American Journal of Biology and Life Sciences
2015; 3(1): 22-25
Published online January 20, 2015 (http://www.openscienceonline.com/journal/ajbls)

Contribution to study monitoring systems of air quality

Mohamed Rezki*, Mouloud Ayad

Department of Electrical Engineering, University of Bouira, Bouira, Algeria

Email address

mohamedrezki197@yahoo.fr (M. Rezki), ayad_moul@ yahoo.fr (M. Ayad)

To cite this article

Mohamed Rezki, Mouloud Ayad. Contribution to Study Monitoring Systems of Air Quality. *American Journal of Biology and Life Sciences*. Vol. 3, No. 1, 2015, pp. 22-25.

Abstract

Preserving the environment in our life is no longer a secondary business and thus that requires a severe monitoring and in constancy of its quality. And among all the full range of the monitoring appear the monitoring of the air. The latter made the object of many successive studies and developments through the application of several traditional techniques (physicochemical analyses) but also biological by observing the bio organizations (human plants, animals and even beings) [1]. We made a comparative study between the different conventional techniques including those of the last generation - those which apply microelectronic processes and non - conventional (called bio-monitoring). We reached quite convincing results. The most surprised result to us is that two types go together and therefore was not a competitive relationship, but rather a complementary relationship with a small advantage for bio-monitoring because it allows a more effective sensitizing of population.

Keywords

Air Quality, Pollution, Bio-Monitoring, Sensors, Atmosphere

1. Introduction [2] [3]

Air pollution concerns especially dioxins and metals (arsenic, nickel, cadmium, mercury and lead). Humans are exposed to these levels by either inhalation or through breathing gases, but one can also have atmospheric repercussions in liquid or solid form. The physicochemical techniques of detection of the air pollution and using the sensors do not indicate with certainty the toxic effect associated these numerical values. Hence need to use other complementary techniques such as bio-monitoring techniques. These are available for all living organisms, from bacteria to birds are potential indicators of organic, plants are most used for air monitoring (lichens, mosses, higher plants) because of their immobility and their integration in ecosystems. However, it is always useful to make a comparative study between the two types of techniques for the optimal selection of the means of monitoring solutions and we have the choice either to use one of both or to use them together according to the type of site and his importance. And so we have two main categories to control the quality of the air, we must define and study their Characteristics in order to find the best way to use them. Moreover it is one of the goals of this study. To achieve these objectives, this study will use the analytical comparison method so that it can be one of the simple decision-support tools for our policy makers.

2. Different Techniques of Monitoring Air Quality

2.1. Bio-Monitoring Techniques [2] [3] [4]

These techniques are mainly used as bio-indicators and as one already mentioned are the plants which are employed, for example one can measure dioxins in the air parts of the plants because the latter have enough exchange surface large with air and it is measured in quantity “ngl-TEQOMS/Kg” of the plant matter.

Bio-monitoring gave different concepts for different types of biological systems depending on the objectives:

- The biomarker is intra-individual level: biochemical molecular alterations, cellular and physiological invisible.
- Organic indicator is placed at the individual level: deteriorations physiological, tissue or morphological visible.
- The integrating bio is at the level of the population and/or community: disappearance or appearance of species, variation of densities.
- The bio accumulating is used as matrix for the proportioning of various pollutants following mechanisms of transfer and accumulation.

So we have several levels of monitoring. The principle of plant bio-monitoring is to study specific reaction of plants depending on the dose of certain pollutants in the air. Bio-monitoring can be one passively, by observing the native vegetation, and actively with vegetable made in situ. Two types of plants are used: sensitive and resistant (to pollution).

The first allows the observation of the reactions of plants to the pollutant at the biochemical level or 'population level'. The seconds are used as support sensor and allow measuring the accumulation of the pollutant.

One of the most advantages of bio-monitoring is being able to draw a map of the pollution within a system (city, Forest, etc.). However, it is still limited in the use of living Matter.

2.2. Physical-Chemical Techniques

2.2.1. Conventional Techniques [5] (eg. Detection of NO_{x}. Mixture of NO and NO_{2}.)

The detection of toxic gases are in these techniques primarily done through the effectuation of gas analyses by spectrometers, these devices are too bulky, fragile and very expensive. One of these conventional methods is the Chemiluminescence, it's recommended because of its sensitivity and short response time - about a second - (see figure 1).

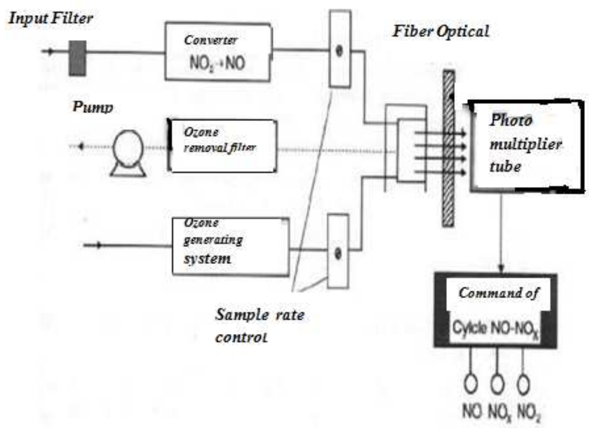

Fig 1. Example of chemiluminescence Detection of peroxide.

