Palestine Technical University Research Journal, 2021, 9(4), 180-191

Microbial Pollution and Heavy Metals in the Work Environment of the College of Engineering and Technology Sciences – Sebha University - Libya (Computer Keyboard as a Case Study)

التلوث الميكروبي والعناصر الثقيلة في بيئة عمل كلية العلوم الهندسية والتقنية – جامعة سبها – ليبيا. (لوحة مفاتيح الكمبيوتر كحالة دراسة)

Amnah Saber[1*], Asma Abdullah[2]

آمنة صابر[1*]، أسماء عبدالله[2]

[1,2] **Environmental Sciences Department, Faculty of Engineering and Technology, Sabha University, Libya**

[2,1] **قسم علوم البيئة، كلية العلوم الهندسية والتقنية – براك، جامعة سبها، ليبيا**

Received: 23/05/2021 **Accepted: 17/10/2021** **Published: 30/12/2021**

Abstract: The paper aims to investigate the concentrations of Pb, Cd, Cr and Ag element of as well as microbial contamination in computer keyboard within the work environment at the Faculty of Engineering and Technology Sciences (FETS) at Sebha University, Libya. The results showed that the mean elemental concentrations (mg/g) in the samples were Pb (14.2±12.9), Ag (7.49±1.44), Cr (6.09±2.88) and Cd (4.43±1.48). The most commonly found heavy metals were Pb (44.1%), followed by (Ag 23.3), (Cr 18.9), and (Cd 13.8) %. The concentrations were higher than the limits allowed by EPA 2009. The concentration of Cd also exceeded the European standards for paint in plastic toys. The concentration of Cr element exceeded the limits allowed in all samples except the IBM brand keyboard. Pb concentration has not exceeded the limit except for the GLK-2010 gaming (16.5 mg/g), IBM (15.5 mg/g), and Discovery (46.4 mg/g) keyboards. Microbiologically, 16 (65%) positive Gram: *Staphylococcus* lactobacillus, mycobacterium, Bacillus, Actinomyces, Micrococcus, Clostridium, Erysprlothrix, Eubacterium and (35%) Gram-negative included Pseudomonas, Aeromonas, Brucella, Aeromonas, Bordetella, Acinetobacter, Bacteroides were isolated. The most polluted sites were administrative offices followed by laboratories and secretarial offices. While the highest numbers of bacteria were isolated from laboratories due to the large daily use.

Keywords: Computer keyboard, Environment, Heavy Elements, Macro, Microbe, Pollution.

المستخلص: تهدف الورقة إلى تقصي عنصر ال\ضرصاص، الكادميوم، الكروم والفضة بالإضافة إلى التحري عن التلوث الميكروبي في لوح مفاتيح الكمبيوتر داخل بيئة العمل بكلية العلوم الهندسية والتقنية. أظهرت النتائج أن متوسط تركيز (ملجم/جم) الرصاص في العينات (14.2 ± 12.9)، والفضة (7.49 ± 1.44)، الكروم (6.09 ± 2.88) والكادميوم (4.43 ± 1.48). وإن أكثر العناصر الثقيلة تواجد كان عنصر الرصاص (44.1%)، يليه وعلى التوالي عنصر الفضة (23.3%)، الكروم (18.9%)، والكادميوم (13.8%). التراكيز كانت أعلى من الحدود المسموح بها من قبل *EPA 2009*. كما تجاوز عنصر الكادميوم المواصفات الاوروبية للأصباغ في الألعاب البلاستيكية ذات المواد الجافة والهشة والمرنة المسموح بها. أما عنصر الكروم تجاوز الحدود المسموح بها في جميع العينات المدروسة باستثناء لوح المفاتيح ماركة *IBM*. فيما لم يتجاوز تركيز عنصر الرصاص الحدود المسموح بها باستثناء لوح المفاتيح العاب ماركة *GLK*-2010 (16.5 ملجم/جم) و*IBM* (15.5 ملجم/جم)، و Discovery (46.4 ملجم/جم). ميكروبياً تم عزل 20 وحدة تكوين مستعمرة تمثل 16 نوع، (65%) موجبة الجرام *Staphylococcus lactobacillus*، *mycobacterium*، *Bacillus*، *Actinomyces*،

* **Corresponding Author E-mail:** amn.alshebani@sebhau.edu.ly

Aeromonas ،*Pseudomonas* سالبة الجرام (35%) *Eubacterium* ، *Erysprlothrix* ،*Clostridium* ،*Micrococcus* ، *Brucella* ، *Aeromonas*، *Bordetella*، *Acinetobacter*، *Bacteroides* . أكثر المواقع تلوثاً المكاتب الادارية، ثم المختبرات والمعامل ومكاتب السكرتارية على التوالي. بينما أكثر الاعداد الميكروبية كانت في المعامل والمختبرات وذلك لكثرة استخدامها اليومي. أحصائياً أثبتت النتائج عدم وجود فروق معنوية بين تواجد العناصر الثقيلة أو أنواع وإعداد الميكروبات المعزولة من لوح المفاتيح عند مستوى معنوية 0.05 حيث كانت أغلب العينات ملوثة وبمستويات متقاربة ومتجاوزة بذلك المعايير القياسية العالمية.

