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The Electronics Industry and Their Chemical Effects in the Environment of Arid Regions of Northwest of Mexico

Gustavo López Badilla, Juan Manuel Terrazas Gaynor

Abstract: ***The electronics industry is very important in the world economy, because is one of more dynamic activities, due to a great quantity and different electronic products manufactured and used in a lot quotidian operations. This type of industry has strongly attracted attention to the environmental authorities in the recent 10 years, due to the deterioration that causes to the ecosystems. The electronics industry generates a lot liquid chemical waste, which are thrown into soils and aquifers that are close to companies. The interest of the relation of environmental problems and the electronics industry has manifested with more frequency, from 20 years ago, especially in countries that regulate strictly to care the ecosystems, being some countries of Europe, United States and Japan. The lack of control in certain liquid wastes from activities of the electronics industry, that are discharged into areas next to companies or by the drainage systems has caused a great deterioration of the ecosystems. This occurs with some companies installed in the Mexicali city dedicated to manufacture electronic products. This city is located in the northwest of Mexico that is a border city with the United States of America (USA), where some soils and aquifers are been damaged for some years. This has negative effects in the population too, by the generation and proliferation of respiratory diseases (RD), being a beginning of some environmental and health crisis, particularly in areas adjacent to these companies. This study examined the environmental problems of the industry electronics in Mexicali, and the increase of persons that suffer of RD, being principally in the winter periods. The analysis was made based in two steps, being the first to evaluate the pollution of soil and water levels with the principal climatic factors as relative humidity (RH) and temperature variations around two companies of the electronics sector to be correlated with the RD levels. The second step was to analyze the pH of soil and water, around the three companies evaluated in this city and to elaborate an evaluation of soils with the Scanning Electron Microscopy (SEM) technique to know their level of deterioration. The study was made from 2018 to 2019.***

Keywords: Deterioration of ecosystems, electronics industry, liquid waste, respiratory diseases

I. INTRODUCTION

The electronics industry is often considered as low pollution emission, according to the laws of environmental regulation in the indoors of this type of companies. This activity is classified according to the pollutant emissions generated during the manufacturing process. From this perspective, the industry is perceived as slightly pollutant; where in the United States annually generates 1.6 % of the hazardous waste, according to the emission reflected from the Toxic Release Inventory (TRI)[1]. From the view the final product is conceived not as a contaminant particularly compared with other industries that produce an environmentally crisis, such as the iron and steel industry, chemicals and petrochemicals companies, pulp and paper manufacturing processes and others[2]. In Mexico are a lot companies of the electronics sector, that are been installed in industrial parks of the most important cities as the Mexico city, Guadalajara and Monterrey and in some most popular border cities with the USA as is Mexicali, Tijuana, Nogales, Cd. Juarez and Reynosa. In Mexicali, the major percentage of the companies (75%) is from the electronics industry, or is dedicated to the manufacture of electronics products. In this city around the companies of the electronics sector, are presented deteriorated soils and an increase of RD in people[3]. This is because it does not take into account the speed at which expands the liquids waste dumped in areas next to these companies. The effect in the environmental of the electronics industry is supervised in a very limited way, regardless of the great damage to the ecosystems in any city of the world and in special in Mexicali. The increase of environmental problems caused by the electronic industry of Mexicali is considered as an important aspect in the deterioration of the ecosystem of this zone of Mexico, by the advancement of the technology and standards for this type of companies. This, is known by the fact that in some nearby areas to more than half of these companies, originate variations in the ecosystems as in soils, water canals, aquifers and in the air quality of this city. The environmental regulations and the limited supervision in this topic with international and national laws regulate the level of demand of the electronic products, but the environmental problems still appear regularly in Mexicali, caused by the electronics industry. This analysis provides some elements for an environmental and industrial policy in Mexico, especially in the northwest of Mexico where is located Mexicali, to consider the great care of the ecosystems[4].

Electronics industry

The electronics industry is one of the most productive, dynamic activities and important worldwide. In 1999 this industry was the largest in the United States after the automotive industry, with a production of 578,000 million[5].

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***** Correspondence Author

Gustavo Lopez Badilla*, Departamento de Ingeniería Industrial, UNEA Universidad, Mexicali, Baja California, Mexico, Email: glopezbadilla@hotmail.com.

Juan Manuel Terrazas Gaynor, Departamento de Ingeniería Industrial, CETYS Universidad, Mexicali, Baja California, Mexico, Email: jmterrazas12@cetys.edu.mx

The electronics industry produce a lot articles including telecommunications systems, TVs , production machinery for other industries, robotics systems, as well of a number of appliances. The production of components electronics and computers has gained tremendous momentum in the past 15 years. In the case of Mexico, electronics production has had an extraordinary momentum, rising by more than three times its contribution to the total gross domestic product (GDP) between 1988 and 1999 [1], reaching 1.2% in the last year in 2012. At the same time, their presence in the world market increased significantly and its share rose from 0.8 % in 1988 to 3% in 2000[6]. The electronics industry in Mexico increased at 1.1% in 1989, 17.4% in 1994 and 54.7 % in 2011 of INEGI 2020[5]. It is important to consider that the industry electronics has gone through a period of crisis at the national level and internationally in the past two years, but still a relevant activity in Mexico. In 2020, under the sector covering the electronics manufacturing industry 30% of the total exports, 10% of investment, employment 9.2% , 9% wages and 5.8% of GDP[6]. In Mexicali has been and important development of the industry of this region and generates more than 25, 000 jobs to people of this city and their suburban places[7].

