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JOURNAL OF PURE & APPLIED MICROBIOLOGY, Nov. 2014. Vol. **8**(Spl. Edn. 2), p. 681-692

Relation of Bacteriological Water and Air Quality in Dentistry Center

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(Received: 06 August 2014; accepted: 31 October 2014)

The water and air around the dental units are constantly exposed to contamination caused by biofilm growth in water ducts of units and dental services and staff and patients are exposed to potential diseases. This study aimed to investigate the relation of bacteriological water and air quality in dentistry center. This study is a cross-sectional. Based on a standard method, 72 water samples were recruited and examined and air sampling of selected areas (72 samples) was carried out using passive method. Water and air bacteriological qualities were determined using (Heterotrophic plate count) HPC testing and identifying and counting of *Staphylococcus aureus* and *Pseudomonas aeruginosa* carried out according to protocol. Results were analyzed using SPSS 16, independent t-tests, correlation coefficient, one-way ANOVA, Kruskal-Wallis and LSD. Bacteriological quality of 90.3% of water samples were over-recommended, 33.3% of air samples were over-acceptable and were assessed as unfavorable condition. The correlation between bacterial infection of *Pseudomonas aeruginosa* (r=0.20) and *S. aureus* (r=0.34) was weak and not significant in air and water, but there was a moderate and significant correlation between the amounts of HPC (r=0.69) in air and water. This study shows that bacterial contamination of water in different unit parts output exceeds the standard and has direct relation with microbial contamination of the air of dental parts and accordingly the safety of staff and patients is exposed to risk; Thereby reducing the contamination burden through appropriate and consistent control measures on the quality of consumed water and air of dental parts according to necessary health guidelines.

Key words: Bacteriological Water and air quality, Dentistry center, HPC, *Pseudomonas aeruginosa, Staphylococcus aureus.*

Offering services in dental clinics exposes dentists, assistants and patients to the types of microorganisms that can be caused through oral pathogens and consumed water in units.[1-5] Dental care providers and patients not only are exposed to potential diseases such as cold, flu, herpetic viral infection and SARS,[6] but also are prone to contamination with pathogenic microorganisms viruses such as viruses of hepatitis B, C and HIV, bacteria such as *Mycobacterium tuberculosis*, *Staphylococcus aureus*, *Legionella*, *Pseudomonas aeruginosa*,[7] but a specific number of opportunistic microorganisms such as *Legionella pneumophila*, *Flavobacterium species*, *Klebsiella species*, *Pseudomonas aeruginosa*, accumulate on the water lines of dental units a develop the biofilm layer. [1,8,9] Biofilm layers

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due to water retention, form and extend further up on the weekends, provide the conditions for growth and reproduction of different types of bacteria in the water.[1, 10, 11] Many dental treatments resulted in production bioaerosols and secretions contaminated with bacteria, viruses, fungi, and mostly blood.[12, 13]

All services provided by dental units, cause the formation of bioaerosols and to create a risk for the susceptible population, including staff, Immunocompromised patients, people with chronic diseases and people who deal with corticosteroids, and immune amplifier medications.[14] The bioaerosols contain pathogenic microorganisms that may originate from the turbine outflow, saliva and oral blood of the patient.[15-17] The bioaerosols cause many contagious diseases and allergies of respiratory tract.[18] Kimmerle *et al*. studying transferable microorganisms through air in dental centers reported that although the number of bacteria in dental room air is not more than that of the general environment, but because of the nature of the microorganisms, host susceptibility and duration of exposure, they have a high risk.[19]