Note that the air to be analyzed is drawn at a constant rate, and introduced into the reaction chamber where it is brought into contact with ozone. The intensity of the emitted light is proportional to the quantity of NO and is collected by an electron photomultiplier. The measurement is performed in two steps on two different samples. A first sample is introduced directly and makes it possible to know the content of NO; a second sample is first treated at high temperature in a quartz furnace which converts atmospheric NO_2 to NO before introduction into the reaction chamber. One then obtains the total content of NO_x and by difference between two measurements that of NO_2.

2.2.2. Microelectronic Techniques [6] [7] [8]

Sensors that detect gases are called ambient sensors, the first sensor was designed in 1960 [6] which had as principle the detection of the changes induced in the resistance of some semiconductor films following the absorption of the molecules thus collected so it is an electronic sensor. In developing this technique there happened to gas sensors which has as a principle the modulation of the resistance of material, chemically sensitive, by the absorption of the gas molecules on the surface. The oxidizing gases interact with the surface of material by capturing one or more electrons of conduction, thus reducing the conductivity of a semiconductor type N. Each catalytic material detects a specific gas, for example the indium oxide is sensitive to ozone and the oxide titanium is sensitive to nitrogen dioxide (NO_2) [7].

Scientists have since developed other techniques that are still in research stage but they have almost the same analysis logic – they follow the same operating principle -.

Among these promising techniques, we have the use of transistors components – such as Mosfet's and their derivates: TFT, SGTFT; Etc.-. If we take the case of the pollutant NO_2 gas, the principle of detection is based on tracing the movement of the output characteristic of the transistors that result in a reduction of output current for NO_2 (it's a strong oxidizing gas absorbed by the sensitive layer of transistor as it becomes negative ions NO_2^-). These negative charges make the threshold voltage of those transistors higher. It's clearly seen in the following curve:

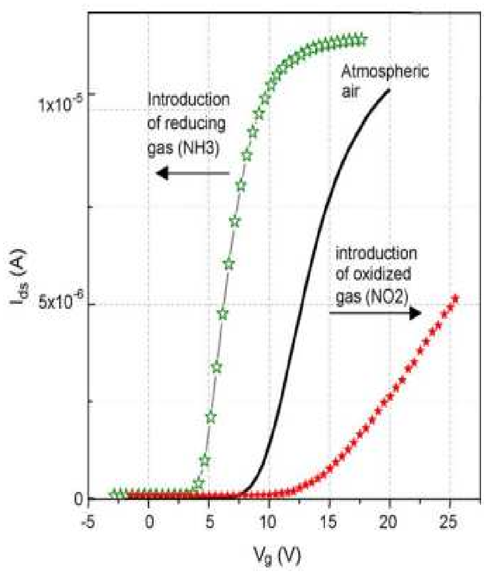

Fig 2. Evolution of the transfer characteristic depending on the nature of the charges detected a SGTFT (suspended gate TFT). [8].

There are other microelectronic techniques such as carbon nanotubes [9], electro active polymers thin film [10] and optical biosensors [11]. The problem with these techniques is their less accuracy in detecting concentrations but there have the advantage to perceive the type of gas.

3. Comparative Studies between the Techniques for Monitoring the Quality of Air and Physical-Chemical Techniques of Bio-Monitoring

This study can be illustrated through the following table:

Table 1. *Characteristics comparison between techniques of physical-chemical and bio-monitoring*

Technical Standard / Specifications	Physical-chemical techniques	Bio-monitoring
Cost	Low due to the benefits of microelectronic technologies	High due to the transport of material and to the slowness of analysis time
Response time	Fast (even instantaneous)	Slow because of the time spent for biological monitoring and the analysis time
Decision support	That does not help because usually the people and the government do not give importance to the physical- chemical results by ignorance	Easy because people are more excited about the results of bio-monitoring they feel themselves threatened because the man is a living being -
Alterations on the environment	Almost no, are techniques no prejudicial.	May exist, for example, if plants are exposed to pollutants for a long period.
Effectiveness in detecting toxicity	Less effective especially for micro pollutants	Efficient because it takes time enough, for example, we can determine the toxic level through the determination of the quantity of toxic matter by accumulation in a living being.

One sees of this table the almost perfect complementarities between the two types of monitoring air quality.

In general we can ascertain that's the microelectronic techniques excels in smallest area and the biological monitoring in the largest one. But we have some simple indicators which can be like an alarm for us such as the non presence of butterfly and ladybug in a region (see figure 03).

(a)

(b)

Fig 3. *Butterfly (a) and ladybug (b): simple indicators of environment quality.*

4. Conclusion

This comparative study of systems for monitoring air quality indeed showed that if we want to get the maximum benefits, it is advantageous to use the physicochemical techniques and bio-monitoring techniques together if resources allow because the physical-chemical techniques are excellent in the detection of atmospheric pollutants (direct detection of concentrations in air) against bio-monitoring is much better for awareness and for the detection of specific micro pollutants whose concentrations in air are difficult to quantify directly.

It remains to generalize such studies in order to preserve our environment.

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