الكلمات المفتاحية: بيئة، تلوث، عناصر ثقيلة، لوحة مفاتيح الكمبيوتر، ميكروب.

INTRODUCTION:

The problem of environmental pollution is the tax that mankind pays for scientific and technological progress, as well under development and mishandling of natural resources and modern technologies. In fact, the FETS has made many serious scientific contributions towards preserving the local environment, for example, but not limited to soil pollution (Al-Shebani & Saber, 2012) air pollution (Nasser et al., 2018), in the field of agriculture (Abdolrhman et al., 2021) in the field of energy industry (Nasser et al., 2021), in addition to the economic cost of eco-system degradation (Nasser, et al., 2017).However, there are shortcomings in researches that deal with environmental problems within the college's campus, such as disposing of wastes of engineering and medical laboratories, expired chemicals, damaged electronic devices and bio solids of workshops. This research highlights an important aspect of pollution, which is microbiology pollution and heavy metals in devices that are under multiple users, such as computers. Computers are one of the most indispensable technologies of the times, and intensively used by all the faculty employees, students, professors, researchers and administrators. Millions of people go to their desks every morning and spend hours clicking on the keyboard in front of the computer screen, but few people are aware of the health risks inherent in their fingertips. For this reason, we considered computers as a target of the present study. Computers with all their components and pigments from solid waste, are increasing in quantity and can transfer toxins and hazardous contaminants such as heavy elements to human and the environment (Sabine and Wendy, 2009). In our bodies, they accumulate and cause considerable damage, as well as the environmental effects of the residues of those paint (Duffus, 2002 Okewole & Omin,2013). This depends on the quantity and nature of the element entering the body or the environment (Adepoju-Bello & Alabi, 2005; US EPA, 2001). Substances found in oil paint such as formaldehyde and benzene, carcinogenic, contain heavy metals and are toxins for the human and ecosystem (Berihun & Solomon, 2017).

The board and the IC packages of a motherboard contain, on the average, 17,400 and 6,700 mg/kg of lead, respectively, of which more than 50% can be leached out in the TCLP test. The Pb concentrations in the TCLP extracts of the vast majority of the PWBs range from 150 to 500 mg/L which is 30–100 times the regulatory level of 5 mg/L for classifying them as hazardous wastes. These are also much higher than the TCLP leaching of Pb from colour CRTs _average 22 mg/L (Sabine and Wendy, 2009). Typical keyboard may contain more than 3,200 germs per square inch, according to the researchers' results (Nasser et al., 2021; Anderson & Palombo, 2009). Eating on these devices also provides a great opportunity for food particles to fall between the keys of the plates to stay there, perhaps for years. Computer keyboards spread contamination in public health places such as hospitals, dental clinics, schools, and other

gatherings (Buers et al., 2000). With the increasing presence of computers in most aspects of our professional environment, recreation and accommodation, 100% of students in university environments access the computer, 92% of them use the Internet regularly and 73.3% use the email (Palmer & Bray, 2001). In addition, there is dual use, such as on-campus Internet cafes that reach all students (Eltablawy & Elhifnawi, 2009). Gram-positive and pathogenic Bacillus cereus (Al-Ghamdi et al., 2011) were isolated by 3%, Pseudomonas putida (66.3%) and Escherichia tarda (30.6%). As demonstrated by (Awe et al., 2013), the contamination of 100 print computers of a group of (offices and Internet cafes, houses, buildings and central markets) in the city of Jeddah in Saudi Arabia with the prevalence of Staphylococci and Bacilli bacteria. As tested by (Rutala et al., 2006) Fifteen keyboards collected from five locations, including E-Library, Resource Room, Dean's Secretaries, Administrative Secretaries and faculty officers, are on campus of the University of Salem Lokoja.

