

# WATER CHLOROFORM LEVELS IN INDOOR SWIMMING POOLS IN A CITY OF KOREA AND IN A CITY OF NEW JERSEY IN THE UNITED STATES

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## Abstract

Chlorinated water in swimming pools contains chloroform at elevated levels compared to chlorinated drinking water. Chloroform levels in four indoor swimming pools (swimming pools A, B and C in a city of Korea and swimming pool D in a city of New Jersey in the United States) were examined. The chloroform levels in the water of swimming pool C (city-managed) were shown to be significantly ( $p=0.0001$ ) different from those of private swimming pools A and B: the mean chloroform levels in the pools A, B, and C are 22.8, 17.8, and 31.1  $\mu\text{g/l}$ , respectively. Furthermore, all of these chloroform levels are significantly ( $p=0.0001$ ) different from those of New Jersey: chloroform concentration of the Korean pools ranged from 10.9  $\mu\text{g/l}$  to 47.9  $\mu\text{g/l}$  with a mean of 23.2  $\mu\text{g/l}$ , while it ranged from 27  $\mu\text{g/l}$  to 96  $\mu\text{g/l}$  with a mean of 64.4  $\mu\text{g/l}$  in the New Jersey pool. The disinfection processes would cause part of this difference since the swimming pools in Korea applied both chlorination and ozonation method, while the swimming pool in New Jersey used chlorination method only.

It was implied that swimming parameters inconsistently vary, resulting in fluctuation of and no constant accumulation of chloroform in the water with the change of time for the day. A regression analysis showed no relationships between sampling time and chloroform concentrations for the sampling day in the swimming pools of Korea. A F-test indicated no significant difference of chloroform concentrations in the morning and afternoon samples collected in the swimming pools.

Ingestion dose was estimated to be 0.58  $\mu\text{g}$  from an hour swimming in a city of Korea, taking into accounting an average of 23.2  $\mu\text{g/l}$  in swimming pools in the city. In extreme situation, the ingestion dose was estimated to be 12.0  $\mu\text{g}$  from an hour swimming in a city of Korea.

## 1. INTRODUCTION

The presence of chloroform and other trihalomethanes (THMs) in swimming pools continues to be the subject of active research because of THMs' potential chronic toxicity and swimmer's health risk from the THMs. The application of chlorine or other chlorine-containing disinfectants to indoor swimming

pools has been demonstrated to produce a spectrum of volatile halogenated compounds including THMs in the water of the swimming pools.

THMs are produced in-situ by the reaction of the chlorine and organic matter of human contaminants such as urine, sweat, and human grease or from cosmetics, such as suntan oil (Chambon *et al.*, 1983; Lahl *et al.*, 1981). The

THMs concentration in the water of swimming pools depends on the number of swimmers in the pools(Lahl *et al.*, 1981), since contamination with organics as precursors of THMs production increases with the number of swimmers. This implies that as time passes for the day, more THMs will be produced in the water of swimming pools, resulting in higher ingestion exposure to chloroform in the afternoon than in the morning. If this is true, individuals can select the time when they swim for the day to minimize the chloroform exposure while swimming. Other parameters which influence the THMs concentration include the chlorine amount(free effective chlorine), the concentrations of compounds which compete for chlorine leading to other than THMs production, the concentration of bromide ions(Trussel and Umphres, 1978), and the extent of outgassing of THMs from water into the surrounding air(Lahl, 1981). In addition, the THMs-contaminated water(tap water and/or ground water) itself which is added to swimming pools elevates the THMs level in the swimming pools. THMs occurs while the process of water chlorination (Rook, 1974; Rook, 1977), and ground water can be contaminated as a consequence of infiltrations from industrial waste-water (Aggazzotti and Predieri, 1986).

