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Study on the Characteristics of Falling Sound According to Change Water Temperature

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Abstract: The purpose of this research is to find how to control temperature of water by using sound. This research suggests to apply sound to controlling water temperature based on the result of scientifically verifying that features of water sound vary depending on temperature. For analyzing features of water sound this study examined sound of water falling by sound analysis tool. Such different features of sound of water falling depending on temperature can be utilized in various fields temperature management for water purifier, sauna, swimming pool and hot spring as well as temperature control in fish farm or natural ecosystem. In terms of research method, water temperature is set on 100°C and reduced by every 10°C to scientifically analyze features of water falling sound. As a result, it was identified that sound is highly susceptible to temperature changes. Therefore, this research tries to make a proposal on application of water temperature control system by water to different fields.

Key words: Water, falling sound, temperature changes, analysis, control, sauna

INTRODUCTION

Water is an important resource that is closely related to our life. It is used as a drinking water as well as for other purposes such as for agriculture, industries, hygienics or leisure. Most of cases utilize water by changing its temperature based on the use. In our life, common examples of controlling water temperature are water purifier, sauna, hot spring and swimming pool as well as in large, fish farm and natural ecosystem. However, so far this temperature management is solely relied on thermometer. The thermometer is useful when controlling a small amount of water but has a less accuracy for managing many individual temperature checks or bit-sized areas. Different from this, if precise data on sound is accumulated its accuracy and durability can be guaranteed. One of the methods for doing this is to let water flow separately regardless of the size and make a system which provides a regular check on water temperature by analyzing sound features. For this system, it is vital to prove that falling sound changes by water temperature and all the results shall be made into a database. That is, the core point in the system of controlling water temperature by using sound is the data on feature of water falling sound by temperature. This research insists that it is possible to utilize features of water falling sound by temperature in various fields that are related to the water (Lim, 2017; Jang, 2012; Han, 2010; Kyoung-Chook *et al*., 2008).

MATERIALS AND METHODS

Recording and analysis of falling sound by water temperature: To analyze features of sound of water falling by different temperatures, temperature of water inside the pot is set at boiling point, 100°C and recorded pouring sound into the cup. Afterwards, sound sample is collected repeatedly by reducing the temperature by every 10°C. At the end, it lowered the temperature to 2°C to record sound sample. All these collected sound sample data are analyzed by sound analysis tool in different domains, time domain, spectrum and spectrogram to find out sound features.

Recording of falling sound by water temperature: For this sound collecting, all the necessary facilities such as thermometer that can measure water temperature, coffee pot, cup and digital sound recorder in sound proof studio.

Figure 1, water is heat up in the pot and once it reaches required temperature by checking it with thermometer, water is poured into the cup for sound

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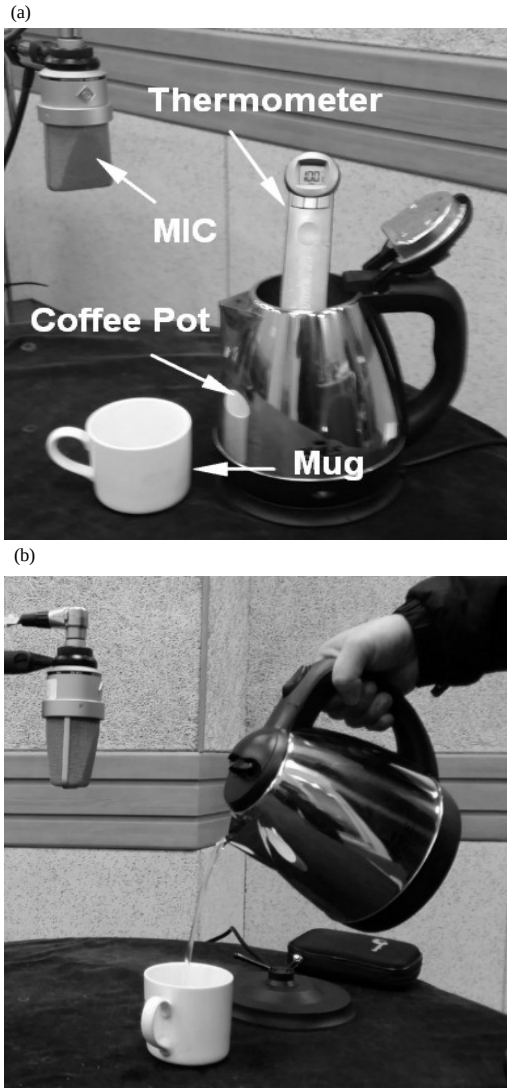