The total number of bacteria ranged from 2.0 to 87.0 X 510 colony formation units/ml, colon bacterial content ranged from 0.8 to 87.0 X 510 colony formation units/ml on keyboards. (Enemuor et al., 2012) Isolated the pathogenic and dangerous bacteria from six switches to computer boards, and (Malik & Naeem, 2014) from keyboards at a university, five different computer centres and a cyber cafe at Kogi State University in Nigeria. And (Onochie et al., 2013) from the surface of 300 computer keyboards found in LCWU computer labs Lahore, Pakistan and the dominant bacteria are Oxacillin Resistant Staphylococcus Aureus, Pseudomonas aeruginosa, Vanco mycin- resistant Enterococcus spp., Salmonela, Shigella, Streptococcus spp., Bacillus subtilis., Micrococcus luteus., Klebsiella spp., And Escherichia coli. revealed (Awad, 2015) the contamination of 250 computer boards, and the dominance of Staphylococcus spp. 43.3%, Escherichia spp. 30.7%, Pseudomonas spp. 18.3% and Bacillus spp 7.7%, respectively. (Ahmed et al., 2009) reported that germs such as abortion-causing Listeria bacteria and food poisoning Salmonella bacteria can survive another 24 hours on the keyboard, and also that the influenza virus can survive for several hours on the keyboard. Insects such as cockroaches can infiltrate through small holes into the computer carrying Salmonella bacteria, but they must go out in search of food and thus crawl over other parts of the computer such as the keyboard in search of food and contamination, in addition to the spread of skin diseases, diphtheria, rash, eczema and fungi Scratch, gastritis, esophagus, gum disorders, pneumonia, hepatitis, septicaemia contaminate the keys of computer boards. The purpose of this paper is to investigate heavy elements (lead, cadmium, chromium and silver) as well as to investigate microbial contamination in the computer keyboard within the work environment at the FETS.

MATERIAL AND METHODS:

Sample Collection:

Samples were collected from 8 computer boards of different colours and manufacturer from the FETS for the purpose of estimating the heavy elements in them. Two colour plates blue and one yellow, two white colour plates (Glk-2010 and Discovery), three black colour plates (IBM and hp, G - MAX), and one grey colour plate (Glk- 2010).

In order to investigate the microbial contamination, 13 samples were collected by swabs from different locations of work environments in some offices and departments at the FETS. The samples were distributed as follows: 4 samples from the Faculty administration, 8 from the offices of scientific departments, and one sample from the researcher's computer

Methods Used:

Estimation of heavy metals: The samples were cut into small pieces (5 g) and submerged in a glass bottle containing 25 ml of 6M nitric acid plus 2 ml concentrated hydrochloric acid. The samples were stirred continuously by electric shaking for 5 hours until the coating was removed. The samples were then filtered by filter paper (Whatman 42) in a 50 mL beaker, and the volume was completed (beaker volume) to the marker with 1.5% nitric acid, and the samples were kept in the bottles until measurement. The heavy elements targeted in the study were estimated using an atomic spectrometer, according to (Al-Shebani & Saber, 2012).

Detection of bacterial contamination: Nutrient agar, blood agar and McConkey media were used in this study and were prepared provided according to manufacturer instructions (Abu Gharara et al, 2010), 2012 for the cultivation, growth and isolation of bacteria. A swab within 1 cm2 from two different areas of the keyboard was taken by lumbar scanner, then put it in a special tube (each swab is placed in a tube). The samples were transferred directly to the laboratory to detect the bacteria. Five millilitres of previously prepared Peptone solution were added to an empty tube, then the cotton swab was placed inside and stirred thoroughly to ensure that the entire sample descended into the solution, as reported in (Al-Shebani & Saber, 2012).

a. Isolation and culture of bacteria: The nourishing agar media was prepared in petri dishes under sterile conditions, allowed to harden and inoculated in a diffusion manner. The dishes were then placed in the incubation at 37 ° C with observation of growth control for 48 hours.

b. Identification: The bacteria were sub cultured on using a needle transplant on McConkey and blood Agar media for identification. The dishes were incubated for 24 hours at 37 ° C for 24 hours to confirm the presence or absence of bacterial growth (Monica, 1984). Noting that the dishes with no growth were incubated for another 24 hours to confirm the growth or not (John et al., 1994) between bacterial types in terms of form and arrangement of cells. (ATSDR. 2012).

STATISTICAL ANALYSIS:

GenStat 12th Edition was used for statistical analysis and significant differences at 0.05.

RESULTS AND DISCUSSION:

Heavy Elements:

The results showed that the paint of all the studied plates contain different concentrations of heavy elements (Table 1). The mean lead concentration in the samples was between (14.2 mg/g ± 12.9), silver

(7.49 mg/g ± 1.44), chromium (6.09 mg/g ± 2.88) and cadmium (4.43 mg/g ± 1.48). In general, the most common heavy metals were lead (44.06%), followed by silver (23.3%), chromium (18.92%), Cadmium (13.75%) respectively

Table (1): The average concentrations of heavy elements studied in the .computer keyboard

Variants	Ag	Pb	Cd	Cr
Mean Concentration (mg/g)	7.49	14.2	4.43	6.09
Standard error	1.44	12.9	1.48	2.88
%	23.2	44.1	13.8	18.9
EPA	0.01	0.15	0.005	0.1
European Specification for Paint in Dry, Flexible and Soft Plastic Toys	-	13.5	1.9	0.02