The previous researches abroad(Aggazzotti and Predieri, 1986; Aggazzotti *et al.*, 1990; Beech *et al.*, 1980; Chambon *et al.*, 1983; Lahl *et al.*, 1981; Norin and Renberg, 1980) showed that typical chloroform concentrations in swimming pools disinfected with sodium hypochlorite only exceed 100  $\mu\text{g/l}$  which is the maximum contaminant level for THMs in drinking water promulgated by United States Environmental Protection Agency(USEPA) and set in drinking water regulations in Korea. Recently, much concern has been given to the THMs in drinking water in Korea, but not to the THMs in water of swimming pools. More interestingly, most of newly-built swimming pools in Korea use both sodium hypochlorite( $\text{NaClO}$ ) and ozone

as disinfectants, implying that chloroform levels will be lower in the water of the swimming pools in Korea than those reported by the previous studies abroad.

Lahl *et al.*(1981) estimated the THMs dose to be 0.07  $\mu\text{g/Kg}$  body burden for a normal swim in Bremen of Germany. The study assumed that 50 ml of water is ingested by adults while 30 minutes swimming for an hour visit to the swimming pools, and average 70 Kg of per person. In extreme situations which may lead to the ingestion of 0.5 l per individual and which the THMs concentrations is the highest(1200  $\mu\text{g/l}$ ) in the water of swimming pools in Bremen, the study estimated the chloroform dose by children to be 7-10  $\mu\text{g/Kg}$ .

Chloroform was found to be present at the highest concentration among THMs in the swimming pools treated with sodium hypochlorite( $\text{NaOCl}$ ) (Aggazzotti and Predieri, 1986; Aggazzotti *et al.*, 1990; Chambon *et al.*, 1983; Lahl *et al.*, 1981; Trussel and Umphres, 1978), and is a class 2B carcinogen with sufficient evidence in experimental animals but inadequate epidemiological evidence(IARC, 1979). This study is designed to examine chloroform levels in water of indoor swimming pools to provide a quantitative data base of chloroform exposure from swimming associated with using both chlorinated and ozonated water in Korea, to compare the chloroform levels measured in the swimming pools in Korea and in a city of New Jersey in the United States which applied sodium hypochlorite only for water disinfection, to compare the chloroform levels in the water samples collected in the morning and the afternoon from the swimming pools of Korea, and to estimate the ingestion exposure to chloroform from a swim in indoor swimming pools in Korea.

## 2. METHODOLOGY

To examine the chloroform levels in the

water of swimming pools, three swimming pools (two private pools and one city-managed pool) were selected in Korea and one in a city of New Jersey in the United States. The swimming pools A and B (two private pools) used both ground water and chlorinated tap water, while the swimming pool C (city-managed pool) used chlorinated tap water only. The all three swimming pools in Korea used both sodium hypochlorite and ozone as disinfectants. The water samples were collected in three indoor swimming pools in Korea between February 19, 1994 and March 19, 1994. The water sampling was conducted in serial time to examine the variation of chloroform concentrations with time. Seven water samples were collected in a swimming pool of New Jersey between July 16, 1994 and July 28, 1993, which used sodium hypochlorite only as a disinfectant. Prior to and right after the water sampling, water temperatures were measured at the sampling sites. Table 1 summarizes the number of water samples taken in four swimming pools by sampling date and time (morning and afternoon).

## 2.1. Sampling

The water samples in New Jersey and Korea were collected using clean 40 ml vials with a PTFE-faced rubber septum and capped immediately. Prior to sampling, vials that were to be used for water collection received 10 mg of sodium thiosulfate to quench residual chlorine reactions. EPA method 502.1 (USEPA, 1981) was applied to collect the water samples.

## 2.2. Analysis

EPA method 502.1, which is based on the two-film mass-transfer theory (USEPA, 1981; Bellar and Lichtenberg, 1974), was used for the water analysis. The analytical systems used in Korea a purge and trap system, a thermal desorbing system (furnace, Tekmar Co.) and a

Table 1. Schedule for water sampling in three swimming pools in Korea and one in New Jersey of the United States.