Harrel *et al*, in their study demonstrated that only through the water unit pollution control, lack of aerosols pollution is not assured, because high frequency ultrasonic scalers can lead to generate bioaerosols from saliva or blood of the patient's mouth, and spread the contamination to the air around the patient.[20] Castiglia *et al*, and SzymaDska *et al*. in their studies, sampling from Dental Centers air showed that microbial contamination of the air for the number and variety of microorganisms, during providing services to patients is more than that during the rest time or after the operation of the unit.[3, 19, 21, 22] Bârlean *et al*, in their study reported HPC of dental units' air, before and after work, 228.3 CFU/m^3 and 430.3 CFU/m^3, respectively, and Staphylococcus aureus was separated from 6/6% of samples.[23] Pasquarella *et al*, also demonstrated in their studies that microbial contamination of tap water and water system of dental units were 51200 CFU/ml and 872000 CFU/ml, respectively, and *Pseudomonas aeruginosa* were founded in samples of tap water and water system of dental units to the amount of 2.38% and 20.06%, respectively.[24] In their study, SzymaDska *et al*, reported *Pseudomonas aeruginosa* contamination of water consumed in units, 20 CFU/ml.[25] During their study, Manarte-Monteiro *et al*, reported the average amount of air microbial contamination 10.4 CFU/plate/h.[26] SzymaDska *et al*, showed that the microbial contamination of indoor air during dental treatment services has been 4 times higher than that of other conditions.[22] In particular, Debattista *et al*, and Rautemaa *et al*, in their studies proved that the contamination has been higher during the application of high speed hand pieces like Dental Piezoelectric Ultrasonic Scaler and turbine than that of other dental treatments.[3, 27] Anderson and colleagues at the University of Copenhagen showed, HPC of turbine head soaked in saliva and has an average of 500,000 CFU/ml.[28] There is usually a logical correlation between water pollution of units and air bioaerosols of dental centers and air microbial contamination can occur as a result of water contamination and vice versa.[29] Messano and colleagues reported the quality of 87.7% of water consumed in units, and 72% of air in the parts of the study dental center are in undesirable condition,[30] so the study and determination of the number and diversity of microorganisms in the water and air of the centers are a valuable indicator of the health or contamination of the centers where are considered as a source of nosocomial infections.[31] This study aimed to investigate the relationship between bacteriological quality of units consuming water and air of a dental center in Tehran.

MATERIALS AND METHODS

This study is a cross-sectional that has been conducted in a dental center of one of the hospitals in Tehran. The research process is described in four steps that the first medium was prepared according to protocol; then we study consuming water of units, survey the measurement of the bacteriological quality of air and finally was carried the statistical analysis and examination of relationship between the bacteriological qualities of water and air.

Preparation of culture media

Culture media were prepared. HPC test that was performed using the spread plate method and according to the standard method (9215C) and by the use of the plate count agar medium (tryptone glucose yeast agar) manufactured by Merck,

Germany.[32] Mannitol Salt Agar (MSA) medium that was prepared according to the standard method (9213D) for counting *staphylococcus aureus*. To ensure that the colonies grown on the surface of the medium are *Staphylococcus aureus*, we carried controls such as the observation of yellow due to mannitol fermentation on the medium, gram staining and observed clustered gram-positive cocci and also coagulase, catalase, DNAase and oxidase tests.[33] P-agar medium was developed under standard method (9213F) instructions for the enumeration of *Pseudomonas aeruginosa*. To ensure that the colonies grown on the surface of the medium, are *Pseudomonas aeruginosa*, we perform controls such as gram staining and observation of gram-negative bacilli, also oxidase and catalase and pigmentation check tests.[33]

Bacteriological water quality

A sample amounts of 72 subjects was calculated according to the statistical equation and consuming water of units was sampled according to standard method.[32] Sterile falcons with a volume of 50 ml were used for sampling, and a sodium thiosulfate solution 3% was used to neutralize the residual chlorine. Sampling was performed on Saturday (before starting the units) and Wednesday (during the operation of units) in units of the selected parts including prosthodontics, restoration and periodontal surgery. Study unit in the above sections were selected randomly. On each day, We sampled four different parts of the unit including before water entering the unit, cup filler, air/water syringe and turbine head duct. Samples were kept at temperatures below four degrees Celsius in cold box, and transported to the laboratory for testing in less than six hours.

Bacteriological tests for counting HPC, *Staphylococcus aureus* and *Pseudomonas aeruginosa*, were performed by culturing 0.1 ml of the sample on plate count agar, mannitol salt agar and p-agar media, respectively. Then the above media were incubated at the temperature of 37°C for 24-48h. After 48 hours, the number of colonies grown on the plate was counted, and the results were calculated in CFU/ml (colony forming unit / mililiter).

