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A Review in Quest for Multi-Functional Environmental Sensors

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Abstract- *Concerns regarding the environment such as air pollution, water pollution, soil pollution, noise pollution and additionally acid rain and global warming cannot be overlooked anymore as they adversely affect all the species which are present on this planet. So, there is a deeper quest of researchers to come out with a multifunctional device to intelligently monitor to multiple pollutions with a single unit to curb this pernicious problem. Nowadays we have a plethora of sensors which are able to sense noise, poisonous gases like carbon monoxide, sulphur dioxide, particulate matters, dust particles, chemical compositions, alcohol, humidity, temperature, position, human presenceetcetera. This paper identifies the past and present research related to the sensing techniques and it also elaborates the usage of sensors in different fields and about innovations in this field. A range of technologies have been used over past years to sense various parameters. In present scenarios, advancement in sensing techniques can be noticed to control air contamination in bigger cities for pollution free air but such air monitoring techniques cannot be established in small cities because of their higher cost. In this paper we are diligently working on the areas of refinement to provide innovative versatile sensors which are more efficacious, genuine, productive, secure, predominant and economical.*

Keywords:- Pollution monitoring, air monitoring, particulate matter, water monitoring, soil monitoring, wireless network sensor.

Introduction

Sensor is an electrical gadget that gives response to a physical stimulus and transmits an out coming impulse (as for measurement or utilizing a control) [1]. The quantities that can be diagnosed by sensors are motion, position, displacement, force, strain, pressure, sound, moisture, light, radiation, temperature, gases, velocity and acceleration etc. Sensor is also known as energy converter. The conversion can be direct or it may require transducers. For instance, a chemical sensor is divided into two parts, one part behaves like a transducer which transforms the energy of a chemical reaction into heat and another part works like a thermopile, which converts the heat energy into electrical signal [2].

Present day Smart Sensors are a product advanced development of last few decades. Smart sensors are a combination of both sensor and actuator [3]. Smart sensors/ intelligent sensors are sensors with integrated electronics that can perform more than one function like data conversion, bidirectional communication, take decisions and perform logical operations. The fundamental requirement for a smart sensor is a combination of a transducer and an associated signal processing system within the

same package. The internal system of such a smart sensor contains the primary transducer, the excitation circuit, an instrumentation amplifier, required filter, analog to digital convertor with sample and hold, data communication system and regulated our supply to all subsystems [4]. Because of the advancements in smart-sensing technology, development of microelectronics is possible at lower cost. Silicon manufacturing proficiencies are utilized to construct both sensor elements and multilayered sensors that are able to procure internal reparation and strengthen authenticity. The future of smart sensor is arduous to forecast as they will be monitored by the new sensing materials or manufactured by different techniques.

II. Types of Sensors

a. Chemical sensor

In 1970s, chemical sensors were introduced which were based on the principle of field effect transistors. A well-organized device that can give details regarding the chemical constitution of its surrounding in both liquid and gaseous phase is known as chemical sensor. Recognition and transduction are two rudimentary steps which are required in the operating of this sensor. The sensing process in a chemical sensor begins by production of physical/electrical signal which is in proportion to the quantity of chemical analyte sensed. It has to be ensured that the primary sensing element interact selectively with the target molecules. As a consequence, physical parameter varies and the output signal is generated through an integrated transducer which records the variations. Chemical sensors are gaining popularity because of its usage in industrial processes, medical stream, and security purposes as it comes in different ranges, compact size, and adequate sensitivity[5].Diagnostic of chemicals in human body can be done through chemical sensors.

b. Biosensor

A device which is used to detect the quantity of a biological analyte (bio-molecule, biological structure, and microorganism) is termed as biosensor. It consists of three parts: a recognizer, a transducer, and an output device. Biosensors must be independent of pH and temperature (physical parameters) and should be used again. Clark and Lyons initiated their work on biosensors in 1960s. These biosensors are available in many categories like enzyme-based, immune sensors, DNA biosensor, and tissue-based biosensors, thermal and piezoelectric[6]. These sensor devices are used in wide range to make better life. Glucose monitoring sensors and pregnancy test kits are examples of these sensors. These sensors are also used to diagnose food quality and its nutritional values. This sensor is also applicable to detect ailments and detecting bio-molecules. To cite an example, electrochemical biosensing processors may be used as a tool to find cancer biomarkers[7].Blood glucose monitoring device senses blood samples and determine its level in human body. Diabetic patients can use this device to check high and low glucose values presence in their body.

c. MOS sensors

A device that detects the concentration of gases by observing the change in resistance of the metal oxide because of the absorption of gases is known as MOS sensor. They are widely used to quantify the changes in physical world, chemical industries, biological system and environmental frameworks. MOS monitoring sensors are able to detect pollution, traffic, weather, temperature, humidity, fire, security systems [8]. This type of detector sensors is used to nail the leakage of carbon monoxide, nitrogen dioxide, sulfur dioxide etc. Intelligent sensors are a part of MOS sensor which uses wireless sensor network (WSN) technology [9]. Sensing properties of metal oxide semiconductors rely on the size of the particle, defect structure and its concentrations [10]. The MOS active-pixel sensor (APS) [11] was introduced by Tsutomu Nakamura by 1985.APS is an image sensor which has photo detector and transistors. These can be seen in digital cameras, DSLR, digital camcorder etc.