Swimming Pool	Sampling Date	Sampling Time (AM or PM)	Number of Water Samples
Korea A	2/19/94	AM	3
		PM	4
Korea B	3/05/94	AM	6
		PM	4
	2/25/94	PM	7
		3/19/94	AM
Korea C	3/01/94		PM
		AM	4
	3/06/94	PM	2
		AM	4
US D	7/16/93	AM	4
		PM	1
	7/19/93	AM	1
		PM	1
	7/22/93	AM	1
		PM	1
	7/28/93	AM	1
		PM	1

gas chromatograph (GC, Hewlett Packard 5890 II) with an electron capture detector (ECD, Hewlett Packard) for halogen-specific compounds. The 1/4 inch (in.) outside diameter (O.D.) and 7 in. length Tenax-filled stainless steel (SS) tubes were connected to the 25 ml-purge device (Supelco). Water samples were purged for 15 minutes at room temperature (12 to 16 °C). The GC column used was a packed column with 96 inch long x 1/4 in. inside diameter (I.D.) glass, SP-1000 and 60/80 Carbowax B). The flow rate of the carrier gas (nitrogen, 99.999% purity) was adjusted to 60.6 cc/min. The GC oven temperature was programmed from 45 °C to 80 °C at a rate of 4 °C/min. The column injection temperature was 200 °C. The temperature of the desorbing system was fixed to 180 °C.

The analytical systems used in New Jersey of the United States consist of a purge and trap system, a purge and trap system, a thermal desorbing system (Perkin Elmer Model ATD 400)

and a gas chromatograph(GC, Hewlett Packard 5890 II) with an mass selective detector(MSD, Hewlett Packard). The 1/4 in. O.D.-3.5 in. length Tenax-filled stainless steel(SS) tubes were connected to the 25 ml-purge device (Supelco). Water samples were purged for 15 minutes at room temperature(17 to 23 °C). The GC column used was a 25 meter fused silica open tubular 0.2 mm I.D. capillary column, coated with 0.33 micrometer crosslinked layer of 5% phenyl-methyl-silicone(Hewlett Packard). The flowrate of the carrier gas(helium, 99.999% purity) was adjusted to 1.2 cc/min. The GC oven temperature was programmed from 45 °C to 200 °C at a rate of 8 °C/min. The column injection temperature was 200 °C. The temperature of the desorbing system was fixed to 250 °C.

### 2.3. Quality Assurance

#### 2.3.1. Instrument Performance

The performance of the entire analytical system was checked daily by analyzing a blank and an external standard. At the beginning of the day, a trap blank and a water blank were analyzed to check whether the blanks and the analytical system were contaminated. If no problems were found, an external standard was analyzed to check the quantitative response. Typically, the blank concentrations were below the detection limits. The response of an external standard was compared to the value calculated from a calibration equation. If the response differed by more than 20%, a new calibration equation was determined.

#### 2.3.2. Precision, Minimum Detection Limit and Recovery

The precision of the water analytical systems for chloroform based on the analyses of seven replicates was 15.9 %. The minimum detection limit(MDL) of the water analytical system was

0.08 ug/l. The recovery of the water analytical system was 90.4 %.

### 2.4. Statistical analyses

Statistical analyses were conducted using the SAS programs(Version 6.03). Using analysis of variance(ANOVA) and Duncan's Multiple Range test, comparisons were made for the chloroform concentrations obtained from the water samples of four swimming pools. Regression analysis was applied to test the relationships between sampling time and the chloroform concentrations in the water of swimming pools.

## 3. RESULTS

The data obtained from the water of four indoor swimming pools are summarized in Table 2. Figure 1 compares the chloroform levels obtained from the Korean swimming pools A, B, and C. ANOVA and Duncan's Multiple Range test showed that the chloroform levels of the swimming pools A and B were not statistically different from each other. However, the chloroform levels in the swimming pool C which used chlorinated tap water only were shown to be significantly( $p=0.0001$ ) different from those in the swimming pools A and B which used both groundwater and chlorinated tap water. As expected because of different disinfection processes in the two countries, the mean value of chloroform levels measured in the swimming pool in New Jersey was statistically( $p=0.0001$ ) different from those of Korea. The mean value obtained from the water samples in Korea is 23.2  $\mu\text{g/l}$ , while the mean value is 64.4  $\mu\text{g/l}$  in the waters collected in New Jersey. On the other hand, the water temperatures in the three swimming pools in Korea were not significantly changeable with the change of both the type of swimming pools and sampling dates. However, the mean water

Table 2. Water chloroform concentrations and water temperatures measured in three indoor swimming pools in a city of Korea and in one indoor swimming pool in New Jersey of the United States.

