ORIGINAL ARTICLE

Potentially Hazardous Trihalomethanes (THMs) Levels in Chlorinated Swimming Pools' Water in Fars Province, Iran

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Abstract

Background: Trihalomethanes are toxic and dangerous substances that are formed in the presence of organic materials when water is chlorinated for disinfection. The Iranian National Standard, World Health Organization, European Union, U.S. Environmental Protection Agency and International Agency for Research in Cancer standards have established a Maximum Contaminant Level for Trihalomethanes for the quality of consumable water. The aim of this study was to determine if the trihalomethanes level in the water of Fars province swimming pools comply with these recommendations.

Methods: The laboratory study design was conducted by utilizing spectrophotometer Hack DR5000 VIS-UV equipment for evaluating trihalomethanes concentrations, digital photometer Palin-test for measuring chlorine and pH to process different samples collected from 43 indoor and outdoor swimming pools in Fars Province, Iran.

The dependent variable was trihalomethanes and chlorine compounds were independent variables. Precise laboratory experimental methods and appropriate statistical analysis were conducted using SPSS.

Results: Mean concentration of trihalomethanes was found to be 242.1µg/l, ranging from 0 to 990µg/l for 43 public swimming pools in Fars province. Association of trihalomethanes and chlorine components with analysis of variance (ANOVA) model was highly significant ($P<0.0001$).

Conclusion: Study results showed that there were strong associations between chlorine compounds and trihalomethanes concentrations. The mean trihalomethanes was 1.2-times (241.2µg/l VS. 200.0µg/l) higher than the national and 3-folds (241.2µg/l VS. 80.0µg/l) higher than the worldwide standards. Therefore, based upon standard recommendations, this conclusion could pose a hazard to public health.

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Introduction

Trihalomethanes (THMs) are a group of toxic volatile organic compounds (VOCs) classified as disinfection by-products (DBPs) that are formed during the chlorination of water when chlorine reacts with naturally occurring organic matters, mainly humic and fulvic acids. These are not eliminated through conventional water purification methods. Components of THMs such as bromoform ($CHBr_3$), dibromochloromethane

($CHClBr_2$), bromodichloromethane ($CHCl_2Br$), and chloroform ($CHCl_3$) are recognized as potentially hazardous, carcinogenic substances. Thus, long term consumption of these halogenic substances may result in adverse health consequences such as cancer and genetic mutation.[1-3]

Chlorine is the most commonly disinfectant used for consumable water. This is routinely carried out in the water treatment process or before treated water leaves the treatment plant to improve quality and prevent the spread of waterborne pathogens and microbiological degradation of water used for drinking and swimming pools.

The chlorination of water was started in New Jersey (USA) in 1908.[4] The cost-effective and aseptic properties of chlorination, disinfection of consumable waters (drinking and swimming pool) using chlorine compounds, became the most accepted form of water purification worldwide.[2,5] Several years later, in 1974 components of trihalomethanes were found to form during the chlorination of drinking water.[6] In addition, in 1995 trihalomethanes were recognized as potentially hazardous and carcinogenic substances.[7]

The general formula of THMs is CHX_3, where X may be any halogen or a combination of halogens. However, generally speaking this term is used to refer only to those compounds containing either chlorine or bromide. Therefore, components of THMs are the ones most commonly detected in chlorinated water.

The most important structural formation factors for THMs are the rate of formation increase as a function of the concentration of chlorine and humic acid, temperature, pH, and the bromide ion. Naturally, water contains humus organic compounds. These natural organic matters (NOMs) in surface waters**,** including humus and fulvic acids, mainly result from decomposition of substances secreted from algae and other aquatic organisms as well as human activities (city sewage, industrial, agricultural waste waters, and trash disposal secretions).[2,8] All of these matters are primarily essential components of THMs.

More than 780 types of disinfection by-products (DBPs) are generated as a result of reaction of additive disinfectants including chloric compounds in water purification systems.[9] Furthermore, most of these DBPs are halogenic and their long term consumption may be associated with adverse health consequences.

Trihalomethanes have been detected in different aqueous matrixes such as tap water, swimming pool water, distilled water, ultrapure water and even in water that has not been subjected to chlorination processes, such as ground water, mineral water, snow, rain water, river and sea water.