The electronics in our quotidian life

The electronic is part of our daily lives, being copper, silver, gold and tin and its alloys, the key elements for their operation, and they can be used to the communication systems over long distances, use in a PC, watch a DVD or simply use an electronic and electric appliance[4]. The electronics have now fully entered our lives through mobile phones, our cars equipments, computers, media players, and all the appliances you have at home. The metals mentioned and their components are not always detectable as they are incorporated into the finished product. Without realizing it, every day we are in contact with these metallic materials, which without they the electronic equipments may not work[1]. The electronics industry makes extensive use of these metals and its alloys, due to the excellent conductivity of the metals. These metallic materials allow the electronic equipment works faster, and with these metals reduce the formation of heat and last longer. On the other hand, the metallic materials mentioned, are used between they and with other metals to fabricate consumer electronics articles as all the entertainment products, televisions, radios, cellular phones and computers. The laminates of the metals are manufactured by specialized treatments and widely used in the electronics industry, and are constituted of the metals mentioned as a strip, and special alloys that give their properties to a variety of materials. In addition these metallic materials provide the possibility to produce very complex components, and also are used to fabricate economic materials. In the production of very small components are used especially as so very thin strip or profile strips of varying thicknesses. The components made with our bands are essential in the production of: various types of connectors, switches, plugs, sockets and circuit boards[5].

Environmental regulations in the electronics industry

The environmental dimension of this phenomenon has generated great concern, especially in industrialized countries. The manufacturing processes in the electronics industry use some chemical substances to clean; prepare to cut and to protect of the corrosion phenomenon, principally[6]. In fact, the importance of environmental policy adopted in the development technology in the electronics industry, deserves careful consideration in the Mexican Republic, especially in materials with which they are constructed and substances used during production as well as its design and the way it tends to segment the market International of these products. All these elements tend to redefine their insertion into the multinational and international industry. While environmental damage in Mexico industry is considered with a low effect, the environmental problems in the electronics industry of Mexicali occur[1]. The environmental policies, particularly in Europe and Japan, have adopted a vision very drastically of care to the ecosystems, considering the environmental impact by of the chemical substances discharged to soils and drainage systems that is the problematic in Mexicali. In the last five years, government authorities of this city have consistently acted, applying administrative and economic sanctions, without getting any positive result to the three companies evaluated. Personnel responsible for the evaluated companies believe that their manufacturing processes are constantly regulated and not generate any type of contamination. The review of the environmental quality of the chemical substances used to the electronic products, require of specialized regulations to recycle and elaborate the confinement[7].

Risks of environmental problems in the populations

The modernization of cities and towns has contributed to the deterioration of ecosystems, generating a destabilization of society that sometimes causes some ecological crisis in populations[8]. This has contributed to the creation of environments that impair the quality of aquifers and soils principally, due to the dumped of liquid waste of the electronics industry, without a care in the right environment. Also, health problems can be caused to the exposition of the chemical substances discharged. Another important factor is the disappearance of some species of plants that produce oxygen (O_2, vital to humans), animals that break the food chain and microorganisms and bacteria which function decay decaying matter in water, air and soil. This is an unwanted part of sustainable development, being an important factor that will continue on the road to an uncertain future for the new generations to leave and could cause a breakdown of society and the origin of new diseases, economic decline and these uncontrollable social problems[9]. The industrialization of large cities leads to advance technologically in activities that develop both industrial plants and cities[8]. The pollution in aquifers and soils near of the industries evaluated is due to solid and liquid waste nitrates, sulfides and chlorides mainly discharged, in groundwater surface and groundwater and irrigation canals of Mexicali[12]. Contamination in soil is also very detrimental since it not only deteriorates the earth's surface, but that certain wastes can flow to locations where the water flows into the ground or underground. Most of the emissions of pollutants from water, air and soil are anthropogenic, resulting from the deterioration of the environment to the generation and spread of diseases mainly respiratory rate, heart, stomach and intestinal[10].

The natural emission sources such as erosion, drought, frost and even earthquakes are a consequence of anthropogenic activities. This contributes to the decline of the family economy and regions, being necessary the medical care and low yield in the industrial operations. Another factor to take into account is the pollution in the indoor of industrial plants, are the generation of infections very easily. The information of the principal air pollutant that is sulfur dioxide was provided for a specialize equipment used by the Environmental Monitoring System (EMS), located in a strategic places in the city[11].

Climatic factors

Climate is composed of several parameters, where the relative humidity (RH) and temperature are the most important in change of weather and have a negative effect in the deterioration of soils. These climatic factors are measured with specialized equipments, which consist of a hygrometer and thermometer that send the information of values to a PC to be evaluated. The information is organized in hourly, daily, weekly, monthly, seasonally and yearly periods, to be correlated to other parameters. Scientists that analyze the AC, consider that the grade of deterioration of soils can be originated by drastic changes in the humidity and temperature in certain times of the year[12].

Respiratory diseases

The RD, are infectious diseases of the respiratory tract with less than 15 days and sometimes turn into the pneumonia evolution. This type of diseases, are a major public health problem, as are the highest morbidity worldwide[3]. Pneumonia is a major complication of IRAS, responsible for a significant number of deaths. The most important predisposing factors relate to environmental exposure, individual and social data. The clinic data was obtained of sample of people from the public clinic located near of the two companies evaluated. The analysis consisted finding out the correlation in winter and summer, between the chemical substances discharged and the generation and proliferation of respiratory diseases.

