as expected to acquire continuous information from the Raspberry pi.

[8] Presented a design, development & testing of wireless system for dust density measurement in low cost because the system is designed and developed with less expensive commercially available components and it can measure density of dust up to 0.5 mg/m^3. The advantages of the presented system are ease of use, can be operated remotely at a very low cost. In this paper they have mainly discussed about the (1) sensor selection i.e., they have chosen

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GP2Y1010AU0F dust sensor which operate without the additional heating resistor and also relatively reasonable which is suitable for low cost and also low power applications. (2) hardware design comprises of two functional units, the sensing node and the base unit which are linked through a wireless communication that is RF. The sensing node consists of an optical dust sensor GP2Y1010AU0F, wireless RF transceiver ST-TR1100, PIC microcontroller (MCU) PIC18F4550 and the power circuit. In the sensing node side, dust density is measured using the dust sensor and a microcontroller. Output of the sensor is connected to the microcontroller which performs digitalization of the sensors output voltage and transmits this information to the base unit via the RF transceiver. The base unit consists of RF receiver along with PC. The base unit receives the data transmitted from sensing node via the RF receiver and forwards it to the PC using the USB communication. (3) Next coming to the software part, a virtual tool made in LabVIEW is created to monitor the machine operation, data acquisition and data storage. The exchange among the PC and the designed device is realized through USB port with the use of HID protocol which is built in function of microcontroller. (4) Real time measurements are displayed on the gauge and as a way to make information evaluation a touch bit simpler the readings are also displayed in the results table. And this paper also presents the comparisons of obtained results between DustTrak DRX Aerosol Monitor 8533 & GP2Y1010AU0F and by comparing these two they concluded that though even there is a large price difference between these two devices there is almost good matching between the results obtained. Hence, they conclude that the sensor used in this system that is GP2Y1010AU0F satisfies the demand in terms of accuracy which is to be most necessary as a sensor and also a low-cost dust monitoring system as they already mentioned in the title.

[9] In this paper, they have studied and designed a system which removes the dust by spraying dust removal linkage. This system works by evaluating the image of coal dust pollution. The components used in this device are visual pollution sensor, control box and spray dust removal device. The devise examines the dust pollution condition in underground coal mine by evaluating it through image contrast, and according to the evaluation results the device intelligently control spray dust removal device. The main characteristics of this system is that it comprehensively evaluates the whole process by image contrast, thus it avoids the wrong operation of the system. Through evaluation of producing dust point and according to the dust pollution degree obtained from the evaluation results the device controls the spraying system. The device operation mainly includes image evaluation and image control of two parts. Firstly, before the begin of equipment operation picture of a clean space is captured as a comparison of benchmark. Using the image sensor settings in creating dust points, image assessment part detects the full space. Device gets the level of dust pollution measurement principle and the setting method of background picture. According to the results of the evaluated image control part functions by controlling opening and closing of producing dust point set of spray device. Control box is installed in each producing dust points. This system has the fast reaction rate and lower error operating rate because the machine vision has higher precision than the human eye and also this would not have the eye fatigue issue. At the same time, the system avoids the direct contact of workers with dust and hence protects the mine workers health and prevents loss of life by monitoring the concentration of coal dust using image contrast and thus improves the production efficiency and also prevents the produce of large amount of dust in underground coal mine.

[10] This paper summarizes a novel on-line coal dust detection method. Its primary features are on-line processing, slip weighted average sampling followed by linear fitting and automatic correcting of K values. They have presented experimental results from an actual coal mine and demonstrated that the system has required sensitivity and reliability to fulfill the need of real time monitoring of dust concentration. The system has both hardware and software to perform real time operation of detecting dust and eliminating the dust. The hardware components used are computer used in the control center, signal converter, powered network substation and a local control system. Last item of the entire components set up consists of a controller, infrared induction switch, electromagnetic valve, water flow switch, dust concentration sensor which works based on the scattered light principle and acousto-optic alarm box. The system software programming is written in Delphi 7.0 and SQL, and is responsible for automatic storing of dust information and components condition, data query, correcting the value of K, underground site management, data backup and recovery, setting of the user authority, concentration alarm setting and submitting a data to remote database. The important characteristics of this system are it displays multiple noticeable characteristics. Primarily, the system is real-time online framework. Secondly, they have used the dust concentration sensor using the light scattering principle, with the help of this it is possible to realize real-time detection and is easily maintainable. At last, a technique of automatically calculating and strong of the dust correction coefficient K ang b is done to improve the accuracy of the sampled data. Finally, they conclude that this system can be used to monitor the dust over a large area and also at a long distance. When necessary, both the history curve and current curves can be displayed or printed in the computer for the user. The system is able to notify the user when to start the dust removal process by determining the dust concentration alarm value and upper limit spray value. And during spraying, the sound and light alarms will be activated. Along with it, the system makes the work of cleaning the deposition of coal dust in mining tunnels easier. Hence, they conclude that the work described in this paper is more significant.