These THMs are likely to have originated from the infiltration of chlorinated water. However, concentrations of these compounds in unchlorinated water tend to be much lower than those usually found in treated plant water. The presence of these levels of THMs may be due to several causes. The sources of chlorinated water to ground water may include the irrigation of lawns, gardens and parks; leaking drinking water distribution and sewer pipes, and industrial spills, among others.[10]

In addition, mineral water contamination with THMs may be derived from disinfection with chlorine of the pipes used in production and bottling plants. In other cases, the concentration pattern is not upheld. In the case of THMs, approximately equal contributions to total exposure come from these sources such as the ingestion of drinking water, inhalation of indoor air, showering or bathing, the ingestion of foods[11,12] and inhalation, and dermal exposure of swimmer in swimming pool.

Although the chlorination of drinking water has many health benefits, there is limited scientific research found on human THMs exposure and carcinogenicity compared to animal models. However, there is enough evidence of carcinogenicity in the experimental animal models to raise concern.[12-14] Numerous experimental animal models suggest a significant correlation between consumption of water containing THMs and the risk of colon, bladder, and rectal cancers.[3,9] Adverse effects of all THMs compounds (*$CHBr_3$, $CHClBr_2$, $CHCl_2Br$, $CHCl_3$*) have been reported concerning disease and health abnormalities in human society by the International Agency for Research in Cancer (IARC).[12,13]

In 1975, trihalomethanes were identified as carcinogenic and ranked in group "A" of cancerous substances by the United States Environmental Protection Agency (USEPA).[3,15] Subsequently, the World Health Organization (WHO) also emphasized the necessity of removing these chemicals from the water used for drinking, swimming, etc. Due to hazards associated with trihalomethanes, in 1998 the United States Environmental Protection Agency reduced the maximum allowed content of these compounds in drinking waters to 80µg/l.[16] Iran's Institute of Standard and Industrial Research determined that the maximum acceptable content for these compounds should be equal to 200µg/l based upon the standard No. 11203[*1] approved in 2008.[17]

For the purpose of protecting public health from possible health hazardous and carcinogenic effects of substances such as THMs, the European Union and the U.S. Environmental Protection Agency (USEPA) have established a Maximum Contaminant Level (MCL)

*The 11203 code is Obligatory Regulation of Iran as a National Standard for Public Swimming Pools issued since 2008.

for the total concentration of THMs components, also known as total trihalomethanes (TTHMs).[18,19] In guidelines for human consuming water (drinking, swimming) quality, the World Health Organization (WHO) has also set values for each of the THMs in drinking and swimming water and proposes an equation to establish a TTHM standard:[12]

$$\frac{\text{C bromoform}}{\text{GV bromoform}} + \frac{\text{C dibromochloromethane}}{\text{GV dibromochloromethane}} + \frac{\text{C bromodichloromethane}}{\text{GV bromodichloromethane}} + \frac{\text{C chloroform}}{\text{GV chloroform}} : \leq 1$$

C=concentration, **GV**=guideline value

Previous studies in Ahwaz, Esfahan, Bandar-Abbas and Tehran found that levels of THMs were above the standard concentration of 200µg/l. These compounds were found in consumable water (drinking, swimming pool) resources.[20,21]

It must be noted that trihalomethanes are absorbed orally and also through respiration and dermal contact. As far as health and hygiene are concerned, the disorders resulting from these pathologically and medically hazardous and cancerous chemicals emerge as innate and reproductive abnormalities and damage to certain body organs such as the liver, kidneys, thyroid gland**,** nervous system as well as adverse effects in blood circulation and biochemistry.[1-3,22]

Specifically, prolonged contact with dosages over 15mg/kg of body weight would cause alterations in the liver, kidneys, and thyroid gland.[22] Today, no comprehensive research has been carried out using advanced analytical techniques on the trihalomethanes level in swimming pool water of Fars Province through scientific approaches.

The research hypothesis is that trihalomethanes in swimming pool water of Fars Province are higher than the national and international standards.

