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Inactivation Efficiency of Bioaerosols Using NANO- oxygen Plasma Air Purification Device (Bioaerosol Removal from Air with NANO- Oxygen Plasma Air Purification System)

Dr. Mehrdad Fojlaley[1], Emmett Imani[2]

1. **Dr. Mehrdad Fojlaley [1 *]**
Postdoctoral Fellow, Faculty of engineering, Ardahan University, Ardahan, Turkey.
2. **Emmett Imani [2]**
Erdwelle Technology Inc. Florida, USA.

Abstract

The indoor air quality of public utility places is very important for human health. Bioaerosols concentration in ambient air quality conditions have effects on the ecosystem and human health. In this study, it is aimed to determine the diversity and number of indoor bioaerosols before and after using the nano-plasma air purification system in a room used as a clean room in Van Regional Training and Research Hospital and to determine its effectiveness. The air samples were collected using passive air sampling method 3 different places 4 Petri dishes (blood agar, EMB agar, SD agar, and chocolate agar, RTA laboratories, Turkey) for a while of 1 hour, 2 hours, and 4 hours in 75 m3 room. The collected agar plates were incubated in the microbiology laboratory of our hospital for 24 hours. Growing microorganisms were evaluated with a conventional and automated device (VITEK 2, bioMe´rieux, France). Before using the nano-plasma air purifier device, the culture results of bioaerosols were found 120 CFU / Petri and 18 different types of microorganisms and 4 hours after using the nano-plasma air purifier device, 20 CFU / Petri and 8 different types of microorganisms (Table 2,3 Figure 1,2). The most produced microorganisms are gram-positive bacteria while the air purifier nano-plasma device is used and the most dominant is Micrococcus spp. was determined. As a result, it was determined that air cleaning devices were very effective in decreasing the number and variety of microorganisms in the indoor air as a cleanroom in the hospital.

Keywords: Bioaerosols, indoor air, nano-plasma air purifier, microorganism. during the spring season.

Introduction

In recent years, dealing with health problems, ecosystem damage and economic damage caused by microorganisms in the bioaerosols form has become very important. Infectious and viral diseases such as new influenza and COVID-19 due to pathogenic organisms have been spread worldwide [1,2]. Exposure to bioaerosols harms ecosystems and human health; also it causes infectious diseases, allergic diseases, acute toxic effects, respiratory diseases, neurological diseases, and cancer [3, 4]. European Union limit values for bioaerosols in residential areas are determined as 5x103 CFU/m3 for bacteria and 5x103 CFU/m3 for fungi [5]. The maximum limits recommended in the United States are determined to be 1000 CFU /m3 according to the National Institute of Occupational Safety and Health (NIOSH); also the total bacteria number not upper than 500 CFU/m3 according to the American Conference of Governmental Industrial Hygienists Conference (ACGIH) [6, 7].

A helpful and economical purification method is necessary due to the growth of health awareness in living regions, especially in the hospital. With the development of technology, electronic air purification systems are widely used to reduce the damage of bioaerosols. Microorganisms, dust, and similar particles in the inhaled air circulate positively. Nano-plasma is the ion form of the oxygen molecule and neutralizes positive charged microorganisms and particles in the air. Because of this neutralization, particles fall to the ground due to their weight. These operations cause prevent the inhalation of microorganisms and particles that negatively affect our health. Many studies are indicating that air purification devices have killing effects on bacteria and fungi [8, 9].

It is important to consider several factors in selecting the most effective air purification device like long-term performance, use minimum energy, and the minimum amount of unwanted harmful microorganisms and particles [10, 11].

In this study, with Nano-plasma technology by generating negative oxygenation, the rate of elimination of microorganisms in bioaerosol form and their load levels by a passive method in the environment used as a cleanroom in the hospital have been determined.

Material and Method

In this research, a Nano-plasma air purification device (Erdwelle Technologies Air and Surface Purifier, Turkey) applied in a clean room with dimensions of 75 m3 meters in Van Teaching and Research Hospital. Before and after the installation of the NANO-plasma, the petri dish was left open for air sampling. The air samples were collected using the passive air sampling method in 3 different places with 4 Petri dishes (blood agar, EMB agar, SD agar, and chocolate agar, RTA laboratories, Turkey) for periods of 1 hour, 2 hours, and 4 hours in the cleanroom. The collected agar plates were incubated in the microbiology laboratory of Van regional training and research hospital for 24 hours. Microorganisms in Petri dishes were evaluated with conventional and automated equipment (VITEK 2, bioMe´rieux, France).