In order to classify the bacteriological quality of water samples, ADA (American Dental Association) recommendation that sets the amount of HPC was used to >200 CFU/ml.[34]

Bacteriological air quality

In the present study, passive method and settle plates were used for sampling bioaerosols in the air. In each set of sampling, all plates were placed to a distance of one meter above ground level and the patient's mouth for one hour.[24, 30]

Media required for bacteriological tests including air containing plate count agar, mannitol salt agar and p-agar, in order to count HPC, *staphylococcus aureus* and *Pseudomonas aeruginosa*, respectively, were transformed to sampling site in cold box while maintaining the sterile conditions and along with the necessary equipment and of the medium, a settle plate was placed in the vicinity of the target unit, and main samples were collected from three selected sectors, including prosthodontics, restorative and periodontal surgery and control of the administration.

To assess three indicators of bacteriological quality of the air in the above sections, including HPC, *Staphylococcus aureus* and *Pseudomonas aeruginosa* during each sampling day, three separate samples and a total of 12 samples were collected. Sampling was performed on Saturday and Wednesday per week while the operation of units and one week per month during three months (first week of the first month, the middle week of the second month, the last week of the third months), and a total of 72 main samples and control were prepared.[35]

Plates containing samples maintained at a temperature of less than six degrees Celsius were transferred to the laboratory in less than six hours and were incubated for 24-48 hours at a temperature of 37 °C. After 48 hours, the number of colonies grown on the plate was counted and results were recorded in CFU/plate/h. In order to classify the bacteriological quality of air samples, the acceptable limit of <25 CFU/plate/h was used,[21, 30] and for comparing the data to the scale of the Air Microbial Index (AMI) was used (number of CFU 0-25:good, 26-50:medium, 51-75:bad and >75:very bad) in 4 groups.[36]

Relationship between bacteriological water and air quality

To study the relationship between the bacteriological quality of consuming water in units and air of dental center sections the results were analyzed using SPSS 16 software, independent t-

tests, correlation coefficient, ANOVA, Kruskal-Wallis and LSD analysis.

RESULTS

Bacteriological water quality

Bacteriological Quality of 90.3% of the water samples exceeded the ADA recommendation (<200 ml /CFU) and evaluated as an unfavorable condition. Maximum, minimum and average number of total bacteria in consuming water of units were 4750 CFU/ml, 120 CFU/ml and 1102 CFU/ml, respectively. Average HPC of all water samples of units on Saturday and Wednesday were 1379 CFU/ml and 824 CFU/ml, respectively (Figure 1). Independent T-test of the results showed that the difference between them is significant ($p < 0.05$). Average number of two other bacteria on Saturday and Wednesday is according to Fig. 1.

The result of ANOVA test on water contamination in different parts of the unit showed that the contamination of the cup filler of the units with the HPC, *Pseudomonas aeruginosa* and *Staphylococcus aureus* of 1668 CFU/ml, 72 CFU/ml and 48 CFU/ml, respectively, was the highest. The lowest average number of the above bacteria was associated with the samples of tap water before entering the unit and is as follows, 361 CFU/ml, 10 CFU/ml, and 3 CFU/ml, respectively. Kruskal-Wallis test indicated that there was a significant difference in values of bacteriological parameters between different parts of unit ($p < 0.05$) (Fig. 2).

The average number of HPC of water samples in different parts of units including sections of prosthodontics, restorations and periodontal surgery showed that the cup filler segment with values of 1704 CFU/ml, 2260 CFU/ml and 1036 CFU/ml, respectively, had the highest rate of contamination compared with other parts of the study unit, Followed by turbine head duct, air-water syringe and water before entering the unit (tap water), respectively (Fig. 3).

