

Survey on and Countermeasures for Chemical Pollution of Water Used in Large Hotels: a Case Study

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Water for hotel use mainly includes air conditioning circulating water and shower water. This paper conducts a survey on the current status of chemically polluted water in hotels in some area and analyses relevant countermeasures, hoping to give an evaluation on the sanitary control and supervision of the large hotels in this area. This paper tests the chemical pollutants in the water for hotel use through an experiment, summarizes relevant survey data, analyses the causes of such chemical pollution through questionnaire survey and provides appropriate countermeasures. The experimental results indicate that the water used in large hotels in this area is highly polluted, so hotels should strengthen sterilization and sanitary control and local authorities should increase their efforts in health supervision so as to safeguard the rights and interests of consumers.

1. Introduction

Large hotels can cater to people's different needs in their business or leisure travels. To evaluate a hotel, comfort and sanitation are the main factors that people will take into account, especially the sanitation of water, which receives much concern (Zhang et al., 2015). With the increase of large hotels, cases of personal injuries caused by chemical pollution of hotel water have been occurring from time to time, especially those caused by the chemical pollution of central air-conditioning circulating water and shower water. In order to protect the rights and interests of consumers and strengthen the sanitary control of large hotels, this paper conducts a random sample survey on the water used in large hotels in an area (Williams et al., 2005).

This paper selects 29 hotels in an area as the subjects, collects water samples from these hotels, performs chemical pollutant tests and identification and uses the software SPSS17.0 to perform data analysis; then it investigates the sanitary control of hotel water through a questionnaire survey and analyses the causes of chemical pollution (Zillich et al., 2014); and at last, it proposes appropriate countermeasures according to the survey findings and causes of chemical pollution. This study is of great significance to enhancing hotels' awareness of sanitary control and reducing their chemical pollution risks (Langer, 1965).

2. Experimental analysis and questionnaire survey

2.1 Experimental subjects and methods

2.1.1 Subjects

The experiment was conducted in September 2017, with 29 3-star or higher-grade hotels as the subjects, including 7 3-star hotels, 7 4-star ones and 15 5-star ones (all hotels are large-scale and have central air conditioning).

2.1.2 Sampling

The water for hotel use studied in this paper mainly includes air conditioning circulating water and shower water. For the air conditioning circulating water, the cooling water sampling points were set at 20cm from the wall of the cooling tower and 10cm below the water level and the condensate water sampling points were set at the centralized drainage pipe; and for the shower water, the sampling points were set at the shower faucets

in the bathrooms. 45 cooling water samples, 13 condensate water samples and 29 shower water samples were collected in total.

2.1.3 Culture and identification of chemical pollutants

The collected samples were pre-treated and the chemical pollutants were identified using chemical reagents according to the *Specification for Hygiene Management of Central Air Conditioning and Ventilation Systems in Public Places* (Johnson et al., 2000).

The isolation media - GVPC medium and BCYE medium and the latex agglutination diagnostic Serum for chemical pollutants were purchased from OXOID. Equipment used in this experiment included the DK-8AD electro-thermostatic water bath (Shanghai Yiheng Technology Co., Ltd.); CO2 incubator (Heraeus); desk centrifuge (Beijing Baiyang Medical Centrifuge Co., Ltd.); and MLS-3020 automatic autoclave (SANYO) (Byer and Carlson, 2005).

2.2 Questionnaire survey

A sanitation management questionnaire form was designed for the central air conditioning cooling water according to the health authority's requirements for hotel management, which mainly consists of two parts - basic information and daily management (Martínez et al., 2010).

Basic information includes the name of the company, number and locations of cooling towers, whether there is any residential rooms around the cooling towers, annual service time of the cooling towers, whether the condensate water pipes are water sealed, and names of the cooling water disinfection drugs (Margenat et al., 2017), with the questions designed as one-choice or fill-in questions; daily management covers sanitation management and maintenance files, management personnel, sanitation examination frequency of the central air conditioning and ventilation system, test frequency of cooling water chemical pollutants, cooling water disinfection frequency and disinfection records, sanitation of the air conditioning control room, cleaning frequency of filtration devices and condensate water coils and disinfection frequency of the domestic hot water system (Leusch et al., 2014).

In addition to questionnaire survey, face-to-face interviews and site visits were also conducted in these hotels as supplementary survey forms.