II. METHODOLOGY

This study examined the environmental problems of the industry electronics in Mexicali, and the increase of persons that suffer of RD, being principally in the winter periods. The analysis was made based in two steps, being the first to evaluate the pollution of soil and water levels with the principal climatic factors as RH and temperature variations around two companies of the electronics sector to be correlated with the RD levels. The second step was to analyze the pH of soil and water, around the three companies evaluated in this city and to elaborate an evaluation of soils with the Scanning Electron Microscopy (SEM) technique to know their level of deterioration. To this analysis was used the MatLab software[13], where are around of 100 electronics industries in Mexicali[14], and were used the ASTM[15], ASHRAE[16] and ISO[17] standards. The evaluation was made from 2018 to 2019. The analysis was made in three steps with the specialized techniques and equipments as mention next:

1 A mathematical evaluation. It was made near of the companies evaluated correlated with the climatic factors .mentioned above. The industrialization of large cities leads to advance technologically in activities that develop both industrial plants and cities. The pollution in aquifers and soils near of the industries evaluated, is due to solid and liquid waste of sulfides principally and nitrates with less concentration level that are discharged from the electronics industry in groundwater surface and groundwater and irrigation canals of Mexicali. Contamination in soil is also very detrimental since it not only deteriorates the earth's surface, but that certain wastes can flow to locations where the water flows into the ground or underground. The analysis in aquifers identified..

2. Analysis of deterioration of soils. This step was made with images of photographs where are observed the chemical substances discharged in soils, showing the major concentration of sulfurs.

3. SEM evaluation. SEM analysis represents the evaluation of surfaces with microphotographies at surface levels indicating the grade of deterioration of the soils. With this evaluation, was determining the chemical agents that are discharged in the soils.

III. RESULTS

The lack or environmental awareness in people of some companies, causes some deterioration of the ecosystems and then can disappears some species of animals and plants and can originates the climate change. All chemicals dumped by industries, are going to stop, one way or another to aquatic and soils of ecosystems, and these can be directly, as seen in the images of this study, and indirectly, which companies or industries throw their waste to the ground, where in the rainy seasons the chemical substances are thrown very far from companies. It is in this way that aquatic and terrestrial organisms are contaminated by the chemicals discharged from the electronics industry, and therefore humans consume contaminated food of animals or plants or are generated the RD. In this situation, it is necessary that industries have specialized treatment plants, which are proper management of their waste. There permissible limits worldwide that refer to the concentrations of substances discharged by the electronics industry, where most people can be exposed without adverse health effects. However, it is recognized that, given the variability of individual susceptibility, a percentage of the population in a city such as Mexicali, you may experience mild discomfort to certain substances or at or below the threshold limit concentrations and even, to a lesser degree, may be affected by a worsening of previous conditions or the occurrence of an occupational disease. Any substance discharges from industrial plants, as is the case of the electronics industry, and can be sent into the air and remain suspended in the atmosphere for long periods of time, can be inhaled by persons, but only particles possess an appropriate size to reach the alveoli. Also influence its solubility in the fluids of the respiratory system, which is deposited. The total amount of a pollutant absorbed through the respiratory tract is a function of the concentration in the environment, exposure time and pulmonary ventilation.