The study aims at investigating consumable water of Fars province swimming pools after chlorination, in order to determine if the levels of THMs meet the standard MCL and do not pose a health hazard. Usually, both drinking and swimming pool waters in Iran are supplied from the same water processing plants that disinfect consumable water with chlorination. However, swimming pools' water are repeatedly disinfected by adding additional chlorine to maintain cleanliness to prevent diseases caused by different contaminants such as urine, sweat, and others. For this reason, such waters are more likely to generate DBPs including trihalomethanes. Thus, it is particularly important to perform the current research on the swimming pools water of Fars Province using modern technology and method to minimize trihalomethanes (THMs) hazards.[23-40]

Materials and Methods

After sampling and transferring the swimming pool water to "Shiraz University of Medical Sciences Laboratory of Water and Wastewater Center", the samples were immediately prepared for testing. They were tested using scientific experimental technique as below.

Laboratory Set-up and Materials

a) Valid and Reliable Experimental Laboratory equipment and Materials Preparation for testing Trihalomethanes (THMs) also Known as total Trihalomethanes (TTHMs)

• Trihalomethanes was tested using Memory-supported Spectrophotometer apparatus: "Hack DR5000 VIS – UV a joint manufactured in USA and Germany", specifically designed for water and wastewater experiments.

• 50-test kit product by Hack Company under the code 27908-000, specifically designed for measurement of trihalomethanes in water, which consists of 4 separate identifiers and solutions.

• Electrical Hot Plate apparatus

• The digital photometer-Palin test apparatus (made in UK) for chlorometry and pH measurements in the swimming pools place

• The automatic digital Burt equipment.

• Erlen, 15 ml screw-lidded laboratory tube, pipette, lidded cell, and volumetric pipette

• Filer pipette

• 0.1N hydrochloric acid vial for making 0.02N hydrochloric acid

• Phenolphthalein, methyl orange, methyl red, bromocresol green, and laboratory distilled water

b) Experimental Laboratory Location and Analytical Methods

• The tests were conducted in the Central Water and Wastewater Laboratory of Shiraz University of Medical Sciences, Shohadaye Valfajr Medical Center, Shiraz, Fars Province, Iran.

• The test was conducted using VIS-UV Spectrophotometer apparatus manufactured by Hack Company/model DR5000 joint product of USA & Germany) with the special kit of the same Company under NO.27908 by Method 10132 water Bath Method (THM plus) for measuring THMs. The values were measured based upon World Health Organization (WHO) Guidelines for Consumable Water Quality (drinking and swimming Pools Water in Iran is the same) by using THM plus 725 program.

• In this method, the content of chlorinated swimming pools water regarding THMs concentration in water was measured in terms of microgram per liter (μg/l). Since maximal and minimal measurements of the apparatus are in the range 10-600μg/liter; therefore, the measurement unit (except for average calculation) is larger than 1μg/liter. There is no need to use the units in hundredth order of microgram.*

• In average, 3-4 samples were taken from each of the total 43 swimming pools of Fars Province, together with the Blank-Test the same day.

• Sampling procedure was followed in accordance with 2347 and 4208 Iran's National Standards. These samples were extracted by the clamped-container from the depth of 30-40 cm in the center of the swimming pools, and, from the depth of 10-30cm in different and distinctive points of the marginal parts of the swimming pools.

• Chlorine was measured in the swimming pools water by the digital Palin-test photometric apparatus using N, N-Diethyl-P-Phenylenediamine (DPD)method. In the swimming pools water, pH value was measured using the same equipment. In addition, the water pH was measured by pH-meter "Metrum -Model 691" instrument in laboratory.

• Trihalomethanes were measured using Hack DR5000 apparatus "Method10132, Water Bath Method, 725THM (Plus)" with the aid of the materials and identifiers of the same apparatus through 24-test steps in accordance with instructions of the manufacturing company of the apparatus and the related kit; then the results were recorded.

• Alkalinity was measured through titration technique using "0.02" Normal hydrochloride acid with identifiers such as phenolphthalein, methyl orange, methyl red and bromocresol green.

• Water temperature was tested and measured in the swimming pool and laboratory.

• In THMs-plus method, trihalomethane compounds are heated with N, N-Diethylnicotinamid in alkaline state and are converted into intermediate dialdehyde. After cooling, pH of this sample is reduced to 2.5 by imposing acidic conditions. The resulting color intensity is associated with the concentration of Trihalomethane compounds in the sampled water.