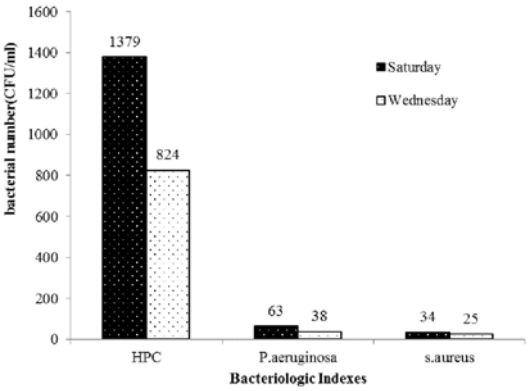


Fig. 1. Comparison of the average number of bacteria in consuming water of units (CFU/ml) during the sampling

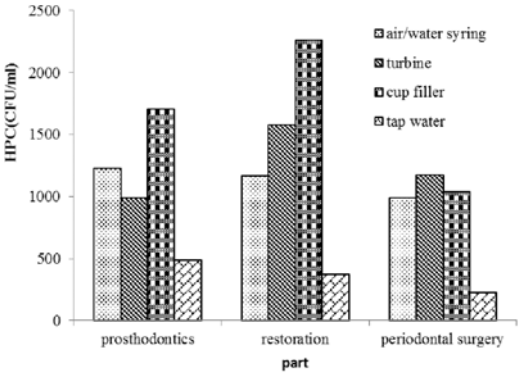
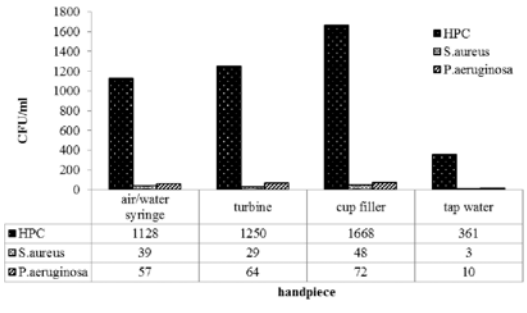
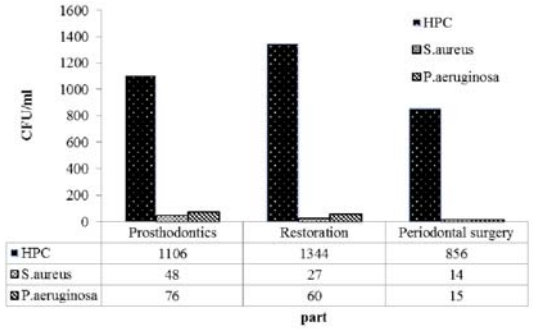


Fig. 3. comparison of the average number of HPC of water samples from different parts of units including the study sectors



	air/water syringe	turbine	cup filler	tap water
HPC	1128	1250	1668	361
S.aureus	39	29	48	3
P.aeruginosa	57	64	72	10

Fig. 2. Average number of study bacteria (CFU/ml) in water samples from different parts of the dental unit



	Prosthodontics	Restoration	Periodontal surgery
HPC	1106	1344	856
S.aureus	48	27	14
P.aeruginosa	76	60	15

Fig. 4. Average CFU/ml bacteriological indictors of water samples from various sections of Dentistry

The comparison between the average numbers of bacteria in water samples in the different parts of dentistry showed that *P.aeruginosa* and *S.aureus* were 76 CFU/ml and 48 CFU/ml in prostheses section and in restoration section, the HPC was 1344 CFU/ml, and higher compared to other sectors (Fig. 4).

LSD test to compare the values of the three studied bacteriological indicators of consuming water of unit parts showed there was a significant statistical difference between the number of bacteria in tap water (before entering the unit), and other parts ($P < 0.05$) (Table 1).

Bacteriological air quality

Bacteriological quality of 52% of the air samples from medical parts of the center is more than acceptable (<25 CFU/plate/h).

Using ANOVA, the average number of bacteria in air of the selected dentistry sections was obtained showing that the average number of bacteria in periodontal surgery was more than that of other sections and was not acceptable. The comparison between the number of bacteria in air of the studied sections and that of the control, using independent T-test showed significant difference ($p < 0.05$) (Fig. 5).