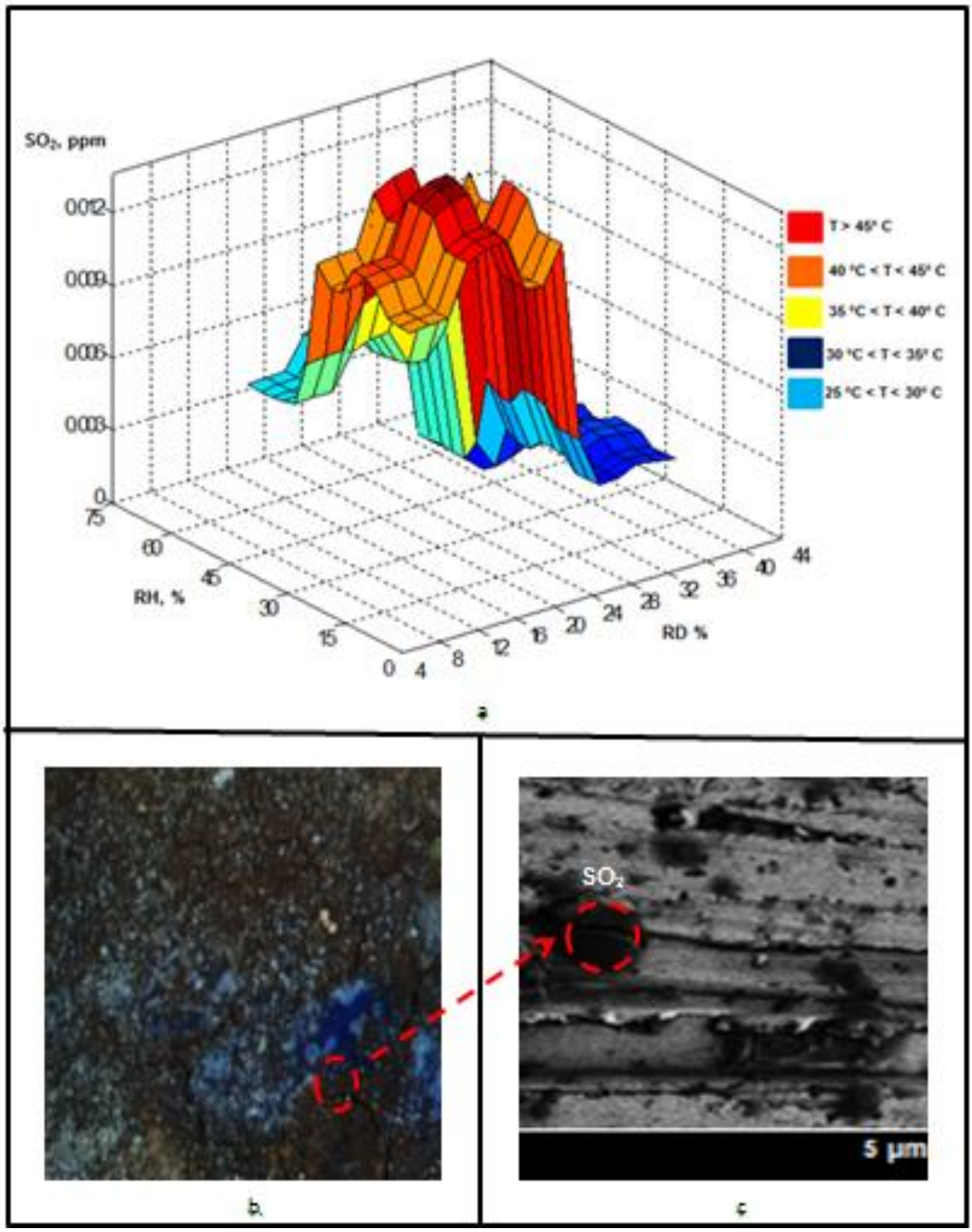

Fig. 1. Evaluation of the negative effect in population and ecosystems next to an electronic industry in Mexicali in the summer period in 2018 in company 1 as: (a) a correlation analysis of climatic and pollution factors with respiratory diseases, (b) chemical substance discharged in soil near of an industry evaluated and (c) SEM analysis.

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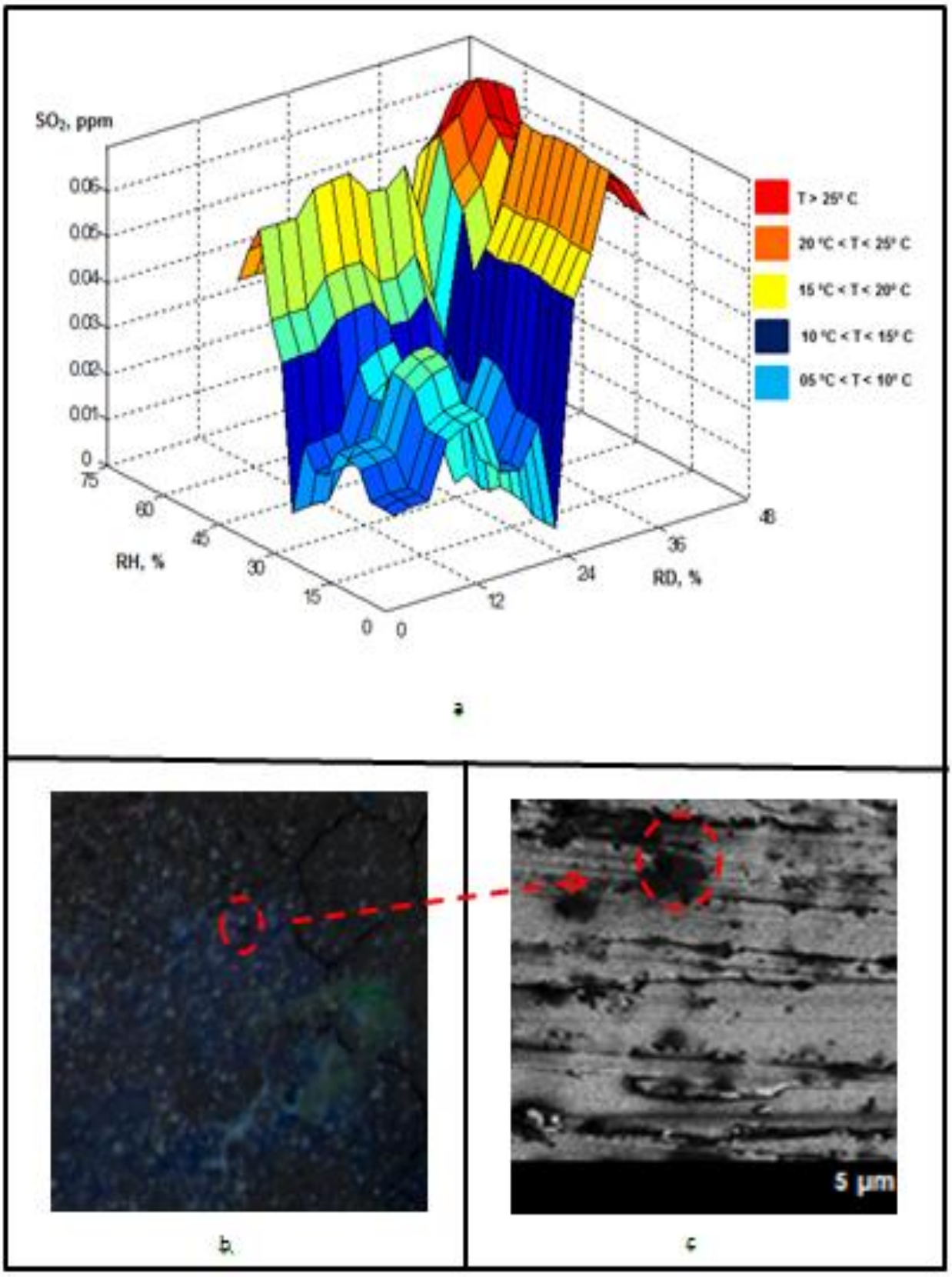