3. Analysis of experimental results, questionnaire survey findings and countermeasures

3.1 Experimental results

3.1.1 Current status of the chemical pollution in the water for hotel use

Table 1 shows the test results of the chemical pollutants in the 87 hotel water samples and their distribution in different grades of hotels (Lan et al., 2017).

Table 1: Chemical pollutants distribution in water used in different grades of hotels

Hotel rating	Total samples number	Chemical pollution number	Contamination rate
three stars level	21	9	42.86%
four stars level	21	9	42.86%
five stars level	45	8	17.78%

It can be seen from the table that the detection rates of chemical pollutants in the water used in 3-star and 4-star hotels were higher than those in the 5-star hotels (Han et al., 2010).

The chemical pollution rates of the hotels of different grades were also summarized, as shown in Table 2.

Table 2: Chemical pollutants distribution in different types of water samples

Water sample type	Total samples number	Chemical pollution number	Contamination rate
cooling water	45	18	42.86%
condensate water	13	1	7.7%
shower water	29	7	24.1%

The above table shows the pollution of different types of water samples. As can be seen, 40% of the cooling water samples were polluted and the proportion of polluted condensate water samples was the lowest – only 7.7% (Tani et al., 2001).

3.1.2 Temperature distribution of the polluted hotel water

As chemical pollution is closely related to the temperature of the water body, the author investigated the temperature distribution of the chemically polluted water used in hotels and the findings are shown in Figure 1 (Peng et al., 2004).

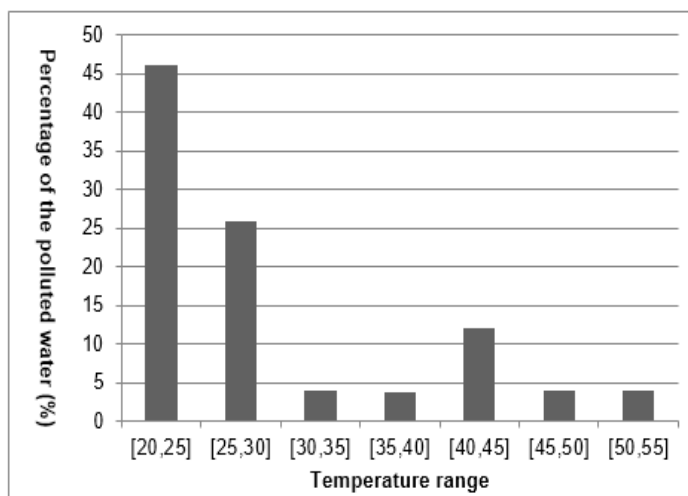


Figure 1: Temperature distribution of the polluted water

As can be seen, the highest temperature of the polluted hotel water was 51.5°C, and the average temperature was 29°C. The chemically polluted water with a temperature ranging between 20°C and 25°C accounts for 46% of all the water bodies (Golden et al., 2001).

3.2 Questionnaire survey

In order to analyse the causes of chemical pollution in hotel water, questionnaire survey was performed on the 29 hotels in combination with site visits to investigate the sanitation of the hotel water, especially the central air conditioning circulating water.

Table 3: Basic information of the central air conditioning circulating water systems

Questionnaire questions	Hotel composition ratio
Central air-conditioning circulating water system management unit	
Hotel Engineering Department	93.1%(27/29)
Commission property management company	6.9%(2/29)
Number of cooling towers	
1~2 sets	24.14%(7/29)
3~4 sets	48.28%(14/29)
Above 5 sets	27.58%(8/29)
Cooling tower location	
Top of the building	96.55%(28/29)
Other locations (around the building)	3.45%(1/29)
Above three year	0
Annual using time of cooling tower	
Three months	31%(9/29)
Six months	38%(11/29)
Above one year	31%(9/29)
Air conditioning room health conditions	
All year	6.9%(2/29)
From mid-April to mid-October	24.14%(7/29)
In early May to October	68.96%(20/29)
Cooling water disinfection drug name	
Chlorine-containing preparations	34.5%(10/29)
Sodium dichloroisocyanurate	10.3%(3/29)
Bactericidal Algicide	55.2%(16/29)

3.2.1 Basic information on the central air conditioning circulating water systems used in hotels

Among the 29 large hotels surveyed, both three-star and four-star hotels account for 24.14% and five-star hotels, 51.72%. In order to better analyse the chemical pollution of the central air conditioning circulating water, the author first summarizes the basic information of the central air conditioning circulation systems in large hotels, as shown in Table 4.