• Extraction and preservation of water samples in 40 ml Teflon-lidded glass bottles is among the important features of the current study. Samples were collected very slowly and gently so as to discharge the air inside the bottles. The bottles were firmly and imperviously sealed by the Teflon lid to make the quantitative and qualitative conditions remain constant. Due to extremely high volatility and instability of trihalomethane compounds, results of samples were immediately analyzed in the same day of sampling based on the temporal standard for checking the accuracy of tests.

Following the experimental analysis, the research hypothesis was verified in the statistical analysis using descriptive-explanatory method, correlation, and in the more advanced stage, analysis of variance (ANOVA), a powerful technique that allows us to create a model, analyze and interpret several observations simultaneously.

The target research parameters of all Fars public swimming pools were analyzed. The next step of the analysis was performed for testing the correlation (r) in convergence and non-convergence directions. According to the analytical results, a significant (S) correlation was observed between the impact of chlorine application and formation of THMs. In the final step, ANOVA allows the use of the model, to analyze and interpret several observations performed in order to verify the hypothesis of association between the increase in trihalomethane concentration and amount of chlorine compounds.

Results

In the present research, all of the 43 indoor and outdoor public swimming pools of Fars Province were studied; 37 (88%) swimming pools were indoor and the remaining 6 (12%) were outdoor. Due to the low number of outdoor swimming pools in this study, THMs concentration was restricted to all pools and not separated. In addition, chlorine disinfection in the studied swimming pools found in the content of residual chlorine was at the standard limit in 13 pools (30.2%), below the standard limit in 18 pools (41.9%), and above the standard limit in 12 pools (27.9%).

Considering THMs and chlorine disinfectant, average of total-chlorine content, average of combined chloride

*Numbers such as 0.01 or 0.9μg/liter are not needed because measurement unit of Trihalomethanes are 100μg/l and 200 μg/l.

Table 1: Mean, Standard Deviation of Trihalomethanes and Related Variables in Pools Water of Fars Province, Iran

	THMs*	Total Chlorine	Combined Chlorine	Free Chlorine Exist	pH Level
Mean±SD	242.07±198.86	2.55±1.88	0.37±0.32	2.17±1.82	7.92±0.36
Range	0-980.00	0.00-7.28	0.00-1.38	0.00-7.20	6.80- 8.60

THMs*=Trihalomethanes

content, and average of free chloride content were respectively, 2.55 ppm, 0.37 ppm, 2.18ppm. (Table 1)

Average THMs production depends on the chloride compounds disinfection method. The average trihalomethanes level in this study was 241.2µg/l, with the range of 0-980µg/l, and in respect to chloride compounds as the disinfectant. (Figures 1-3, Table 1)

Accordingly, convergence direct correlation coefficient of THMs by-products level and chloride compounds was confirmed in the samples collected from all of the Fars Province public swimming pools water with a significant association (P<0.0001).

Trihalomethanes formation had a significant convergence correlation to the following variables: total chlorine content (r =0.546, P<0.0001), combined chlorine (r=0.571, P<0.0001), free chlorine content (r