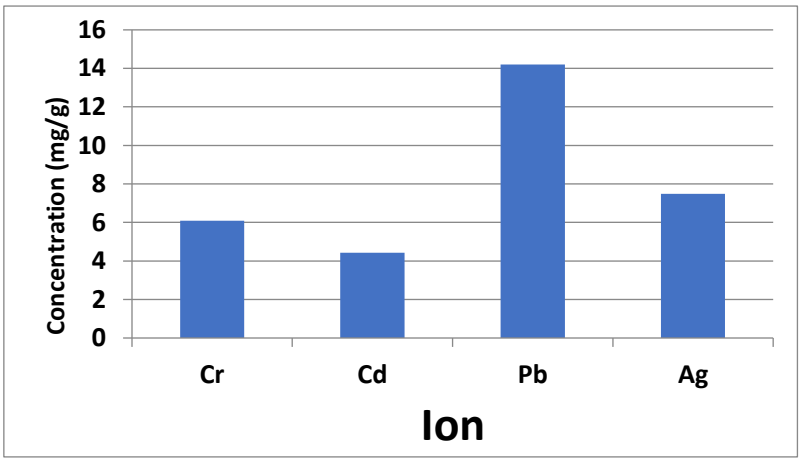

Figure (1): Concentrations of heavy metals in the computer keyboard pigments

Figure (1) shows the concentration of heavy metals was the same in most of the keyboards examined, except the discoloration of the white paint keyboard brand Discovery (17.2 mg/g), which is the most contaminated with heavy elements compared to the lowest height found in the coating of the keyboard black dye G.Max and average (5.88 mg/g).

Lead Element:

A very toxic metal, whose high levels have entered the environment through human activities such as industrial processes and fuel burning, or as additives in some paints and coatings of various products. The results shown in Figure (2) indicate that lead is present in all samples (100%). The concentration of lead in keyboard samples exceeded the allowed limit by the Environmental Protection Agency _EPA_ (0.15 ppm) but did not exceed the limits according to the European Specification for Paint in Dry, Flexible and Soft Plastic Toys (13.5 ppm) excluding Discovery White (46.4 mg/gm), Glk-2010 White (16.5 mg/gm) and IBM Black (15.5 Mg/g). These concentrations are high, especially for the everyday computer user and for children. After ingestion of these molecules enter the bloodstream to be transferred to the

brain and other organs, and sometimes lead accumulates in the blood and over time reaches very high concentrations. It also causes several health problems such as its effect on brain development and low intelligence , stated (Sabine & Wendy, 2009) that there is no fixed level or security level for toxic substances. What is safe yesterday being no longer safe and what is safe today may not be safe tomorrow .

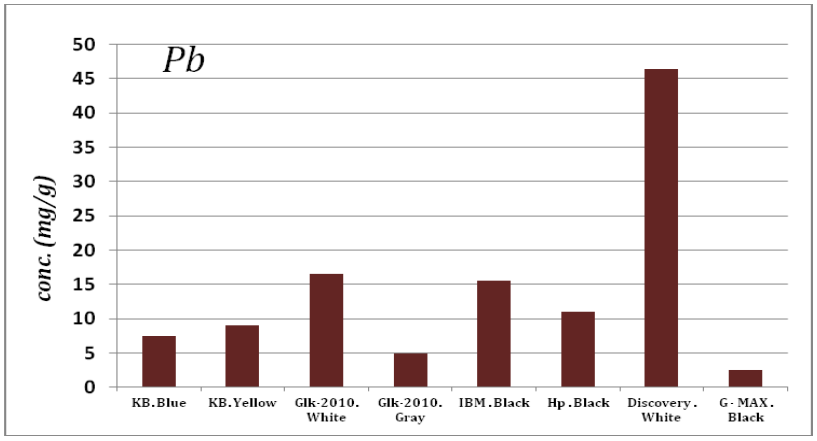

Figure (2): Concentration of lead (mg/g) in the computer keyboard pigments

Silver Element:

Silver is usually combined with other elements such as sulfur chloride and nitrates, and is used in electronic devices, dental fillings and others. The results obtained (Figure 3) indicate that the concentrations of silver element within the paint components of the computer board ranged from (10.3 mg/g) in the discovery brand of white colour and (5.1 mg/g) in the blue keyboard. The concentration of Silver in all samples exceeded the allowed limits for the presence of silver element in keyboard and plastic paint according to the Environmental Protection Agency _EPA_ (0.01 ppm). Long-term exposure to high levels of the silver element leads to a condition called arygria, a gray-blue appearance on the skin and other body tissues. Exposure to high levels of silver in the air leads to breathing problems, irritation of the larynx, lung and stomach pain. While silver contact with the skin causes allergic reactions such as rashes, swelling and inflammation of some people. In drinking water should not exceed (0.10 ppb). At work site air 0.01 mg/m^3 day/8 working hours, 40 working hours/week (Sabine and Wendy, 2009).