Table 1. Results of comparison of the mean number of bacteriological indicators in Handpieces water output

Bacteriological index	Handpiece	handpiece	P.value
HPC	air/water syringe	turbine	0.713
		Cup filler	0.105
		Tap water	0.023
	turbine	air/water syringe	0.713
		Cup filler	0.207
		Tap water	0.009
	Cup filler	air/water syringe	0.105
		turbine	0.207
		Tap water	0.0001
	Tap water	air/water syringe	0.023
		turbine	0.009
		Cup filler	0.0001
S. aureus	air/water syringe	turbine	0.725
		Cup filler	0.449
		Tap water	0.025
	turbine	air/water syringe	0.725
		Cup filler	0.685
		Tap water	0.010
	Cup filler	air/water syringe	0.449
		turbine	0.685
		Tap water	0.003
	Tap water	air/water syringe	0.025
		turbine	0.010
		Cup filler	0.003
P. aeruginosa	air/water syringe	turbine	0.375
		Cup filler	0.455
		Tap water	0.003
	turbine	air/water syringe	0.375
		Cup filler	0.105
		Tap water	0.034
	cup filler	air/water syringe	0.455
		turbine	0.105
		Tap water	0.000
	Tap water	air/water syringe	0.003
		turbine	0.034
		Cup filler	0.0001

Average number of bacteriological indicators, HPC, *Pseudomonas aeruginosa* and *Staphylococcus aureus* in selected sectors were 40, 17 and 16, respectively in CFU/plate/h.

Bacteriological quality of air samples from different parts according to AMI standard showed that only 2% were in very bad condition (Fig. 6).

Average air HPC on Saturday and Wednesday were 44 CFU/ plate/h and 35 CFU/ plate/h, respectively (Fig. 7). Independent T-test on the results showed that there was not a significant difference in the average number of all three bacteria between days of sampling was ($p > 0.05$).

The intensity of the correlation coefficient between relative humidity and temperature and air pollution of studied sections was moderate and significant. Correlation test performed on relative humidity and the contamination of air HPC in sections showed that there was a significant and direct relationship ($p = 0.0001$, $r = 0.698$) (Table 2).

Relationship between bacteriological water and air quality

The results of correlation testing between the average number of bacteria in air and water showed that there was a poor correlation for *P. aeruginosa* and *S. aureus* and for HPC there was the direct and significant relationship and the correlation intensity is moderate ($p = 0.0001$, $r = 0.66$) (Table 3)

The highest correlation coefficient between bacteriological water and air quality of indicators including HPC, *P. aeruginosa* and *S. aureus* were that of restoration, periodontal surgery and periodontal surgery respectively (Table 4).

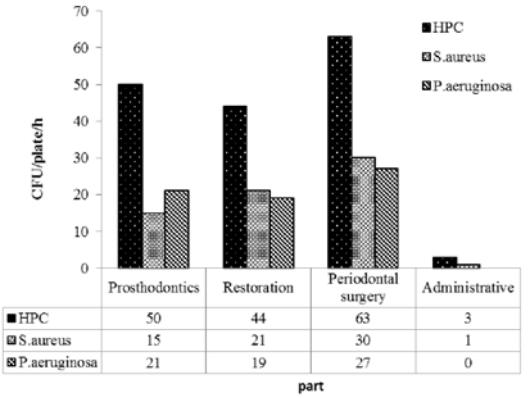


Fig. 5. The mean number of air bacteriological indicators in dentistry parts (CFU/plate/h)

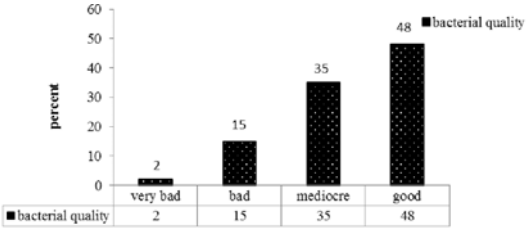


Fig. 6. Bacterial quality status in dentistry parts According to AMI standard

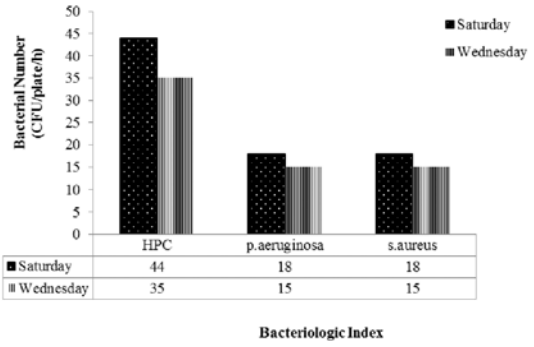


Fig. 7. The mean number of air bacteriological indicators in dentistry parts based on weekdays (CFU/plate/h)