[11] This project aims to build a portable dust monitoring system which can be monitored from any location using the diaphragms pump. Designed instrument size is 20 x 30 x 8 cm and dust size are estimated no greater than 10 microns. The system is highly efficient and build with low cost. This system measure oscillates of quartz crystal microbalance, mass balance compares two frequency of quartz crystal in same circumstance for blunder of environment. The diverse frequency compute to find the distinctive mass. Since much thickness dust to full quartz crystal which must choose dust size by the device named as impactor for long period and

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know the dust size measurement. Main components or circuits used are frequency mixer SCM-1, low pass circuit and two oscillator & Jfet circuit. Frequency mixer is used to mix frequencies of 2 crystal. Impactor are cascaded to select any size dust continuous in any appropriate work. Microcontroller inputs the signal of mixer and reads it and convert from frequency in real time. Different signal from quartz crystal are compared and convert to real mass. This system measures and catch exact mass of dust hence the system is highly efficient. The dust is measured with QCM is direct mass and real high exact mass. Impactor chooses the dust size below 10 microns. Frequency type measurement was used here of two crystal then compute that in real time. The time taken by the instrument for measurement is approximately 30-60 min & the maximum sensitivity of the instrument is 200 µg/Hz. These all parameters reduce or decreases the environment error to high exact mass.

TABLE I. COMPARISION TABLE

Year	Title	Approach	Description
2018	Coal mine disaster management robot using IOT technology	Robotic machine incorporated with the raspberry pi3 version which is managed via web page and scripted in python	Proposed a method of designing a rescue robot to extract the mining explosions related information and can monitor the work place from control room by alerting
2013	Use of Air-and-Water Spraying Systems for Improving Dust Control in Mines	Consists of two medium spraying nozzles which requires only a little volume of water (somewhere in the range of 0.1 and 0.4 dm3/min) and a little volume of air (somewhere in the range of 50 and 150 dm3/min).	Portrays air and water splashing system which decrease the concentration of dust by up to 80%, planned at the KOMAG Institute of Mining Technology, utilized in long wall shearers, in road headers, at move purposes of transports and in roadways.
2019	Miniaturized Wearable Respirable Dust Monitor (WEARDM) for Underground Coal Mines: Designs and Experimental Evaluation	Wearable respirable dust monitor (WEARDM) made of elutriator, virtual impactor, dryer, dual resonator and pump	Presented a plan, fabrication and experimental evaluation of WEARDM & each components used in it. System directly measures the respirable mass fraction of the dust in underground coal mines
2018	Fine dust monitoring system based on Internet of Things	IOT Technology using protocols MQTT and CoAP. Embedded system of fine dust sensor (GP2Y1012AU0F), Arduino microcontroller and wi-fi module (ESP8622)	Presented a system to measure and monitor the fine dust particles (PM2.5) in indoor environment using IOT technology along with which transmits the collected dust data to the smartphone using the app.
2018	Application for outdoor dust monitoring using RF wireless power transmission	RF WPT method by examining the TX91501 Power transmitter	Designed & developed the outdoor dust monitoring system by using RFWPT method in order to solve the issue of power supply consumption
2017	Fiber-optic based Sensors for Dust Monitoring	Sensors with single optical fiber, Sensors with two optical fibers, Sensors with bundle of optical fibers	Tested Fiber optic-based sensors for measuring dust concentration in variety of applications including mining operations.
2017	A Mobile Application for Fine Dust Monitoring System	Versatile application made of fine dust sensor that is sharp GP2Y1010AU0F, Arduino and Raspberry pi model 3	Presented effectively accessible cost proficient dust monitoring system that recovers fine dust levels within a prescribed location also sends quick alerts to the administration supporters who live nearby.
2013	Low-cost Wireless dust Monitoring System	System made of optical dust sensor GP2Y1010AU0F, wireless RF transceiver ST-TR1100, PIC microcontroller (MCU) PIC18F4550, RF receiver along with PC and a virtual tool is made in LABVIEW	Presented low cost wireless system for dust density measurement because the system is designed and developed with less expensive commercially available components such as dust sensor GP2Y1010AU0F.
2012	Spray dust removal device based on the image contrast	Evaluating the image of coal dust pollution through image contrast and accordingly the device intelligently controls spray dust removal device. System consists Visual pollution sensor, control box and spray dust removal device	Designed a system which uses the evaluation results of the image of coal dust pollution obtained through image contrast in order to remove the dust by spraying dust removal linkage
2008	An on-line detection system for coal mine dust	System consists of computer, signal converter, powered network substation and a local control system. Last item of the entire components set up has a controller, infrared induction switch, electromagnetic valve, water flow switch, dust concentration sensor based on the scattered light	Designed online method of detecting a coal dust concentration having features like on-line processing, slip weighted average sampling along with by linear fitting and automatic correcting of K values.

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		principle and acousto-optic alarm box. The system software programming is written in Delphi 7.0 and SQL.	
2007	Portable Dust Monitoring Unit Using QCM	Measure oscillates of QCM, mass balance compares two frequency of quartz crystal in same circumstance. System has frequency mixer SCM-1, low pass circuit and two oscillator & Jfet circuit	Build a portable dust monitoring system which can be monitored from any location using the diaphragms pump.

III. CONCLUSION

The conclusion of this paper, the various different methods which makes the water sprinklers automated depending on the level of dust in the vehicle surrounding environment are specified. This technique or method of automating the water sprinkler mainly depend on the dust sensor & its characteristics. The features or characteristics of various types of dust sensors used in different methods of automating the water sprinkler to eliminate the dust concentration and maintains the dust level in the environment are studied. And Literature review of different types of dust monitoring systems used in real time and some experimental work relating to the dust monitoring systems using different approaches have been studied. The main aim of this paper is to study different approaches of automating the water sprinkler by using dust monitoring system in order to reduce the dust level in the environment mainly in the mining areas, where the mine worker's health are most affected by this coal mine dust and in severe cases it may leads to loss of life.

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