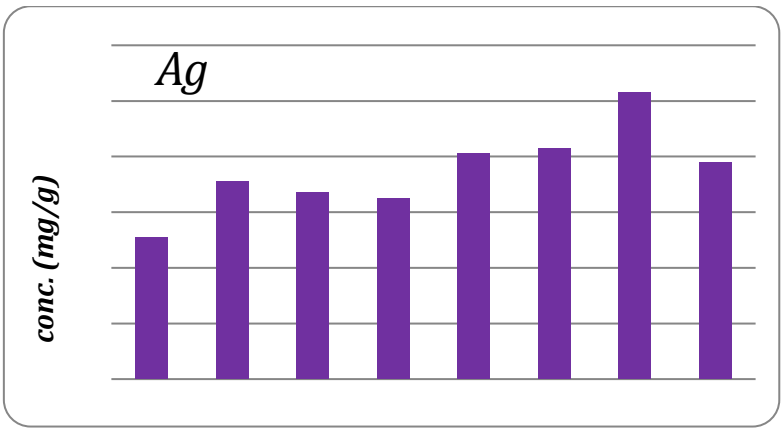

Figure (3): Concentration of silver (mg/g) in the computer keyboard pigments

Chromium Element:

A metal that can exist in a solid, liquid or gaseous form. It is used in metal alloys such as protective coatings on metal, paint and rubber. The results in Figure (4) show that chromium is present in most of the studied samples, where the permissible limits on the presence of paint in the keyboard and plastic exceeded the limits according to the Environmental Protection Agency _EPA_ (0.1 ppm), and the European specifications for painting in dry, flexible and soft plastic toys except for the black - coloured IBM keyboard (15.5 mg/g) which was free of any concentration of the silver element. Chromium causes cancers in humans. High levels of breathing can cause irritation of the lining of the nose, nasal ulcers, colds, and breathing problems such as asthma, coughing, and shortness of breath. Its contact with the skin can cause skin ulcers, or skin allergies such as severe redness or swelling and irritation of the skin, and prolonged exposure can damage the liver, kidneys, and nerve tissue. Its concentration should not exceed 0.0005 - 1.0 mg/m^3 of work site air 8 hours/working day, 40 working hours/week (Sabine and Wendy, 2009).

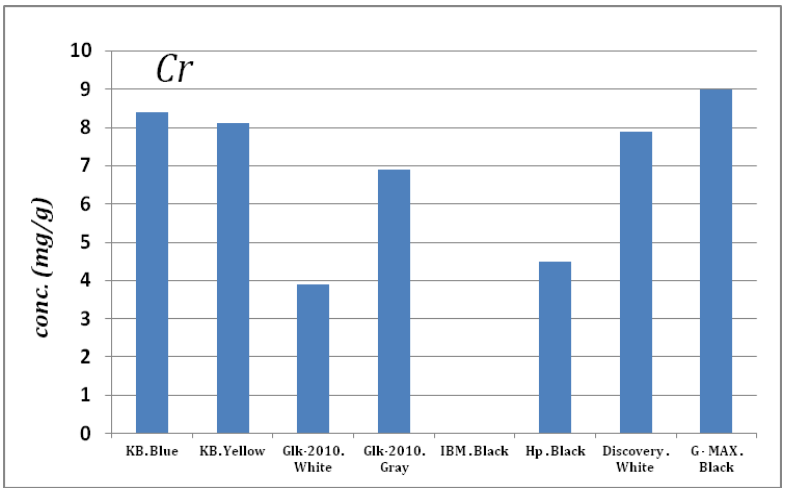

Figure (4): Concentration of chromium (mg/g) in the computer keyboard pigments

Cadmium Element:

A very toxic element that is not easily oxidized, and seeps into the soil, water, and air from mining, industrial work, burning coal and household waste. Cadmium is strongly associated with soil atoms. Fish, plants and animals swallow cadmium from the environment. It is used in many areas such as pigments, metal coatings and plastics, and is widely used in metal and plastic coatings. The results obtained (Figure 5) revealed the presence of cadmium in all studied samples ranged between (2.8 and 7.7 mg/g) in the brand keyboard HP and IBM respectively. All concentrations have passed the permissible limits for the presence of paint in the keyboard and plastic by EPA (0.005 ppm), and European specifications for painting in dry, flexible and soft plastic toys (1.9 ppm) except for the discovery brand white (46.4 mg/g) Glk-2010 white (16.5 mg/g) and IBM black (15.5 mg/g). These concentrations can cause cancer in humans, especially smokers when exposed to high levels of the element, where severe damage to the lungs, and cause irritation of the stomach, vomiting and diarrhoea. Long-term exposure to low levels leads to accumulation in the liver, and the possibility of kidney and lung diseases with osteoporosis. The

limits allowed by WHO in the work area air should not exceed 5 g/m^3 8 hours a day, 40 hours a week, (Sabine & Wendy, 2009). It has also been reported that extremely high prenatal exposure to cadmium can cause low body weight and affect the skeleton of young people in the growing stage (Harper, 2000).