Table 2. Results of correlation of the number of bacteriological index

Temperature (r,p)		Humidity(r,p)		variable Bacteriological Index
0.012	0.504	0.0001	0.698	HPC
0.037	0.428	0.002	0.593	*P.aeruginosa*
0.018	0.479	0.001	0.641	*S.aureus*

with Humidity and Temperature

Table 3. Correlation intensity between mean of number of bacteria in water consumption units and air of parts

Bacteriological Index	HPC	*S.aureus*	*P.aeruginosa*
Correlation Intensity (r)	0.69 Moderate))	0.34 (Weak)	0.20(Weak)

Table 4. Correlation coefficient between bacteriological water and air quality of indicators

Bacteriological Index	HPC	*S.aureus*	*P.aeruginosa*
Part Name	0.69	0.38	0.42
Prosthodontics Restoration	0.8	0.28	0.27
Periodontal surgery	0.69	0.77	0.46

DISCUSSION

A review of various studies indicate that assessing the bacteriological quality of air and water in dental centers is very important, because of the effect of these factors in the transmission of a variety of pathogenic microorganisms, and threatening the health of staff and patients. Because of this matter, in the present study, the simultaneous examination of the bacteriological quality of consuming water of units, and air of selected sections and the relationship between the items was done, separately. Reviewing the studies of bacteriological quality of dental centers shows that some bacteria are the source of most pollution. For example, Sacchetti *et al*, and walker *et al*, reported *P. aeruginosa* as the most common and the highest bacterial contamination of consuming water samples of the studied dental units.[37, 38] Qasem Pour and colleagues investigating the role of consuming water in dental units in the mechanical transmission of oral bacteria, reported that most microorganisms found in consuming water of units, are *Staphylococcus aureus*.[39] Ghaemmaghami *et al*, reported that 37.5% of units' water contamination areas of periodontics and surgical section were related to *Pseudomonas* and *Staphylococcus*, and 61.5% of water contamination in areas of endodontics, prosthodontics and restoration were related to *Staphylococcus aureus.*[40] In the study by Begum Taheri *et al*. major contamination of water samples were also related to gram-negative bacilli such as *Pseudomonas aeruginosa.*[41] As a result, in the evaluation of the air and water bacteriological quality of the study, in addition to the main indicator of such studies that is HPC, the status of contamination indicating bacteria, including *Staphylococcus aureus* and *Pseudomonas aeruginosa* that have an important role in the pathogenesis of some patients and susceptible individuals have been studied.

Bacteriological water quality

The number and diversity of microorganisms in dental center air and water are considered as the most important indicators of health status, or contamination of such environments. For this reason it is necessary to control the bacteriological quality of the water-air. The results showed that the bacteriological quality of consuming water for 90.3% of units is contaminated over-expected and with the average HPC of 1102 CFU/ml is more than the acceptable recommendation by a factor of five (diagram 1). Field studies conducted show that the main causes of the high contamination rate may be due to low residual chlorine of water entering the units is such that in most studied cases, the residual chlorine is less than 0.3 mg/l, another reason may be the lack of residual chlorine in hand pieces output, water stagnation in the water supply system of units, resulting in excessive growth of biofilm in water supply lines. On the other hand, improper exploitation, lack of adequate and timely disinfection of components of the units have been also added to the above problems and caused to aggravate the undesirable quality of consuming water in units.

Messano and colleagues reported in a study that 87.7% consuming water quality of studied dental units is in unfavorable condition,[30] that in the percentage of samples with high contamination is consistent with our results. According to various studies, high performance of units may be one cause for the increase in biofilm thickness and thus increase the amount of

contamination of consuming water and air of sections. In a study Montebugnoli and colleagues reported that newly installed units have less contamination than older units.[42] Barbeau *et al*, considered prolonged operation of units as factor for increasing biofilm thickness, thus increasing contamination levels.[43] Study conducted by Sacchetti *et al* on microbial contamination of dental unit water showed that contamination level is higher in units followed by operation,[37] that agreed with the findings of this research.