Fig. 2. Evaluation of the negative effect in population and ecosystems next to an electronic industry in Mexicali in the winter period in 2018 in company 1 as: (a) a correlation analysis of climatic and pollution factors with respiratory diseases, (b) chemical substance discharged in soil near of an industry evaluated and (c) SEM analysis.

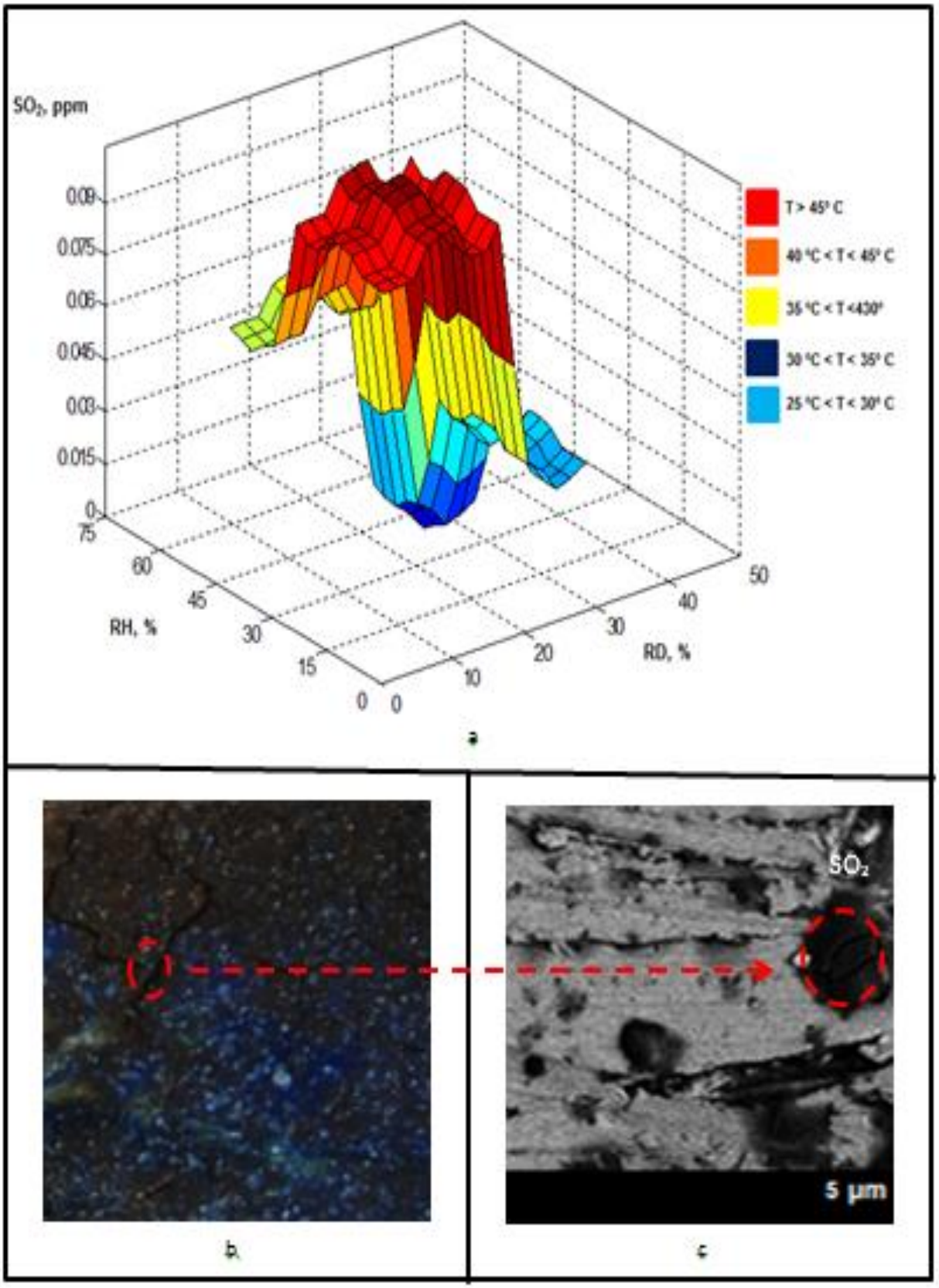

Fig. 3. Evaluation of the negative effect in population and ecosystems next to an electronic industry in Mexicali in the summer period in 2018 in company 2 as: (a) a correlation analysis of climatic and pollution factors with respiratory diseases, (b) chemical substance discharged in soil near of an industry evaluated and (c) SEM analysis.