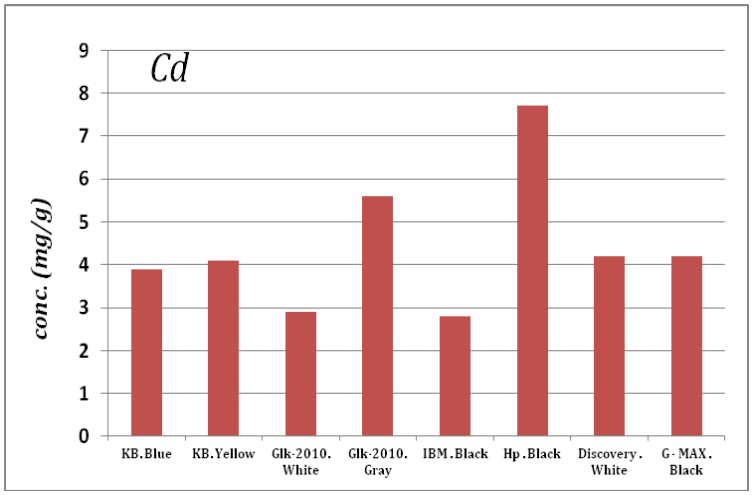

Figure (5): Chromium concentration (mg/g) in the computer keyboard pigments

All concentrations of the heavy metals obtained were higher than the limits allowed by EPA 2009, for lead, chromium, cadmium and silver in plastics (Nassar *et al.,* 2018). Comparing the concentrations obtained in the studied samples with the European specifications for paint in plastic games with dry, brittle and flexible materials, it was found that the element cadmium exceeded the limits allowed. The chromium element exceeded the limits allowed in all the samples studied except the IBM brand keyboard where there is no concentration. Lead concentration has not exceeded the limit except for the GLK-2010 gaming keyboard (16.5 mg/g), IBM (15.5 mg/g), and Discovery (46.4 mg/g). The current results are consistent with studies (Murray,2004; Ogilo *et al.,* 2017) in the plastic coating containing toxic heavy elements. Among the results obtained (AL-Qamhawi, 2008) in his study with the different place of collecting paint where the mean concentrations of Zn, Pb, Cr and Cd were 321.77, 289.59, 77.54, and 73.45 µg/g for the paint chip samples respectively.

Bacterial Contamination:

Isolation and identification of microbes:

From the results obtained, there was a diversity in the types and numbers of bacterial microbes growing on media and varied according to the place of work isolated from it. The isolation of 20 colony formation units representing 16 different species in some traits and shared in other traits. Isolated bacterial colonies varied from small to large size and most of them are smooth colonies scattered on the media. The isolated colonies included white colour (40%), yellow (20%), orange (5%), cream white (30%) and cream yellow (5%). The prevalence of Gram-positive over Gram-negative bacteria was 70%. Most of these bacteria were *Bacillus* form (65%) and spherical (5%) and colonies of bacterial *Bacillus* spherical to the same microbe (25%). Gram - positive and fermented colonies of McConkey medium were 21.43%. While 42.86 of this colony analysed the agar blood medium. The results showed the isolation of 13 Gram-positive microbial colonies (65%) representing nine strains: *Staphylococcus lactobacillus,*

mycobacterium, Bacillus, Actinomyces, Micrococcus, Clostridium, Erysprlothrix, Eubacterium, and seven Gram-negative isolates (35%) including *Aerosomon, Pseudon Aerusomon, Bordetella, Acinetobacter, Bacteroides*.

Microbial Propagation:

From the results obtained, there was a diversity in the types and numbers of bacterial microbes growing on media and varied according to the place of work isolated from it (Figure 6). The secretarial office keyboard in the college contains a small number of microbes, where the largest number of them in the computer keyboard M Site F, probably due to the use of computer keyboard by the laboratory in the department and the following move these microbes from the hands to the secretarial device in the department, followed by a board Office computer keys D, B, G respectively. Secretary is one of the most people who use the keyboards and therefore naturally the presence of fewer microbes on these boards, but they do not exist in the case of repeated usage per day. Thus, the results obtained are a reflection of the reality of the Secretariat dealing with keyboards. In addition, using a transparent cover on the keyboard after cleaning it can protect them from what may occur and not leave the opportunity to provide a suitable growth environment for such microbes. The presence of bacteria may be attributed to the contamination of the hands of people who work on the same panel. Keyboards in the offices of department heads had the least microbial contamination, with the most microbial sites being B and E. Subsequently, sites A, D and C. While the computers in the various laboratories of the FETS are the most used than the other computers for the daily needs, and most of the microbes were in the laboratory B and C in the same location compared to laboratory A located in F.