Swimming Pool	Number of Samples	Mean Chloroform Levels( $\mu\text{g/l}$ )	Conc. Range ( $\mu\text{g/l}$ )	Water Temp. ( $^{\circ}\text{C}$ )
Korea A	17	22.8	12.4-34.4	$30.3^{\text{a}} \pm 0.5^{\text{b}}$
Korea B	19	17.8	10.9-35.4	$28.4^{\text{a}} \pm 0.1^{\text{b}}$
Korea C	14	31.1	17.8-47.9	NA
US D	7	64.4	27.0-96.0	$22.3^{\text{a}} \pm 0.4^{\text{b}}$

\* Superscripts, a and b indicates arithmetic mean and standard deviation, respectively.  
 \* NA means not-available.

temperature measured in winter in the swimming pools in Korea was higher than that measured in summer in New jersey.

As shown in Figure 2, the chloroform levels measured in the morning and the afternoon from three swimming pools of Korea appeared not to be different from each other: the mean value and the concentration range are  $21.7 \mu\text{g/l}$  and from  $10.9 \mu\text{g/l}$  to  $33.8 \mu\text{g/l}$  in the morning, respectively, and in the afternoon are  $24.7 \mu\text{g/l}$  and from  $11.9 \mu\text{g/l}$  to  $47.9 \mu\text{g/l}$ , respectively. An F-test also showed no significant differences between the data sets.

Figure 3 shows the variation of chloroform concentrations with the change of time in the water of two swimming pools(A and C) for two

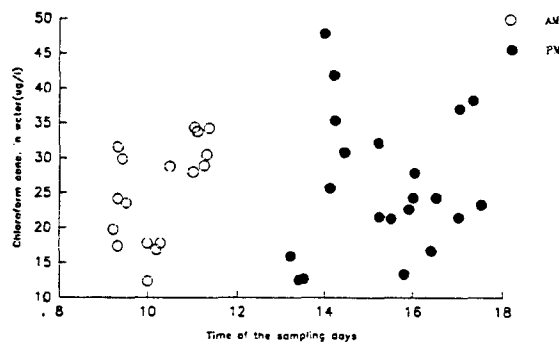


Fig. 2. Distribution of chloroform concentrations in the all three swimming pools A, B and D in the morning and the afternoon.

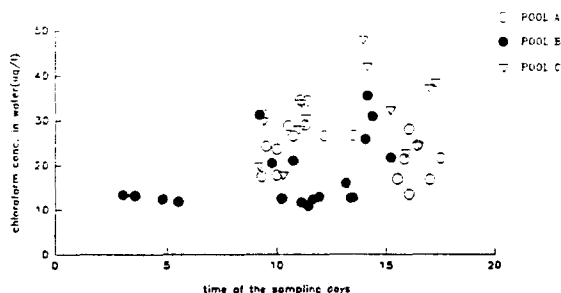


Fig. 1. Changes in chloroform concentrations( $\mu\text{g/l}$ ) with time in the swimming pools A, B, and C.

sampling days, respectively. The selection of the data sets for the comparison was based on the number of water samples available. Regression analysis showed no significant relationships between sampling time and the chloroform levels in the water of the swimming pools for the sampling days.

#### 4. DISCUSSION

The mean value( $64.4 \mu\text{g/l}$ ) of chloroform levels measured in the water of the swimming pool in New jersey was shown to be statistically

higher than the mean values (23.2  $\mu\text{g/l}$ ) measured in Korea. In addition, the chloroform levels measured in Korea was much lower than those reported by the previous studies abroad (Aggazzotti and Predieri, 1986; Aggazzotti *et al.*, 1990; Beech *et al.*, 1980; Chambon *et al.*, 1983; Lahl *et al.*, 1981; Norin and Renberg, 1980). The previous studies used swimming pools where sodium hypochlorite only was applied for water disinfection and found that typical chloroform concentrations exceeded 100  $\mu\text{g/l}$  in the water of the swimming pools. Different parameters influence the chloroform contents in the water of swimming pools (Lahl, 1981; Trussel and Umphres, 1978). Since different swimming parameters compensate each other, it is not easy to completely explain the difference between the two data sets (Chambon *et al.*, 1983; Lahl, 1981).