In the study, the Nano-plasma air purification device by generating OH- and negative ions is effective in the removal of bioaerosols in the environment. The schematic of the nano-plasma air purification device is given in fig1.

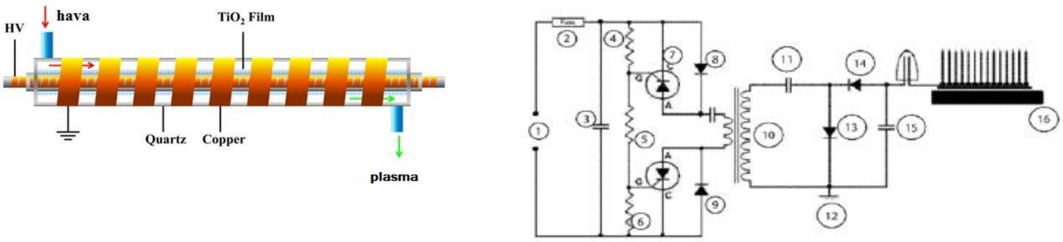

Fig. 1. Schematic of the nano- plasma air purification device.

Results and Discussions

Before and after using the Nano-plasma air purification system, the total number of microorganism that grew in the samples which were taken during 1, 2, and 4 hours, was calculated.

The change of colony numbers over time before and after applying the Nano-plasma air purification system are given in table 1.

Table.1. variation of colony numbers over time before and after using the NANO-plasma air purification device.

Table 1. variation of colony numbers over time before and after using the NANO-plasma air purification device.

Duration (hour)	**Without Erdwelle's Nano-Plasma Unit (Average CFU)**	**With Erdwelle Nano-Plasma Unit (Ortalama CFU)**
1 hour	10	1
2 hour	43	9
4 hour	120	20

As we can see in table 1, before utilizing the Nano-plasma air purification device the number of aerosols was found to be 120 CFU / petri dish at the end of 4 hours, while after using the Nano-plasma purification 20 CFU / petri dish was found at the end of 4 hours.

Types of Microorganisms and their numbers in the air before and after the 4 hours Nano-Plasma purification process are given in table 2.

Table 2a. Types of Microorganisms and their numbers that present in the air before applying the Nano-plasma system.

Microorganisms	**Numbers**	**Percent (%)**	**Current Percent (%)**	**Cumulative Percent (%)**
Aeromonas salmonicida	1	0,8	0,8	0,8
Aspergillus spp.	3	2,5	2,5	3,3
E. casseiflavus	3	2,5	2,5	5,8
Glabicatella sulfıdifaciens	1	0,8	0,8	6,7
Kocuria kristinae	3	2,5	2,5	9,2
Kocuria rosea	6	5,0	5,0	14,2
Kocuria varians	3	2,5	2,5	16,7
Micrococcus spp.	55	45,8	45,8	62,5
S epidermidis	17	16.6	16,6	64,2
S hominis ssp. hominis	9	7,5	7,5	65,8
S. lentus	3	2.5	0,8	66,7
S. warneri	1	0,8	0,8	67,5
S. capitis	6	5,0	5,0	73,3
S. caprae	1	0,8	0,8	74,2
S. lugdunensis	2	0,8	0,8	94,2
Str pneumoniae	1	0,8	0,8	96,7
Str. mitis/oralis	2	1,7	1,7	98,3
Str. Salivarius spp. salivarius	2	1.7	1.7	98.3
Total	120	100,0	100	

Before using the Nano plasma air purification device, 18 different types of Microorganisms (Micrococcus spp. 45.8%, S. epidermidis 16.6%, S. hominis ssp. hominis 7.5%, Kocuria rosea 5%, S. capitis 5%, Aspergillus spp. 2.5%, E. casseiflavus 2.5%, Kocuria kristinae 2.5%, Kocuria varians 2.5%, S. lentus 2.5%, S. lugdunensis 1.7%, Str. mitis/oralis 1.7%, Str. salivarius spp. salivarius 1.7%, Aeromonas salmonicida 0.8%, Glabicatella sulfıdifaciens %0.8, S. warneri 0.8%, S. caprae 0.8%, Str pneumoniae 0.8%) observed.