Fig. 1: Recording of falling sound by water temperature: a) Water falling sound recording tools and b) Water falling sound recording

recording. From 100-2°C, sound of water falling is recorded at 10°C interval. The reason for setting the minimum temperature at 2°C is because the lowest temperature before turning into an ice is 2°C. For sound recording, water has to be in a liquid form. As water freezes at lower than 0°C temperature, at lower than 2°C water goes through the process of becoming an ice and the sound might not be the pure water falling sound. For the method of collecting water falling sound, first, water is heat up to 100°C and reduced by every 10°C to record sound of water falling into the cup. At last, water is lowered to 10°C and afterwards, to the lowest point of 2°C for sound recording.

Analysis water falling sound by temperature: For analyzing water falling sound by temperature, water temperature is divided into 2, 30, 70 and 100°C to compare data by changes in graph of time domain, spectrogram and spectrum.

Analysis water falling sound by temperature: The time domain graph is for changes in sound by time. Based on time domain graph by water falling sound by temperature, changes in falling sound by temperature and time are analyzed. Looking at Fig. 2 of time domain graph on water pouring sound, a of 2°C shows that there is a big decibel variation from low frequency to high frequency by time.

After wards when it is 30°C as in Fig. 2b, 70 and 100°C there is a gradually smaller variation in decibel by time. This means that as temperature is low, the general frequency band shows a big difference. That is, the lower the temperature, higher the sound features (Ahn and Bae, 2006).

Analysis water falling sound by temperature: The spectrogram graph shows dispersion of energy across all the band from low frequency to high frequency area. The difference in energy of falling water by temperature is identified by each frequency band. The horizontal axis is time domain and vertical axis is frequency band.

First of all, looking at the spectrogram graph of water pouring sound at 2°C as shown in Fig. 3, it is found out that the red-colored bar appears vividly across all the frequency band compare to other spectrogram graphs. What is more, the color of bar is gradually becoming paler from high frequency band to low frequency band in the sequence of water pouring sound at 30°C in Fig. 3b at 70°C in Fig. 3c and 100°C in Fig. 3d. Especially, in spectrogram graph showing water pouring sound at 100°C in Fig. 3d, it is shown that energy in low frequency band under 2,000 Hz has the vivid red color and over that frequency, all the high frequency bands are showing the pale red color. This is because the colder the water, the stronger the energy across all the band from low frequency to the high frequency. In contrast, if temperature is high, energy for high frequency sound decreases and that of for low frequency survives. The meaning of having the strongest energy in spectrogram graph means that the sound is very strong and clear. In other words, if temperature water is low, it produces stronger and clearer falling sound but if temperature is high, its strength and clarity decreases while making a soft and low-tone sound.