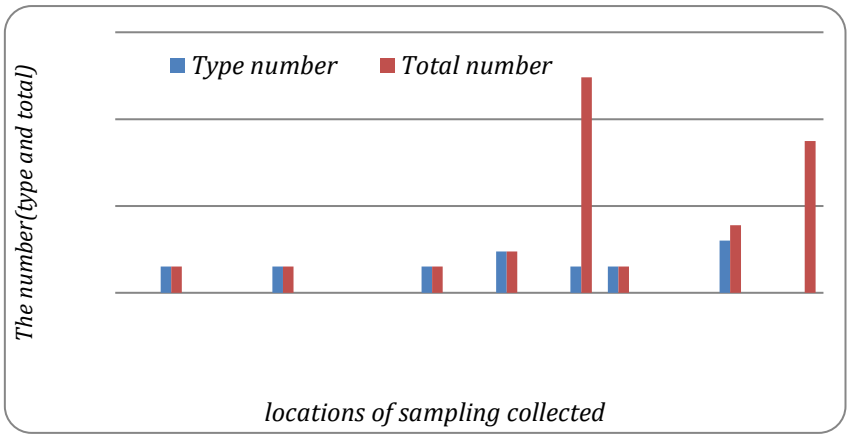

Figure (6): The total number and number of species of isolated microbes

The diversity of bacterial colonies from one location to another may be due to the frequent use of these plates on a daily basis, which is seen in sites F and G compared to other working places that have fewer numbers and diversity or absence of bacterial colonies in some panels, which may be due to the non-use of these devices. This might be due to the cleaning of these boards by the users. From the computer lab at site G that is isolated from other areas and open to students, 56 bacterial colonies of the same type were isolated compared to site F where 6 bacterial colonies of different species were isolated.

These results are consistent with the study (Ahmed *et al.,* 2009) which showed that computers are contaminated with microbes wherever they are, and the study (Buers *et al.,* 2000) that hospitals and their accessories contain high rates of microbial contamination, as well as the study (Padma *et al.*, 2012) disinfectants and disinfectants eliminate most of the possible microbes on the keyboard (Rutala *et al.,* 2006; Awe *et al.,* 2013; Enemuor *et al.,* 2012; Malik & Naeem, 2014; Onochie *et al.,* 2013) Isolate the same microbes and did not correspond with them in the rule of gram-negative bacteria.

CONCLUSIONS:

The results of this study proved that there were no significant differences between the presence of heavy elements, or types and preparation of microbes isolated from the keyboard on different places of isolation of those microbes at a significant level of 0.05. This may be due to most of the samples were contaminated at similar levels and exceeding the limits of international standards. Computers are important things that we cannot do without and through the results of the study; we recommend to educate users of the risk that can be caused by the toxic and dangerous elements or contaminated with microbes, taking care to deal with the computer keyboard, especially children. In addition to cleaning the computer keyboard occasionally to eliminate microbes, and not to eat food and drink while sitting and working on the computer because of the rest of the eating environment suitable for these microbes, wash hands thoroughly with water after getting out of the sessions of the water and return to the use of the computer keyboard.

REFERENCES:

Abu Gharara, I.; Ahmed, A.; and Samia A. (2010). Study of bacterial contamination in the intensive care environment and operating room at Murzuq General Hospital". Research submitted to complete the requirements for obtaining a bachelor's degree, Department of Medical Laboratories, Faculty of Engineering Technical Sciences, University of Sabha.

Abdolrhman, I., M., Almathnani, A., M., Abobaker, E. A, Saber, A., K., and Alsadi, S. (2021). Evaluation of salinity effect on growth and productivity of Rhodes grass (Chloris gayana). International Journal of Engineering Research and Development, 17(4), 28-38.

Adepoju-Bello, A., A. and Alabi, O., M. (2005). Heavy metals: A review. The Nig. Journal Pharm., 37, 41-45.

Agency for Toxic Substances and Disease Registry (ATSDR). (2012). Toxicological Profile for Cadmium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Ahmed, Y., A., Abu Zaid Abu, Kh., and Abdulmutallab, M., S. (2009). Study of Concentration of Lead Element in Toys, Accessories and Pencils. Research submitted to complete the bachelor's degree, Department of Environmental Sciences, Faculty of Engineering and Technical Sciences, Sabha University.

Al-Ghamdi, A. K., Bdelmalek, S. M. A. A, Ashshi, A. M., Faidah, H., Shukri H. And Jiman-Fatani, A. A. (2011). Bacterial contamination of computer keyboards and mice, elevator buttons and shopping carts. African Journal of Microbiology Research. 5(23), 3998-4003.

Al-Qamhawi, I, (2008, May 3-4) A computer keyboard may be more dirty than a toilet chair. Article Al-Quds Al-Arabi newspaper. pp 27-28.