In this study, factors such as relative humidity and air temperature were directly related to increased air pollution that is consistent with the studies of Kedjarune and colleagues,[44] Shivakumar and colleagues,[45] and Azari and colleagues.[46]

The significant difference of the average HPC of unit water between days of sampling, Saturdays and Wednesdays, (Diagram 1) is also due to the fact that Saturday is the first working day during the week, after a day of suspension on Friday and water stagnation in the water supply system of units can be effective in improving the pollution on Saturday. This means that the days of the week can be a variable influencing the degree of pollution of consuming water in units. Another reason could be the residual chlorine concentration in water. On Wednesday, the average chlorine concentration was more than that of Saturday, it may affect on the higher bacterial populations on Saturday compared with Wednesday, such that the chlorine in the water can prevent the growth of heterotrophic bacteria and the formation of new colonies and reduces contamination. In the Study conducted by Honarmand *et al*, on water bacterial contamination of dental units of Zahedan Medical University there was no significant difference in bacterial contamination between Thursday and Saturday.[47] In the study conducted by Me'marian *et al*, the sampling had been performed on Saturday and mid-week that contamination on Saturday was higher than that of the mid-week.[48] Most studies, including the study of the Honarmand,[47] Able,[49] Watanabe,[50] Me'marian,[48] have reported results consistent with those of the present study.

The results showed that the water output contamination is different for different sections of units. Based on one-way ANOVA, the mean comparison of bacterial count in various sections of units showed there was a significant difference between them, so that the highest mean bacterial count is that of the cup filler and the minimum was related to water before entering the unit that was consistent with the study conducted by Honarmand *et al*, on the bacterial contamination of dental unit waterlines of Zahedan University.[47] In this study, cup filler in all section especially restoration section was more contaminated in terms of the three bacterial indicators, especially HPC, compared to other sections of the unit, the water contamination of the section, after the entry of water into the water system of unit increased significantly, (Diagram 2 and 3). This increase reflects insufficient residual chlorine of water entering the unit, lack of effective disinfection of the water piping system and improper exploitation and maintenance of units, and thus the growth of the biofilm in walls of waterlines. The difference in infection rates in different parts of the unit can also be due to their usage, water flow velocity and the amount of flushing in sections of unit. Generally, in cases where the water pipes of the same materials and the same size are used, water flow rate and frequency of water use per day could affect the amount of contamination in components of the unit. Studies by Gugelmin,[51] Ribeirao,[52] Wirthlin,[53] Smith,[54] show that the contamination of filler cup and syringe are low. In a study conducted by Smith *et al*, it was showed that contamination of high frequency turbine was higher than that of water syringe and cup filler and contamination of two latter parts was higher than that of the tank,[54] which contrasts with our results. The results of the study conducted by Labbaf *et al*, showed the greatest amount of aerosol was at the prosthodontics section, and the lowest amount was at Endo section, that contrasts with our results.[55] In the present study, the average contamination of different parts of the units in prosthodontics, restoration and periodontal surgery, corresponds with the study by Honarmand *et al*.[47] High contamination levels in cup filler is probably due to the lower water consumption compared to other parts of the unit, and stagnation of water, thus biofilm creation in the inner wall of the tube.

Bacteriological air quality

Excessive bacterial contamination in indoor air of dental spaces has been always

worrying and dust contaminated with various germs exists in the air of dental section.[46] The results of the study on bacteriological quality of the air in all studied sections including prosthodontics, restoration and periodontal surgery, revealed that the extent of microbial contamination of the air in 52% of samples exceeded the acceptable level (<25 CFU/plate/h) and the microbial quality of air in the sections ranged from moderate to very bad. However, the condition was quite different in the control. Messano and colleagues in a study reported that 72% of the air of dental center they were studying was in an unfavorable situation,[30] which indicates that the situation is far worse than the results of the present study.