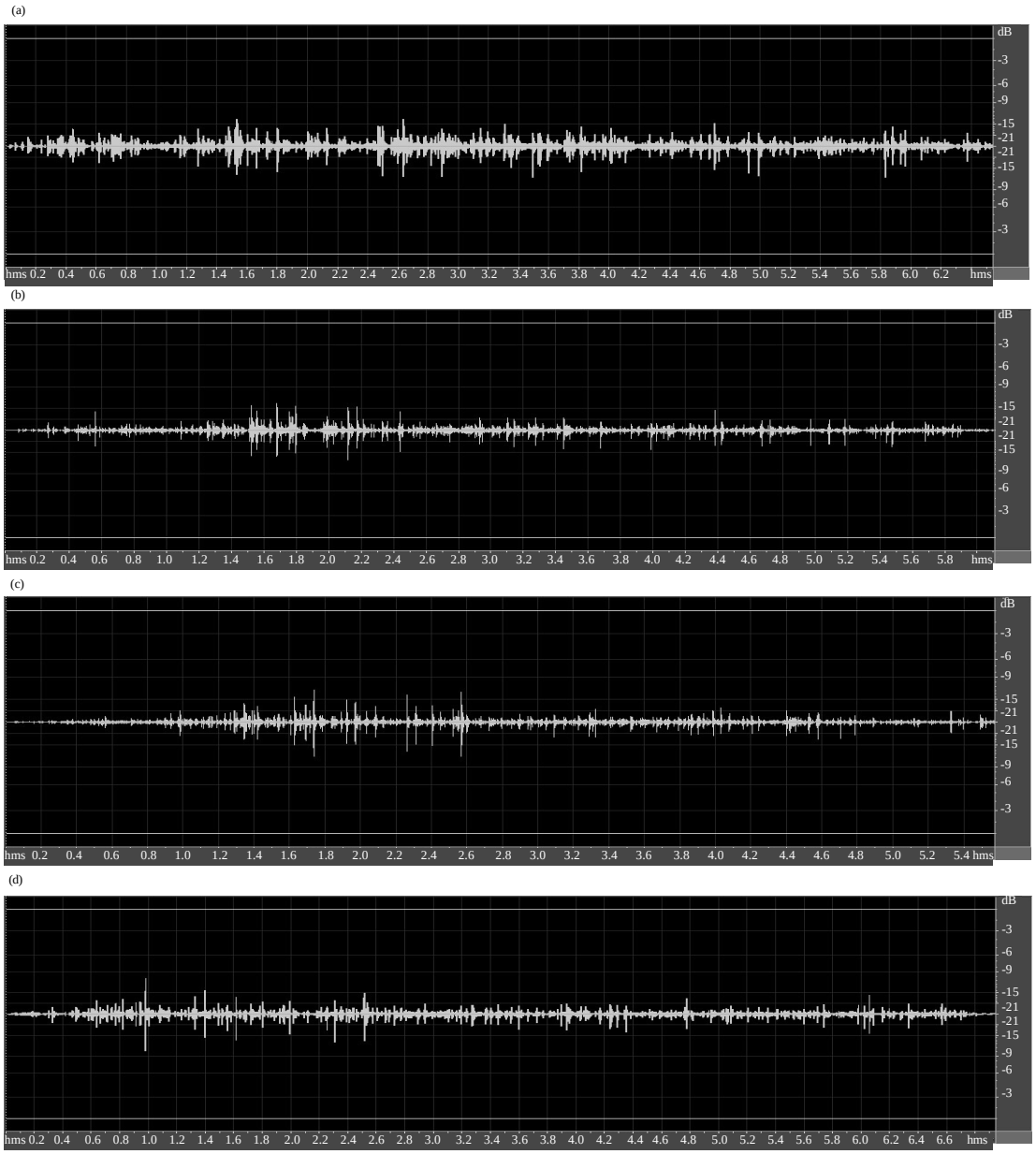

Fig. 2: Time domain graph: a) 2°C water falling sound; b) 30°C water falling sound; c) 70°C water falling sound and d) 100°C water falling sound

Analysis of spectrum: As spectrum graph shows height of graph by each frequency band, it is a good analysis tool for analyzing difference in each sound based on volume by each frequency. The horizontal axis means frequency band (Hz) and the vertical axis means volume (dB). As shown in Fig. 4, spectrum graph showing water pouring sound by temperature shows big or small volume difference depending on the frequency band. Firstly, 100°C temperature graph has a higher volume compare to others in low frequency band and as it goes over 300 Hz, going to wards the high frequency band, the volume is low compare to other graphs. For 2°C temperature graph, it had a higher volume at 400-600 Hz compare to other graphs. Beginning from 1,200 Hz towards the high frequency band, the figure was higher than others.

For 70°C temperature graph, it was higher at 700-800 Hz but as it reaches the high frequency area, volume actually went down, followed by 100°C graph. There were not much difference for 30°C graph under 200 Hz area but as it went up to high frequency band, volume decreased compare to 2°C graph but higher than 70°C graph.