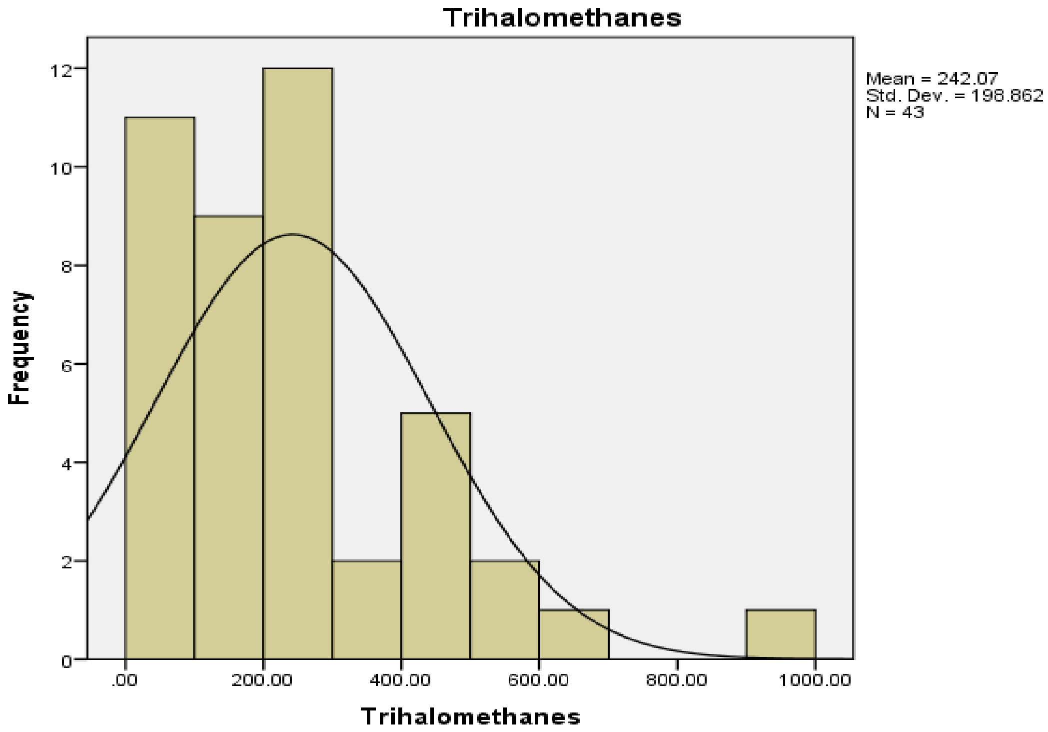

Figure 1: Mean and Standard Deviation of Trihalomethanes levels after chlorination of water in Fars Province Swimming Pools.

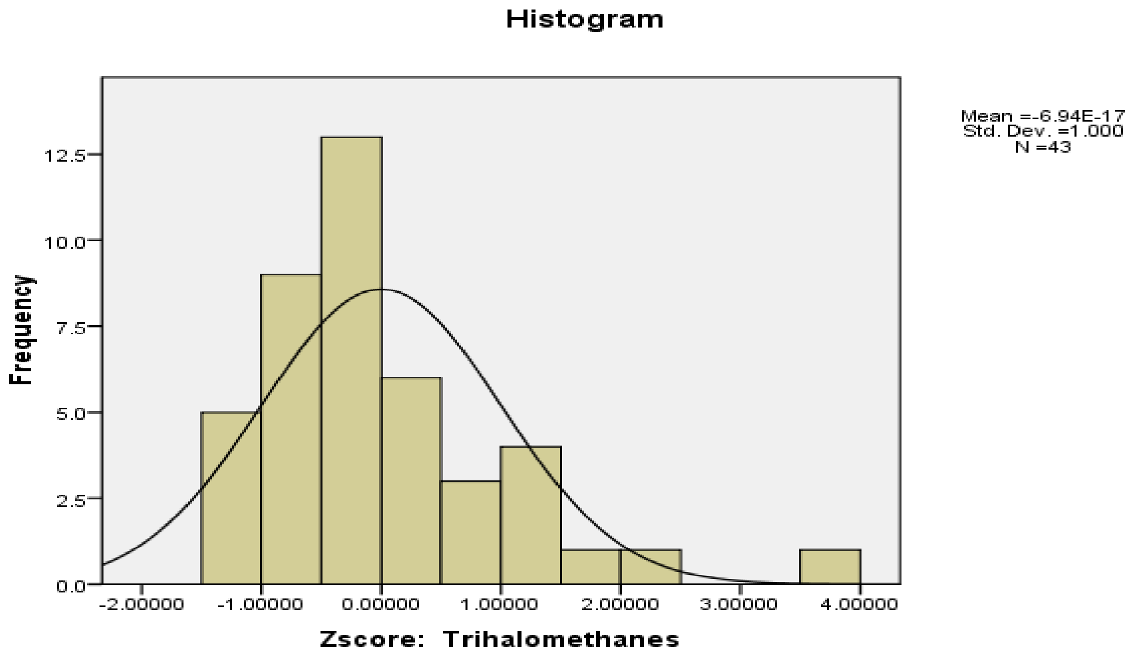

Figure 2: Mean and Standard Deviation of Z-score Trihalomethanes levels after chlorination of water in Fars Province Swimming Pools.