Al-Shebani, A., Saber, K. (2012). The use of bacteria in the treatment of hydrocarbon-contaminated soils and their favorable environmental and biological conditions. Research submitted to complete the requirements for obtaining a master's degree, Department of Environmental Sciences, Faculty of Engineering Technical Sciences, University of Sabha.

Anderson, G., and Palombo, EA, (2009). Microbial contamination of computer keyboards in a university setting; American Journal of Infection Control., 37(6), 507-509.

Awad, S., H. (2015, October 5). The Danger Under the Fingers. Al-Ahram Daily Newspaper Article.

Awe, S., Eniola, K., I., T., and Livingstone, S., T. (2013). bacteriological assessment of computer keyboards and mouse used in salem university, lokoja. American Journal of Research Communication, 1(12), 398-412.

Berihun, D. & Solomon, Y. (2017). Assessment of the Physicochemical and Heavy Metal Concentration from Effluents of Paint Industry in Addis Ababa, Ethiopia. International Journal Waste Resource, 7(4), 306-310.

Bures, S, Fishbain, JT, Uyehara, CF, Parker, JM, Berg, BW. (2000). Computer keyboards and faucet handles as reservoirs of nosocomial pathogens in the intensive care unit. American Journal of Infection and Control, 28(6), 465-471.

Duffus, J., H. (2002). Heavy Metals, Pure Chemistry. Univ. Press. pp 793-807.

Eltablawy, S., Y., and Elhifnawi, H., N. (2009). Microbial Contamination of Some Computer Keyboards and Mice in National Center for Radiation Research and Technology (NCRRT). World Applied Sciences Journal, 6 (2),162-167 .

Enemuor, S., C., Apeh, T. A. And Oguntibeju, O. O. (2012). Microorganisms associated with computer keyboards and mice in a university environment. African Journal of Microbiology Research, 6(20), 4424-4426 .

Harper, C. A. (2000). Electronic packaging and interconnection handbook, (3rd) Edition, McGraw-Hill, New York.

John, G. Holt; Neel, R. Krieg; Peter; H.A. Sneath; James, T. Stalew; and Stanley, T. Williams (1994). Bergeys Manuol of determinative Bacteriology, (9th) Edition, Philadelphia Lippincott Williams & Wilkins.

Malik, K. and Naeem, N. (2014). Study of bacteria on computer s mice and keyboards. International Journal. Curr. Microbiol. App. Sci, 3(4), 813-823.

Monica, C. (1984). Medical laboratory Manual for Tropical countries. Vol.(2) :Microbiology, Doddington (14 Bevills Close, Doddington, Cambs. PE15 0TT):M. Cheesbrough.

Murray, M. (2004). Electronics comes clean—solving the E-waste crisisin California. Waste Manage, March—April, 59—65.

Nassar, Y, Aissa, K, and Alsadi, S. (2018). Air Pollution Sources in Libya. Research & Reviews: Journal of Ecology and Environmental Sciences, (6)1, 63-79.

Ogilo, J. K., Onditi, A. O., Salim, A. M. and Yusuf A. O. (2017). Assessment of Levels of Heavy Metals in Paints from Interior Walls and Indoor Dust from Residential Houses in Nairobi City County, Kenya. Chemical Science International Journal, 21(1), 1-7.

Okewole, A. I. and Omin, B. E. (2013). Assessment of Heavy Metal Contents of Some Paints Produced in Lagos, Nigeria. The Polytechnic Journal of Science and Technology, 8, 60-66.

Onochie, C., Ch., Anyim C. Alo, M., N., Onwa, N., C., Okonkwo, E., Ch., and Afiukwa, F., N. (2013). bacteriological examination of computer keyboards and mouse devices and their susceptibility patterns to disinfectants. American Journal of Microbiology, 4 (1), 9-19.

Padma, S.; Sivagamasundhari, S., Suchithra, S., Gurusamy, T., and Kalyani, J. (2012). Assessment of Aerobic Bacterial Contamination of Computer Keyboards in a Tropical Setting. The Journal of the Association of Physicians of India, 60.

Palmer, S., R., and Bray, S., L. (2001). Longitudinal study of computer usage in flexible engineering education. Australian J. Edu.Tech., 17, 313-314.

Sabine, M., and Wendy, G. (2009). Human Health Effects of Heavy Metals. Environmental Science and Technology Briefs for Citizens. Center for Hazardous Substance Research, Issue 15.

US EPA (2001, January 20). 40 CFR Part 745: Lead: Identification of Dangerous Levels of Lead: Final Rule. US Environmental Protection Agency, Washington, DC.

Rutala, W., A., White, M., S., Gergen, M., F., and Weber, D., J. (2006). Bacterial contamination of keyboards: efficacy and functional impact of disinfectants. Infection Control & Hospital Epidemiology, 27 (4), 372-377.