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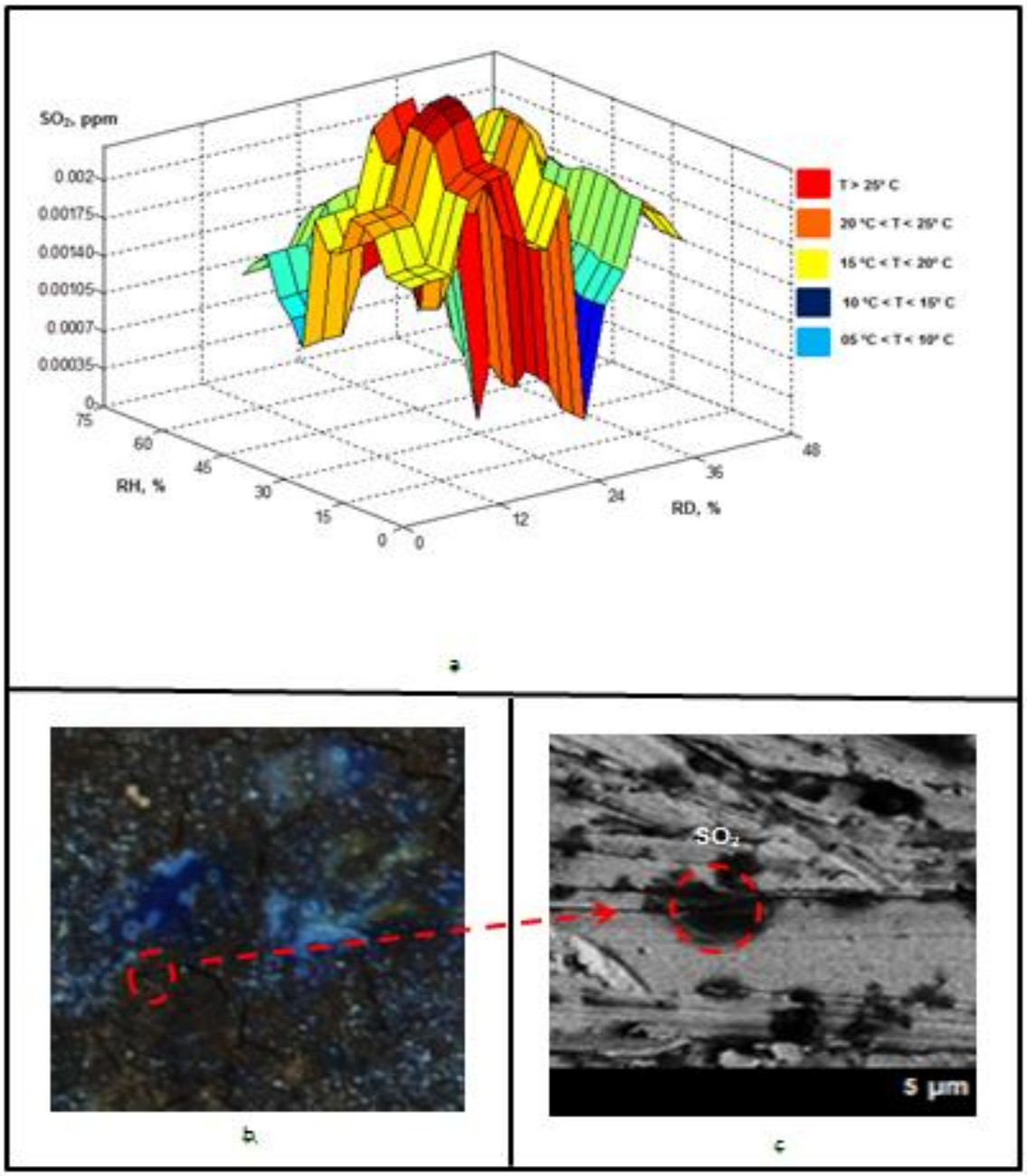

Fig.4. Evaluation of the negative effect in population and ecosystems next to an electronic industry in Mexicali in the winter period in 2018 in company 2 as: (a) a correlation analysis of climatic and pollution factors with respiratory diseases, (b) chemical substance discharged in soil near of an industry evaluated and (c) SEM analysis.

The figures 1, 2, 3 and 4 show the degree of deterioration of the soil next to the two companies evaluated. This caused serious damage generated by pouring waste chemicals of the electronics industry. In the four figures, was obtained correlations between 85%, to 96% as a ratio of the main climatic variables mentioned, observing as the air pollutant that generates a greater effect on soil degradation, such as sulfur dioxide (SO_2) and different rates of RD. The SO_2 is thrown as chemical waste forms a mass in conjunction with the blue floor that tends to penetrate aquifers that are contaminated by this chemical. The RD was increased up to 44 % on the medical care of this type of disease, and were generated near of the industrial plants analyzed and spread to other areas of Mexicali, where sometimes a number of patients present was attended in a health clinics located in various areas of the city. The evaluation indicated by the temperature levels according to the color of each index presented in the specified ranges. The analyses of the summer were in July and winter in December. In the figure 1a was represented by the analysis of company 1 in the summer period of 2012, showing the levels of 50 % to 70 % , with concentrations of 0.013 ppm of SO_2 and temperature ranges greater than 45 ° C. The RD indices were generated by about 36 % as a maximum. In contrast to levels of 40 % to 60 % RH, temperatures below 25 ° C and lower concentrations to 0.003 ppm of SO2, while the RD rates were higher with about 45% . The highest correlation was 92 % in this figure was a rate of 33 % for ER, with 48% RH , 46 ° C for temperature and 0.013 ppm of SO_2.