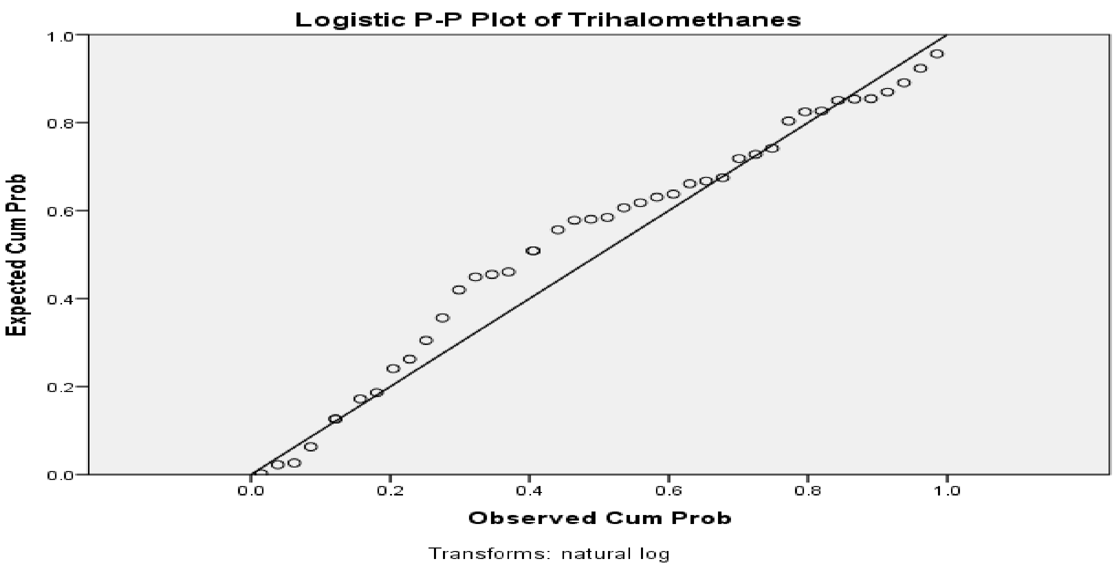

Figure 3: Logistic Plot of Trihalomethanes Levels (Transforms Natural Log) after chlorination of water in Fars Province Swimming Pools.

Table 2: Correlation Coefficient of Trihalomethanes with Related Variables in Pools Water of Fars Province, Iran

	Level of Sig.*	Total Chlorine	Combined Chlorine	Free Chlorine Exist	Residual Chlorine	Chlorine Odor	disinfection method	pH Level
THMs**	*r*	0.546	0.571	0.496	0.422	-0.312	0.560	-0.380
	P value	0.0001	0.0001	0.001	0.005	0.005	0.0001	0.012

Sig.*=Significant, THMs**=*Trihalomethanes*

=0.496, P<0.001), residual chlorine (r=0.422, P<0.005), and type of disinfection method (r =0.56, P<0.0001). However, Trihalomethanes had a significantly weak inverse correlation with chlorine odor (r=0.312, P<0.005) and pH level (r=0.380, P<0.012. (Table 2)

There was no significant correlation of THM and the pool's location (indoor/outdoor) status, THMs and changing of pool water, THMs and pool alkalinity, pool water circulation, float particles, water temperature, pool ventilation, maximum and minimum number of swimmers, or pool appearance. In addition, there were no significant correlations between THMs and gravel filtration, carbon filtration, pool clearance status, microscopic water color, and cloudiness.

In advanced analytical step in different models, results indicated a significant association between the increase in THMs content and parameters including total-chlorine content (P<0.005), combined chlorine (P<0.001), and free chlorine (P<0.03) residual chlorine content (P<0.02).

These results reflect the existence of a highly significant and strong association of the predictive variables (chlorine compounds) and the increase in THMs formation. Considering the association of trihalomethanes and chlorine disinfectant, we found that other independent variables that may affect this association in this study account for confounding and interaction. We also tested for any confounding and interaction by these covariates and no change was found in association of trihalomethanes and chlorine disinfectant. However, these covariate independent variables were shown to lack such an effect.

Discussion

A major finding of this study was that the mean of trihalomethanes concentrationis higher than the Iranian Standard in publicly consumed water and worldwide standards (WHO, USEPA, EU, IARC). In this study, the mean average trihalomethanes was 1.2-times (241.2µg/l VS. 200.0µg/l) higher than the national and 3-folds (241.2µg/l vs 80.0µg/l) higher than the worldwide standards for maximum contaminate level (MCL).