Table 2b. Types and their numbers of Microorganisms that present in the air after 4 hours utilizing the Nano-plasma device.

Microorganisms	**Numbers**	**Percent (%)**	**Current Percent (%)**	**Cumulative Percent (%)**
E. casseiflavus	1	0,8	84,2	84,2
Kocuria rosea	1	0,8	85,0	85,0
Micrococcus spp.	11	9,2	94,2	94,2
S. capitis	1	0,8	95,0	95,0
S. caprae	1	0,8	95,8	95,8
S. epidermidis	2	1,7	97,5	97,5
S. hominis ssp. hominis	2	1,7	99,2	99,2
S. warneri	1	0,8	100,0	100,0
Total	20	100,0		

As shown in Table. 2a, 8 different microorganisms (Micrococcus spp. 9.2%, S. epidermidis 1.7%, S. hominis ssp. hominis 1.7%, E. casseiflavus 0.8%, Kocuria rosea 0.8%, S. capitis 0.8%, S caprae 0.8%, S. warneri 0.8%) observed.

Figure. 2, Shows the contribution of microorganisms in the air before and after Erdwelle's Nano plasma air purification.

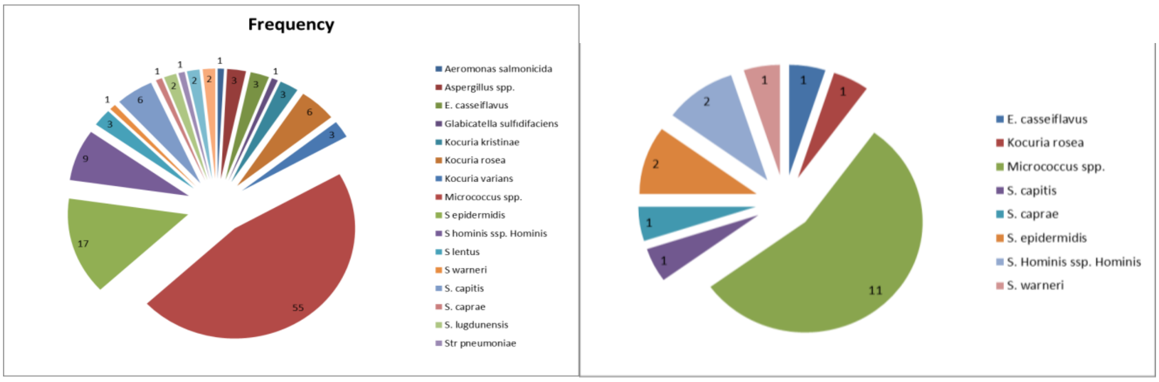

Fig. 2. Contribution of microorganisms in the air before (right) and after (left) Erdwelle's Nano plasma air purification application.

As illustrated in figure 2, for two cases (before and after applying systems), the most common and dominant microorganisms in the air are positive Gram bacteria and Micrococcus spp. respectively.

Conclusion

Nonthermal plasma disinfection has been received much attention. Active species and UV are easily generated by cold atmospheric plasma and therefore it can be used as a sterilization tool for bacteria or bacteriophage [12,13]. This method can be used for indoor air purification.

In this research, a Nano-plasma air purification device (Erdwelle Technologies Air and Surface Purifier under the brand Medwave, Turkey) applied in a cleanroom. Before and after using the Nano-plasma air purification system, Gram-positive such as coagulase-negative staphylococci, Kocuria spp., Streptococci, and Enterococci bacteria are the most common microorganisms that are present in the air. The most dominant Microorganisms that present in the air are Micrococcus spp. After utilizing the NANO-plasma air purification system, 3 Aspergillus molds, and the only negative gram bacteria (Aeromonas salmonicida) were completely removed from the environment.

The results were confirmed that the Nano-plasma air purification process was very effective in decreasing the number and variety of microorganisms in the indoor air because of its ability to generate both OH- and negative ions which destroy the Microorganisms.

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