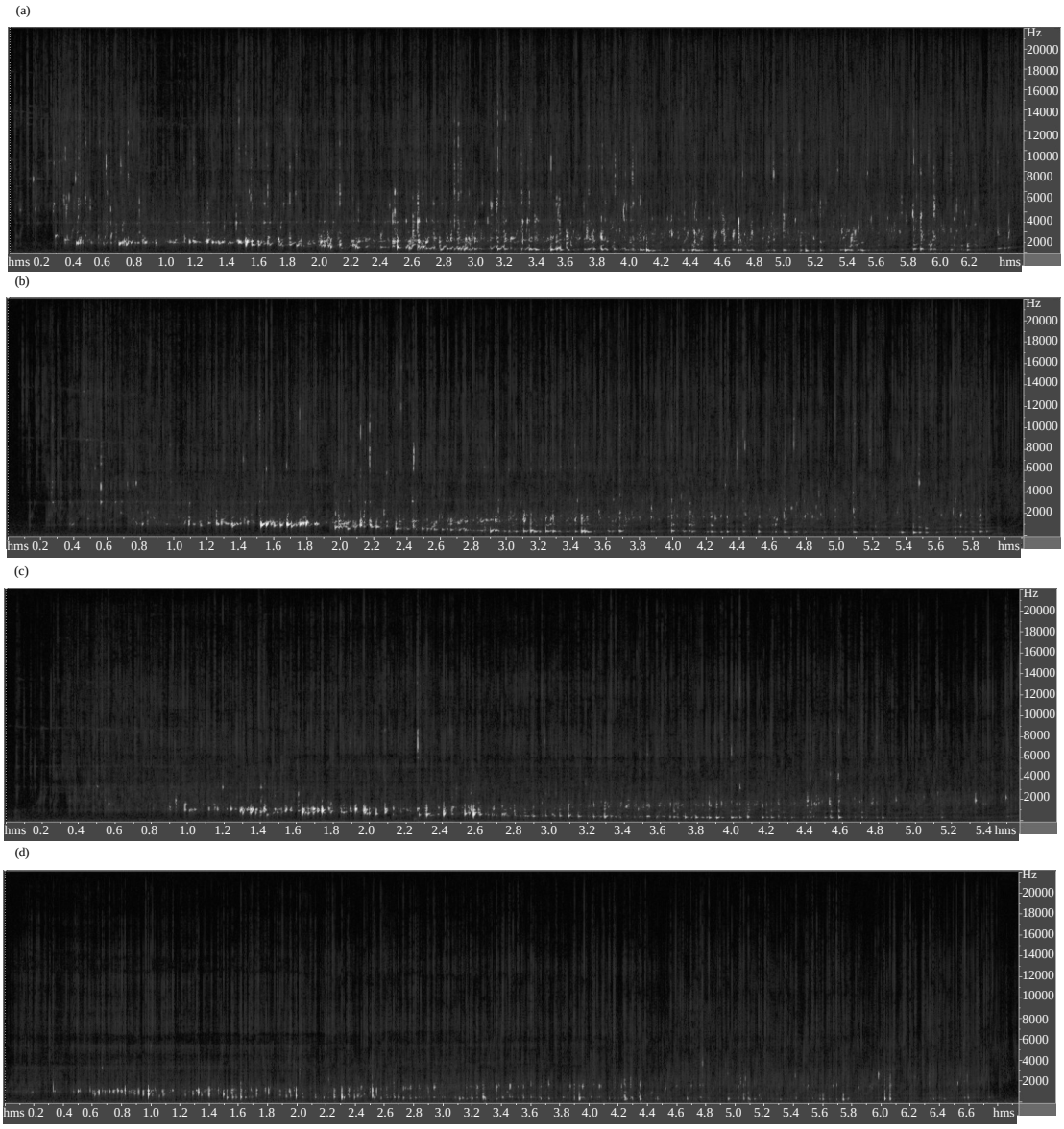

Fig. 3: Spectrogram graph: a) 2°C water falling sound; b) 30°C water falling sound; c) 70°C water falling sound and d) 100°C water falling sound

Water temperature control system of water sound: What if we measure water temperature by sound? We might have already fet that it sounds different when pouring cold water and hot water. This is because temperature of water varies the sound features. Based on such features this study attempts to build a system which can identify and control water temperature by sound. To develop a system for controlling hot water by water falling sound, data on water falling sound by temperature in the current condition has to be accumulated first.

As shown in the flow chart in Fig. 5, we can build up a system for managing hot water based on water falling sound. In accordance to the flow chart, once water falling sound is input, it determines how to control the temperature by comparing its sound with the existing data by temperature it may maintain the current temperature if the sound is same with the standard temperature, increases the temperature if the sound is lower than the set temperature and decreases the temperature if the sound is higher than the set temperature. As the accuracy of water temperature management system is highly dependent on surrounding environment, a precise data on water falling sound by temperature based on constant standards as well as various sounds by temperature has to be established.