The nearby clinics evaluated companies, received The figure 1b shows a damaged ground after being poured into it , liquid wastes from Company 1, mainly derived from sulfur to appear dark blue to react with soil components . This was observed at 6 hours after being thrown these chemicals. The soils were damaged , and small cracks were generated in these zones, and this caused them to be infertile and could not grow plants in them or any kind of grass. After observing this process of deterioration , assessment of a small section of compressed soil affected was selected to the SEM analysis in which the chemical elements were obtained in the test analysis was performed , with the sulfur to combined with oxygen in the air near the ground, generating the SO_2 . Also, were observed in less concentration, nitrogen oxides, which could be confused with those containing soil from decomposing microorganisms. In the SEM micrograph of the micro products containing sulfur identified mainly by microscopic analysis are appreciated. The sulfur oxide (SO) is used in certain processes in the electronics industry to electrochemical attack, to improve electrical and thermal conductivity in electronic microcomponents. In Figure 2a the same process developed in the previous figures indicated the winter period in the winter season of 2012 company 1 evaluated, where a small increase in the percentage of 44 % to 48 % in patient care in ER appeared, with children most affected. In this evaluation the highest correlation was 90 % in the rates of 45 % for RD, 71% RH, 0.07 ppm SO2 and 28 °C of temperature. The small increase in patient care RD was mainly due to the combination with the greenhouse effect presented in the winter. Figure 2b represents an image of chemical waste dumped in another area close to firm 1 in more dispersed areas of concentration of SO_2, as Figure 1b. Here as Figure 1b, small cracks are seen quickly soil deteriorated observed. Figure 2c shows the microanalysis of a small section of floor damaged by indicating substances discharged as Figure 1c, with the highest concentration of SO_2. The Figure 3a corresponding to company 2 in the summer period of 2012, indicating the higher correlation analysis of 96% to evaluate rates of 31% for RD, 59% RH, 47 ° C temperature and 0.1 ppm of SO_2. The RD in this analysis increased up to 50% of care for patients of this type of disease. to Figure 3b, also observed cracks soil deterioration and increased concentration in the discharged liquid substances, sulfur being the major component as in other analysis. Figure 3c shows the SEM microanalysis also indicating the presence of SO_2 generated in the company scrapped SO close to the ground with O_2. Figure 4 shows the correlation of 89% with indices 27%, 47% RH, 28 ° C temperature and 0.0025 ppm of SO_2. In Figure 4b, the highest concentration of waste discharges observed with cracks in certain sections o the image, and Figure 4c shows the microanalysis of the presence of micro-sulfur with SO_2 as the main compound.

Analysis of pH levels in soils and aquifers

Evaluation of pH in underground aquifers, lakes, rivers and canals near of the companies evaluated, was made. the pH levels indicate the grade of acidity or alkalinity, depending the value of the . Depending the range es mention next, being 0 being 0 to 6 as acidity level 7, as without acidity and alkalinity and 8 to 14 as alkalinity. Table14 shows the average pH levels in surface water near of the industrial plants analyzed, indicating at nearby industrial plants are most affected places.

Table 1. pH levels in soils near of the two companies evaluated (2018-2019)

COMPANIES	Company 1				Company 2			
	100[a]	250	500	1000	100[a]	250	500	1000
2011								
Spring	4.9	5.2	5.6	6.2	5.8	3.7	8.2	8.8
Summer	5.5	5.4	5.8	6.3	5.2	5.3	9.4	8.7
Autumn	5.7	5.3	5.7	6.5	3.4	7.1	9.5	8.5
Winter	5.1	5.3	5.7	6.1	5.6	5.4	3.4	4.7
2012								
Spring	4.7	5.1	5.7	6.0	7.8	5.6	5.0	7.7
Summer	5.0	5.0	5.6	5.6	5.7	9.1	8.2	8.2
Autumn	5.0	5.0	5.6	5.6	5.7	9.1	8.2	8.2
Winter	5.0	5.0	5.6	5.6	5.7	9.1	8.2	8.2

[a] Distance in meters around the two industrial plants evaluated to determine the pH levels..

IV. CONCLUSIONS

The lack of control of solid and liquid wastes from industrial plants, and in domestic and commercial activities are important elements in the climate change, that every day feel its consequences with natural disasters such as drought, frost, earthquakes and drastic changes of climatic and environmental damage our environment.

There have been a wide variety of environmental impact studies with significant results that support the lack of awareness of environmental care and will generate an important source of sustainability of human life, animals and plants. Still, they continue to have problems with this analysis environment and informs the community and government authorities and other sectors, it is necessary to consider care for our environment, and prevent some types of natural disasters that are the cause of great human and economic losses. This study shows how it is necessary to control landfill companies, where the authorities and society play an important role in the care and preservation of ecosystems, to avoid environmental problem situations. This leads to the awareness of personnel involved in the use of chemicals, even with great control contemplated by the companies, it appears that continue to discharge such substances that do so much damage to society and the environment. One proposal was to design and fabricated an automatic system that has the ability to detect when chemicals that damage ecosystems and create diseases, mainly respiratory rate affects both wing world population to be thrown. This automatic system is in the period of design and will be fabricated early next year. With this automatic system will be improve the care of the ecosystems to Mexicali and other regions.