The swimming pools (A, B and C) in Korea were disinfected by both chlorination and ozonation method, while the swimming pool in New Jersey used chlorination method only, indicating that more chlorine amount should be present in the swimming pool in New Jersey. Based on the introduction of threshold values for oxidizable substances and ammonia content, a maximum concentration of free effective chlorine of 0.5-0.6  $\text{mg/l}$  (according to pH and

process combination) is recommended for the destroying of bacteria, spores, and viruses. According to the managers of each swimming pools used in Korea, the free effective chlorine is typically kept at the range of 0.2 to 0.4  $\text{mg/l}$  in their swimming pools and ozone process is accompanied with. This knowledge helps to partially understand the difference of chloroform levels in the swimming pools between in Korea and in New Jersey, since Lahl *et al.* (1981) showed that chloroform and other THMs increase with increasing chlorine contents.

Another knowledge available to understand the difference is the difference of water temperatures measured in the swimming pools of the two countries. Since the mass transfer coefficient for chloroform increases as temperature increases, the volatilization will increase (Andelman, 1986; Weiss, 1985). The water temperature ( $29.3 \pm 1.0$ ) measured in the swimming pools in Korea was higher than that ( $22.3 \pm 0.4$ ) in the swimming pool in New Jersey, implying that the higher water temperature in Korea results in more outgassing of chloroform from water to the air of swimming pools and then, lowering the chloroform concentration in the water of swimming pools.

Two-private swimming pools (A and B) in Korea use both ground water and chlorinated tap water, and the city-managed swimming pool C uses chlorinated tap water only, while all of their disinfection processes are similar. Figure 1 shows the chloroform levels in the swimming pools A, B, and C. F-test with  $p=0.0001$  showed that the chloroform levels in the two private swimming pools were significantly different in the swimming pool C, implying that since the chloroform level in the former was higher than that in the latter, the ground water used in latter was not contaminated by chloroform.

Considering only the effects of the number of swimmers on the chloroform concentrations, more chloroform will be produced in the afternoon than in the morning because of more organics can be present in the afternoon as

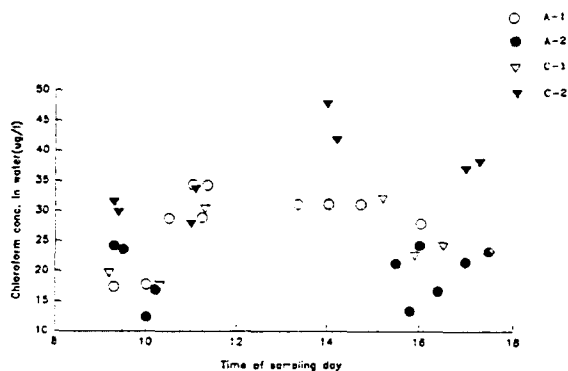


Fig. 3. Variation of chloroform concentrations ( $\mu\text{g/l}$ ) with time in the swimming pools A and C: 1 and 2 represent sampling days.

indicated in the "Introduction". The chloroform levels in the swimming pools of Korea varied inconsistently with time. An F-test indicated no difference of the chloroform levels between in the water samples collected in the morning and the afternoon from the swimming pools (see Figure 2). In addition, another F-test based on the data which were shown in Figure 3 showed the relationship between water chloroform concentrations and sampling time was not significant. These may be explained by that refresh water is continuously added to the swimming pools and other parameters inconsistently vary for the working day, resulting in fluctuation of and no accumulation of chloroform in the water with the change of time.