d. Environmental sensors

Warren Johnson was the inventor of electric thermostat sensor which was able to keep temperature within a degree of accuracy and this sensor came into the market in 1883. In early 1950s, Samuel Bagno invented motion sensor that was used as an alarm system. He used ultrasonic frequencies as well as Doppler Effect to make his device. Applications of motion sensor were to determine the location of a person within a room, calculate the movement of stars. In the recent world this technology is used for tracking purposes and helps in the management of air traffic control. Apart from that temperature, noise, radiations, humidity, light and gases are monitored by sensors in both outdoor and indoor atmospheres. Motion sensor may help to save electricity as it switch offs the light in those rooms which are not in use. An outdoor change includes volcanic eruptions, earthquakes, weather forecasting and monitoring of soil moisture [12]. A pressure sensor computes the pressure of gases and liquids. Biometric and piezo-resistive pressure sensors are inserted in boilers and gas turbines to calculate pressure values. Nuclear and electromagnetic radiations are sensed from radiation detectors.

III. Monitoring of natural parameters by pollution sensors

3.1 Air pollution

Degrading air quality is the noticeable danger to mankind, thus it is required to check air quality and regulate it properly. Therefore, foremost step is to analyze and detect the presence detrimental gases in the atmosphere which lead to deterioration of air quality. Air pollutants are categorized into some categories; carbon compounds, chlorofluorocarbons, hydrocarbons, metallic pollutants and particulate matter etc [13].

Sources of air pollution are classified into following types;

- Vehicles: there is a rapid surge of vehicles in private as well as public sector which lead to the higher concentration of particulate matter in air. Across major cities of India 800 out of 1000 tons of pollutants are released.
- Industrial waste and thermal power stations: Industrialization led to air pollution at a higher pace and it releases chief pollutant which are leading to the deterioration of many monuments in Fatehpur Sikri, while thermal power plants consume million tons of cost and release ash, hydrocarbon along with other gases.
- Anthropological sources: burnt crop waste, stoves, refrigerator and aerosol spray, nuclear weapon testing by army etc. So, sensing the source of pollutants may be advantageous to us we can clean the polluted content from the air.

Table 1: Sensors to monitor different gases.

Gases	**Sensors**
Methane	MQ-2, MQ-4, MQ-214
Butane	MQ-2, MQ-6, MQ-306A
LPG	MQ-2, MQ-5, MQ-6
Smoke	MQ-2, MQ-3, MQ-135, MQ-303A, AQ-2
Carbon monoxide	MQ-7, MQ-9, MQ-309A, MQ-307A, AQ-7
Flammable gases	MQ-9, MQ-309A, AQ-2
Hydrogen gas	MQ-8

3.2 Soil pollution

Good quality of soil is required for agricultural purposes. Vegetables, rice, fruits, grain, all plants are grown in a soil, and so for healthy food we all are dependent on soil to feed ourselves. Soil is contaminated because of many reasons like when it comes with the contact of chemicals, sprays, soil erosion, and acid rain. So, quality of soil can be improved by soil monitoring. IOT is the best

method to reduce the level of pollution by monitoring the environment of soil. Necessary steps can be taken to mitigate the problem. Tensio-meters and watermark sensors are used to sense the moisture of soil. Ph sensors are also needed to check the Ph level of soil.

3.3 Water Pollution

Water plays a key role in human survival. The world is covered with approximate 71% of water, out of which only 2.5% is fresh water, hence it is an essential resource that must be maintained and monitored well. Water quality is decreasing nowadays with the harmful contaminants. For the development of mankind not a single person is concerning about the purity of water, all are spoiling the water bodies. To control the level of pollution, IOT offers us solutions to sense the pollutants by which we can purify the water for our household purposes. We can also reuse the wastewater in an innovative way by using IOT to measure its potential. Surveyed data describes that sensor can control pollution level. Heavy metals in water can be sensed by biosensors (ISFET) and salinity by SBE 16plus V2 sensor. Concentration of nitrates are sensed by ISUS V3 sensors.

IV. Conclusion

We have to design that type of model which is appropriate in sensing pollution contents which are spoiling our surroundings. A good model can provide us valuable result as compared to observe manually, whereas the challenge to take most favorable and useful data separation from the device. Understanding of suitable defensive and novelizing proof is required to be achieved from such models in coming future and this is the range to be examined carefully so, we can come in the contacts of new ideas for better outcomes.

The above-mentioned papers show our efforts to check reasons behind environmental pollution to improve the state of our ecosystem. The wireless sensor networks permit faster installation of sensor nodes as these networks provides self-configuring, self-detecting, self-solving facilities. It also offers network expansion. The leakage detection of combustible gases information is provided to the people by activating the buzzer alarm. The system can monitor the location of leakage point and display it to the computer so proper action can be taken. The work in future in case of monitoring air pollution can be: to eliminate the intrusion of spare gases from atmosphere while determining gases (Ammonia, Benzene, Carbon Monoxide, and Smoke), proper allocation of hazardous waste and their tiers [14]. The research gap in case of soil pollution is to find effectual technique to minimize the need of data to provide even nutrition level to plant by seeing and revising pH level of fertilizers [14], [15]. In future, soil moisture can be controlled by remote operators efficiently[16] and valid research will be done to eliminate man in fields using automation. This can be done by using smart techniques for agriculture, advance & smart sensors and by changing old techniques with advanced technology. Although there have been numerous advances in Water Quality Monitoring (WQM) over the years, there are several issues that need more advance research. Energy harvesting techniques which may support sensors network to remain in work for longer period of time should be considered in the research work.

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