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REFERENCES

1. López B. G., (2008). “Doctoral Thesis: "Caracterización de la corrosión en materiales metálicos de la industria electrónica en Mexicali”, *Instituto de Ingeniería*, Universidad Autónoma de Baja California.
2. Elizabeth Romero Samaniego, Sandra Luz Toledo Perea, Margarita Cervantes Trujano, Gustavo Lopez Badilla, María Marcela Acosta Gómez, Karina Cecilia Arredondo Soto (2018) “Use of novel FMEA method in the manufacturing processes of electronics industry in arid environment”, International Educational Applied Research J., 2 (3), 54-68.
3. Marco Antonio Reyna Carranza, Margarito Quintero Núñez, Kimberly Collins, Vildósola Reyes (2003) “Analisis de la relación del PM_{10} con las enfermedades respiratorias de la población urbana de Mexicali, Baja California. Un estudio de series de tiempo”, *Revista Mexicana de Ingeniería Médica*, 24 (2), 1-12.
4. Gustavo López Badilla, Rosa Angélica Arreola Álvarez, Lluvia S. Martínez Valdez, Yuliana Mendieta Rodríguez, Mariela García Rodríguez, María del Carmen Pérez Marmolejo, José L. Rocha Crespo (2013) “Corrosion of electronic devices of the electronics industry of Mexicali, B.C. México influenced by H_2S pollution”, *Revista Nova Scienta*, 1-15.
5. Rainer Alt (2018) “Electronics markets and current general research”, *Electronics Market J.*, 28 (1), 123-128. [CrossRef]
6. Bouwman, H., Heikkilä, J., Heikkilä, M., Leopold, C., Haaker, T. (2018). Achieving agility using business model stress testing. *Electronic Markets, 28*(2). 22-34. [CrossRef]
7. Helm, S. V., Ligon, V., Stovall, T., & van Riper, S. (218) “Consumer interpretations of digital ownership in the book market”, *Electronic Markets J.*, 28 (2), 1–13. [CrossRef]
8. Reboul M, Baroux B (2010) “Metallurgical aspects of corrosion resistance of aluminum alloys”, *Materials and Corrosion J.*, 3 (1), 12-24. [CrossRef]
9. Gerhardus Koch (2017) “Costs of corrosion”, Book.. Trends in Oil and Gas Corrosion Research and Technologies. Production and Transmission, *J., Woodhead Publishing Series in Energy*, 3-30. [CrossRef]
10. A. Moncmanova (2007) Book. “Environmental Deterioration of Materials”, Southampton, U.K.: *WIT Press Publishing*, 2007,. 87.
11. Kalpakjian S. (2014) “Manufacturing Engineering and Technology, 2nd Ed., Upper Saddle River, New Jersey*: Prentice Hall*, 89.
12. G. López, B. Valdez, M. Schorr (2011) “Análisis de EEA en la Corrosión de Cobre Utilizado en la Industria Electrónica de Ambientes Áridos y Marinos,” *Revista Electrónica Nova Scientia* 7 (4) 1-16. [CrossRef]
13. S. Azarm, Engineers Guide to MATLAB (Upper Saddle River, New Jersey: Prentice Hall, 2010): p. 156.
14. INDEX-Mexicali (2020) “Reporte de Empresas Maquiladoras de Mexicali,”. 45.
15. ASTM International, Standard Guide for Measurement Systems Analysis (MSA), ASTM E2782-11e1, 2011. ISO, Corrosion of metals and alloys - Corrosion of metals and alloys - Classification of low corrosivity of indoor atmospheres - Part 1: Determination and estimation of indoor corrosivity, ISO 11844-1, 2005.
16. ASHRAE Handbook: Heating, Ventilating and Air Conditioning Applications, American Society of Heating, Refrigerating and Air Conditioning Engineers (Peachtree Corners, Georgia: AHRAE, 1999): pp. 11, 73.
17. [17] ISO 11844-1, “Corrosion of Metals and Alloys—Classification of Low Corrosivity of Indoor Atmospheres-Determination and Estimation of Indoor Corrosivity” (Geneva, Switzerland: ISO,

AUTHORS PROFILE

Gustavo Lopez Badilla, is a professor and researcher in the UNEA University located in Mexicali, Baja California, Mexico. He is a teacher with experience in environmental, materials and corrosion topics; where he has developed a diversity of research in various industries such as electronics, metalworking, agriculture, food and beverages, textile and biomedical. He has knowledge in industrial processes and simulation methods with techniques of mathematics, physics and chemistry achieving solutions in industries designing and applying automated electronic systems and devices. Since he began his career in Electronics Engineering, he had an interest in aspects of science, where during his undergraduate studies, he had the opportunity to develop some research to evaluate climate conditions and pollution, especially air, from of automobile and industrial emission sources, and to achieve a relationship with some health symptoms, mainly of respiratory tract infections in the population. He has participated by giving lectures in various scientific congresses in some cities of the Mexican Republic . He has supported students from the high school level to participate in scientific conferences for their integral development as students. He has received various awards for his participation in scientific congresses, as well as participation in research when he was studying for his master's and doctorate degrees.

Juan Manuel Terrazas Gaynor, is a professor of the CETYS University with extensive experience in industrial processes and analysis at a microscopic level, where he has developed a large number of studies of corrosion and materials topics with groups of researchers from different educational institutions and industries focused mainly on the type of electronics. He has participated in several conferences as a speaker and has generated solution methods to eliminate defects in the electronics industry of Mexicali. He has been a great promoter of science for college-level students and has taught several courses in physics, chemistry, and mechanics topics. He is an expert in metallurgical topics. It is currently focused on areas of interest such as automation and control, robotics and microelectronics that support applied research projects in the field of intelligent manufacturing.