Ingestion dose estimated in this study was to be 0.58  $\mu\text{g}$  from an hour swimming, corresponding to a specific 0.008  $\mu\text{g}/\text{Kg}$  body weight, taking into accounting an average of 23.2  $\mu\text{g}/\text{l}$  in the Korean swimming pools. In the extreme situations which the maximum chloroform concentration is 47.9  $\mu\text{g}/\text{l}$ , the ingestion dose by children was estimated to be 12.0  $\mu\text{g}$  from an hour swimming, corresponding to a specific 0.4  $\mu\text{g}/\text{Kg}$  body weight. For the estimations, it was assumed that a 50% of ingested chloroform is absorbed into the human body (Fry *et al.*, 1972; Lahl *et al.*, 1981), that 0.5 liter of swimming-pool water is ingested by children, and that the average body weights of a reference person and a child are 70 Kg and 30 Kg, respectively (Syneder *et al.*, 1984). The estimated dose by a adult in this study lies about one-tenth of the corresponding dose from an hour swimming in Bremen of Germany, recalculated using Lahl *et al.*'s study (1981). The difference of the doses estimated in the extreme situations in the two countries implies that from an hour swimming, children in Bremen take chloroform 25-fold above the chloroform burden that children in the studied city of Korea take.

## 5. CONCLUSIONS

Disinfection processes influence the chloroform concentrations in the water of swimming pools. Water disinfection is typically conducted using sodium hypochlorite in swimming pools in many countries. In the swimming pools studied in Korea, both sodium hypochlorite and ozone were used for water disinfection. The present study implied that combination of ozone and sodium hypochlorite for water disinfection can improve the water quality for chloroform in swimming pools compared to the swimming pools disinfected with sodium hypochlorite only and then, lowers the ingestion exposure to chloroform while swimming.

The chloroform concentrations in the swimming pools of Korea were not significantly different between in the morning and afternoon, and did not consistently vary with the change of time for the day. Considering the chloroform concentration only for the estimation of ingestion exposure to chloroform while swimming, it is not easy for individuals to predict the time when the individuals swim for the day for least ingestion exposure.

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## REFERENCES

- Aggazzotti, G. and G. Predieri, 1986, Survey of volatile halogenated organics (VHO) in Italy. Levels of VHO in drinking waters,

- surface waters and swimming pools, *Water Research*, 20(8), 959-963.
- Aggazzotti, G., G. Fantuzzi, P. L. Tartoni and G. Predieri, 1990, plasma chloroform concentrations in swimmers using indoor swimming pools, *Arch. Environ. Health*, 45(3), 175-179.
- Andelman, J.B., S.M. Meyers, and L.C. Wilder, 1986, Chemicals in the environment, 323-330.
- Beech, J. A., R. Diaz, C. Ordaz and B. Palomeque, 1980, Nitrates, chlorates and trihalomethanes in swimming pool water, *Am. J. Public Health*, 70(1), 79-82.
- Belar, T. A. and J. J. Lichtenberg, 1974, Determining volatile organics at microgram-per litre levels by gas chromatography, *Amer. Water Assoc.* 66, 739-744.
- Chambon, P, M. Taveau, M. Morin, R. Chambon and J. Vial, 1983, Survey of trihalomethane levels in Rhone-Alps water supplies. Estimates on the formation of chloroform in wastewater treatment plants and swimming pools, *Water Research*, 17, 65-69.
- Fry B. J., T. Taylor and D. E. Hathway, 1972, Pulmonary elimination of chloroform and its metabolite in man, *Arch. Int. Pharmacodyn. Ther.* 196, 98-111.
- International Agency for Research on Cancer, 1979, IARC monographs on the evaluation of the carcinogenic risk of chemicals to humans. Some halogenated hydrocarbons. Chloroform. Lyon International Agency for Research on Cancer. 401-427.
- Lahl, U., K. Batjer, J.V. Duszeln, B. Gabel, B. Stachel and W. Thiemann, 1981, Distribution and balance of volatile halogenated hydrocarbons in the water and air of covered swimming pools using chlorine for water disinfection, *Water Research*, 15, 803-814.
- Norin H., and L. Renberg, 1980, Determination of trihalomethanes (THM) in water using high efficiency solvent extraction, *Water Res.* 14, 1397-1402.
- Rook, J. J., 1974, Formation of haloforms during chlorination of natural waters, *Water Treat. Exam.* 23, 234-243.
- Rook, J. J., 1977, Chlorination reactions of fulvic acids in natural waters, *Environ. Sci. Technol.* 11(5), 478-482.
- Syneder, W. S., M. J. Cook, E. S. Nasset, L. R. Karhausen, G. P. Howells, and I. H. Tipton, 1984, Report of the task group on reference man, International commission on radiological protection papers, No. 23 (Pergamon Press, New York), 360.
- Trussel R. R. and K. Umphres, 1978, The formation of trihalomethanes. *J. Am. Wat. Wks. Associ.* 604-612.
- U.S. Environmental Protection Agency, April 1981, The determination of halogenated chemicals in water by the purge and trap method, Method 502.1, Environmental Monitoring and Support laboratory, Cincinnati, Ohio.
- Weiss, C. F., 1985, Volatilization of organic groundwater contaminants in a shower environment, Undergraduate Independent Work, Department of Chemical Engineering, Princeton University.