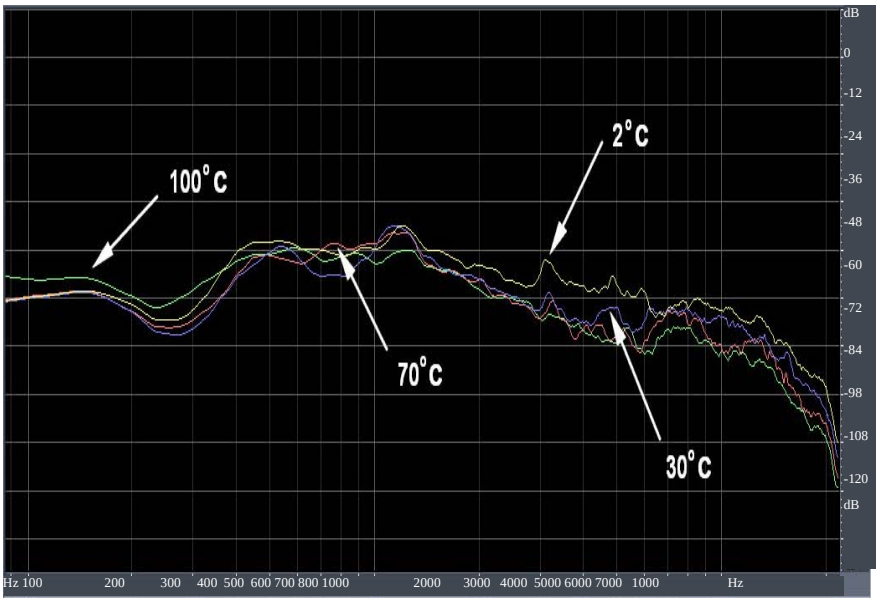

Fig. 4: Spectrum graph analysis

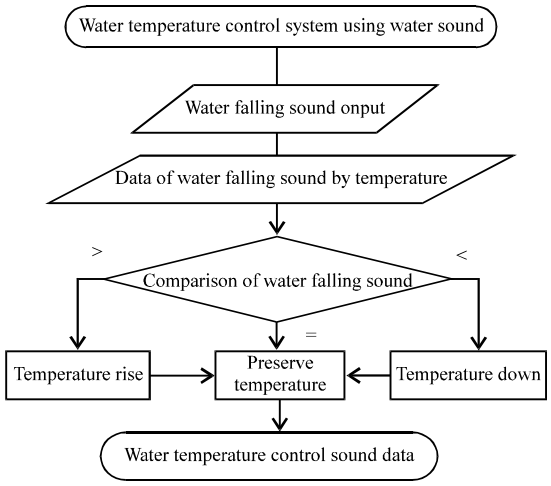

Fig. 5: Water temperature control system of water sound

RESULTS AND DISCUSSION

To identify difference in water falling sound by temperature this research analyzed features of falling sound by temperature. The analysis for finding out sound features by water temperature is done by time domain for examining volume features by time, spectrogram graph for examining sound energy by frequency band and spectrum graph for examining volume changes by frequency band. As a result of comparing time graph, spectrogram graph and spectrum graph by water temperature, volume and energy in low frequency the highest in 2°C, followed by 30, 70 and 100°C. In contrast, as it goes up to the high frequency band, volume and energy both decreased. This means that the sound in high temperature delivers more low sound and as it moves to the low temperature, the sound is stronger. That is, if temperature is low, high sound is expressed stronger and clearer whereas if temperature is high, low sound is produced stronger and clearer.

CONCLUSION

The purpose of this research is to study sound features by water temperature and find ways to apply to various fields. In those places requiring water temperature control, maintaining and managing temperature is very important. Before, it was controlled by using thermometer but there is a possibility of corrosion, especially such durability issue may rise if water temperature is high. Also, in those place where a large number of hot water devices are operated and managed, it is not easy to control water temperature just by thermometer. Based on this, it studies to find and suggest how to apply system for managing water by sound. As a result, the colder the water, it tends to have a strong high frequency band, producing a high tone sound. In contrast, as water gets hot, high frequency band becomes weak and low tone sound becomes noticeable. Such result is analyzed and proven by the test. The test result can be used in various fields such as water purifier, sauna, hot Spring, swimming

pool where temperature of water has to be maintained. Of course, it can also be utilized for managing changes in water temperature in ecosystem such as mountain, fish farm, etc.

SUGGESTIONS

This research suggests a method of controlling water temperature at a constant level by checking water sound on a regular basis. It will be largely used in various fields for more accurate temperature management if used with thermometer method.

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