Maximum and minimum number of HPC in air samples of dental sections were 82 CFU/plate/h (periodontal surgery) and 0 CFU/plate /h (the control), respectively. Despite the higher average number of the studied bacterial indicators in the air of sectors on Saturday, Comparison between the results of Sunday and Wednesday showed no significant difference, that means the days of the week is not an important factor on the rate of bacterial contamination of the air. Due to the sampling at working hours of units, lack of local hoods, use of treatment methods that lead to spread the produced bioaerosols in air of the sections, such as using turbines, are among the factors that increase the level of microbial contamination in the air of the sections. These conditions can be serious threats to the health of staff and patients, especially those at risk.

Cellini *et al*. by one-year monitoring of microbial status of a dental center in Italy concluded that all values obtained during the day, were less than 50 CFU/plate/h.[56] Castiglia during his study showed that 56.2% of the samples exceeded the limit (25 CFU/plate/h).[21]

The comparison between the results of the statistical tests on diversity and number of bacteria in the air of dental operating sections do not show significant differences between sections (Diagram 6). This could be due to the openness of the connecting space between the units. Similar results were also reported by Lasemi and colleagues.[57]

Relationship between bacteriological water and air quality

Survey of the relationship between bacteriological quality of consuming water of units and bacteriological quality of air in this study showed there was no significant correlation in HPC ($r = 0.69$) (Table 3). Due to the type of activity of sections and studied indicators, the correlation was the highest for HPC with $r = 0.8$ in restoration section, for *Staphylococcus aureus* with $r = 0.77$ and for *Pseudomonas aeruginosa* with $r=0.46$ in periodontal surgery. The calculated correlation coefficients mostly positive and of values greater than 0.3 show statistically-significant relationships between them and the increased bacterial contamination load of consuming water in units and the increased bacterial contamination load of air in studied sections of this research. According to the results, after the operation of units, air and water contamination increased. This increase may be due to lack of anti-retraction device installation in the studied units, returning patient's mouth microbial flora through suction into the water system unit or negative pressure caused by the turbine when standing. In this way, water contamination and consequently air pollution of dental sections will be aggravated.

Ino Sciaky *et al*, by studying contamination of air syringes of dental units identified the presence of bacteria such as *Staphylococcus aureus* in the water and air supply surrounding dental units and reported the relationship between the contamination of consuming water and air of different dental sections as the current research.[58]

Crimi and colleagues examining the relationship between air and water contamination, showed that there was a direct correlation between air pollution and water contamination that water contamination can cause air pollution, which is consistent with our results.[29] Borella and colleagues also reported that similar genotypes of studied bacteria in air and water of different parts of the dentistry and high levels of serum antibody of dentists and staff compared to other segments of society, is indicative of the relationship. [59]

CONCLUSION

According to the results, contamination of different parts of the unit, due to biofilm formation in the water system ducts of the unit and possibly return of blood and saliva and oral secretions from patient's mouth into water system of the unit, exceeds the rate of contamination of water before entering the unit. However Dental Piezoelectric Ultrasonic Scalers and high-speed turbines lead to generate bioaerosols contaminated with water output from various parts of the unit that can threaten the safety of dentists, assistants and patients; therefore to reduce the contamination of consuming water measures such as installing anti-retraction device to prevent the return of saliva, blood and oral secretions of patient's mouth into water system of unit, using the filter along the way of the consuming water of the unit to reduce bacteria suspended in water, using independent water tank before entering the unit and its disinfection, the use of disinfectants to disinfect the body of the unit, performing the flushing at the beginning of the day for 2-3 minutes at the patients intervals for 20-30 seconds, using sterile water in cases of surgery or services to individuals with impaired immune systems, washing patient's mouth with an antiseptic mouthwash such as Chlorhexidine before starting the dental process, and improving knowledge of the dentists, technicians and assistants about the possibility of water contamination in units and air pollution of sections, should be done. If preventing and controlling the contamination of consuming water in units do not reach the desired results, dentists and assistants can be encouraged to use personal protective equipment (PPE) such as mask, face shield, and simultaneously a local hood and a strong suction should be used for appropriate ventilation during providing dental services, so that the risks of water and air contamination of dental sections will be reduced.

ACKNOWLEDGEMENTS

The present study was derived from the thesis "relation of bacteriological water and air quality in dental centers". We would like to thank the health research center of Baqiyatallah University of Medical Science and faculty of health for conducted by the financial and technical supports respectively.

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