## 국내 및 미국 뉴저지주의 수영장 물에서의 클로로포름

### 조 환 근

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염소처리된 수영장 물에는 염소처리된 음용수에 비해 높은 농도의 클로로포름이 존재한다. 네 개의 수영장(국내 수영장 A, B 및 C 와 미국 뉴저지주 수영장 D) 물에서 클로로포름 농도를 조사하였다. 수영장 C(시 관리)에서 측정된 클로로포름 농도는 개인 운영 수영장 A 와 B 에서 측정된 클로로포름 농도와 통계적으로( $p=0.0001$ ) 다르게 나타났다: 수영장 A, B, 및 C 에서 측정된 클로로포름 농도는 각각 22.8, 17.8 및 31.1  $\mu\text{g/l}$  이다. 또한, 국내 수영장과 뉴저지주 수영장 물의 클로로포름 농도는 서로 통계적으로( $p=0.0001$ ) 다르게 나타났다: 국내 수영장 물의 평균 농도와 농도 범위는 각각 23.2  $\mu\text{g/l}$  과 10.9-47.9  $\mu\text{g/l}$  이며, 뉴저지주 수영장 물의 평균 농도와 농도 범위는 각각 64.4  $\mu\text{g/l}$  과 27-96  $\mu\text{g/l}$  였다. 국내 수영장은 살균제로서 차아염소산과 오존을 혼용하며, 뉴저지주의 수영장은 차아염소산만으로 살균하므로, 두 지역의 그러한 차이는 100%는 아닐지라도 최소한 살균 처리 공정의 차이에 기인한 것으로 추정된다.

수영 변수들이 일관성 없이 변하여, 시간이 경과함에 따라 물속의 클로로포름 농도의 증가 및 감소가 불규칙하게 변했고, 클로로포름의 축적도 일정치 않았다는 것이 암시되었다. 회귀 분석 결과, 시료 채취 시간과 클로로포름 농도 사이에 유의성 없는 것으로 나타났다. 또한, F 시험 결과는 수영장으로 부터 오전과 오후에 채취된 물 시료의 클로로포름 농도는 서로 다르지 않게 나타났다.

국내 수영장 물의 클로로포름 평균 농도를 23.2  $\mu\text{g/l}$ 로 간주하여, 한 시간 수영을 할 때 식도를 통해서 체내에 흡수되는 클로로포름의 양은 0.58  $\mu\text{g}$  으로 추산되었다. 극단적인 상황에서는, 한 시간 수영을 할 때 식도를 통해서 체내에 흡수되는 클로로포름의 양이 12.0  $\mu\text{g}$  으로 추산되었다. 수영장 물에서의 클로로포름 함유량만을 고려해 볼 때, 오전 또는 오후에 수영을 하든지 간에 식도를 통해서 체내에 흡수되는 클로로포름의 양은 차이가 없는 것으로 간주된다.