3.2.2 Questionnaire survey on the sanitary control of central air conditioning circulating water in hotels

In addition to the investigation on the basic information of the central air conditioning circulating water systems, the author further investigated the sanitation management of central air conditioning circulation. According to the health authority's requirements, large hotels need to establish sanitation management and maintenance files for central air conditioning to make sure hotel water meets sanitary requirements. Through this questionnaire survey and site interviews, it is found that out of the 29 large hotels, 10 did not have complete files, accounting for 34.5% of the total, including 5 3-star hotels, 4 4-star hotels and 1 5-star hotel. Among those with complete files, there are 14 5-star hotels, 3 4-star ones and 2 3-star ones (Zoller et al., 2009). The specific survey findings are shown in Table 4.

Table 4: Sanitary control of the central air conditioning circulating water systems

Questionnaire questions	Hotel composition ratio
Central air-conditioning health maintenance files	
No management file created	0%
Management file incomplete	34.5%(10/29)
Management file information is complete	65.5%(19/29)
Whether someone to maintain health	
yes	100%
no	0
Central air conditioning ventilation system health testing frequency	
One year	10.3%(3/29)
Two years	89.7%(26/29)
Above three year	0
Chemical contaminants detection frequency	
Three months	31%(9/29)
Six months	38%(11/29)
Above one year	31%(9/29)
Air conditioning room health conditions	
Unsanitary	10.34%(3/29)
General	17.24%(5/29)
sanitary	72.42%(21/29)
Shower water disinfection frequency	
One year	3.4%(1/29)
From time to time	17.2%(5/29)
Not disinfected	79.3%(23/29)

3.3 Countermeasure analysis

3.3.1 Summary of survey findings

According to the survey results, the detection rate of chemical pollutants exceeded 50%, in which, the detection rate of chemical pollutants in central air conditioning water was 40% and that in shower water was 24.1%, indicating that the chemical pollution is very serious in the water used in large hotels in this area.

In terms of the temperature distribution of the chemically polluted hotel water, 73.1% of the polluted water had a temperature ranging between 20~30°C, which is relatively close to the temperature in spring and autumn in this area, so sanitation management should be further enhanced on hotel water in spring and autumn.

From the questionnaire form, it can be found that the sanitation management of large hotels need to be improved, especially for the 3-star hotels, where the water is highly polluted. Therefore, sanitation management and maintenance files need to be more complete, special personnel should be assigned to maintain hygiene, and the disinfection frequency should be increased.

3.3.2 Countermeasure analysis

In response to the chemical pollution of the water used in large hotels in this area, according to the supervision and management regulations of the local health authority, this paper proposes the following 6 countermeasures:

- (1) A fuzzy comprehensive evaluation model should be established to comprehensively evaluate the water sanitation of the hotels according to such indicators as hotel star, season, testing and disinfection of chemical pollutants, sanitation of the air-conditioning control rooms and management and maintenance files. For hotels with average or poor ratings, the health authority should order them to close up for rectification.
- (2) Spring and autumn are high-occurrence seasons for chemical pollution of hotel water. Therefore, more efforts should be made to check the ventilation of central air conditioning and control hotel sanitation
- (3) Disinfection and testing of shower water should be strengthened in hotels. Local health authority should enhance its supervision on the sanitation of shower water in hotels and establish relevant laws and regulations.
- (4) For the central air conditioning circulating water systems in hotels, it is suggested installing cooling towers and developing better disinfection plans based on local climate characteristics.
- (5) Rational design, installation and maintenance of water pipelines in hotels are ways to effectively reduce chemical pollution, and should therefore be paid great attention to in the preliminary design and subsequent maintenance of hotels.
- (6) More publicity should be conducted among hotel staff on the hazards of chemical pollution in hotel water and training programs should be provided to help increase the management personnel's awareness of hotel sanitation management.

4. Conclusions

In order to help enhance the sanitation management of large hotels in an area, this paper carries out a survey on the chemical pollution of hotel water in 29 large hotels in this area. By taking samples from central air-conditioned circulating water and shower water, performing analysis of water samples and conducting the questionnaire survey, this paper collects the information on the pollution of hotel water and analyses the countermeasures:

- (1) The chemical pollution of the water used in large hotels in this area is not so good, with the pollution rate of the water samples exceeding 50%.
- (2) Large hotels should enhance the sanitation management of central air-conditioned circulating water and shower water and follow the 6 countermeasures proposed in this paper to reduce the probability of chemical pollution in hotel water and protect the personal safety of consumers.

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