Trihalomethanes (THMs) are now partially preventable and controllable. The water disinfection by-products (DBPs) are formed during the chlorination of water, when chlorine reacts with naturally occurring organic matters, mainly humic and fulvic acids. There are 780 types of chemicals[9] as disinfection by-products formed in drinking and swimming pool waters, depending on the type of disinfectants used. These toxic volatile organic compounds (VOCs) are not eliminated through conventional water purification methods. Investigation and elimination of these potentially hazardous, carcinogenic substances by public health experts in consumable waters after production and before entry into water supply system distribution and consumption centers merits continued attention. In this study, we investigated the association between trihalomethanes (THMs) concentration and chlorine reaction after chlorination of water in Fars public swimming pools.

Descriptive findings of this study indicated an increase in trihalomethane concentration due to chlorine disinfectant in the water of all 43 public swimming pools (88% indoors and 12% outdoors) of Fars Province.

In light of study hypothesis, THMs excess level through the results of water samples from Fars province public swimming pools in the present research with the average trihalomethane content equals to 242.1µg/l. According to the value recommended by Iran's National Standard (200µg/l)[17] for consuming water, the standard limit (80-100µg/l) in the World Health Organization, European countries and United States Environmental Protection Agency (USEPA),[3,12,15,16,18,19] it is clearly obvious that the level of trihalomethane concentration is above the permissible guidelines level in these consumable waters (drinking, swimming pools), and the findings of the current study are in agreement with the previous research.[20,21]

Taking into account the role of chlorine compounds related to increase of the trihalomethane concentration based upon laboratory experimental analyses and statistical analyses, the impact of the respective chlorination content was evaluated on the average increase of these detrimental toxic chemicals (trihalomethanes). The findings of the present research on the chlorine disinfection confirmed the strong association between the amount of this disinfectant and increase in trihalomethanes concentration.

Concerning the impact of the residual chlorine compounds on the trihalomethanes formation of the available classifications, the minimum increase was observed in the below standard level; intermediate increase standard level and maximal increases were reported in the above standard level, respectively. As to trihalomethanes and chlorine disinfection in all Fars public swimming pools, the average trihalomethane formation depends on the disinfection application method. Average effects of different disinfectant types imply that the largest increase in average trihalomethane content occurs in the combined application method compared to gaseous chlorine or perchlorine applications alone. For further conforming of increase in average trihalomethane level in the present study, we performed the analysis for testing the correlation in convergence and non-convergence directions in order to determine the associations of the trihalomethane chlorine compound. Significant and direct correlations existed between the increase in the trihalomethane concentration and chlorine compounds (total chlorine, combined chlorine, free chlorine, and residual chlorine). Among the tested parameters, total chlorine, combined chlorine contents, free chlorine, and residual chlorine, as well as type of disinfectant all had highly significant and strong correlations with the increase in trihalomethane concentration($P<0.0001$).

When we were standardizing those independent factors (chlorine compounds) related to the dependent variable (THMs), there remained a high correlation between THMs and chlorine compounds. In more advanced analysis, we put all predictor variables (chlorine components) related to THMs with other study variables in the analytical model. Therefore, in this analysis we still found a strong association with THMs as a dependent variable and predictor variables such as chlorine components. Confounding and interaction, although they are different concepts, both were involved in the assessment of an association between two or more variables so that additional variables that may affect this association could be found. For this purpose, finally, in manipulation of this model, we also tested for any confounding and interaction by another covariate and no change was found in association of THMs and chlorine compounds ($P<0.0001$).

Since the source of drinking and swimming pool waters in Fars province is almost the same, the formation and augmentation of trihalomethanes above the national standard limit (200µg/l) and international (WHO, EU, IARC) guidelines (80µg/l) as well as other contaminants may pose a threat to public health.

Consequently, the study hypothesis and study findings demonstrated that there is excess THMs association with chlorine components in Fars public swimming pools compared with the Iranian Standard in public consuming water and worldwide standards (WHO, USEPA, EU, IARC). They are 1.2-times (241.2µg/l vs. 200.0µg/l) higher than the national and 3-folds (241.2µg/l vs. 80.0µg/l) higher than the worldwide standards for maximum contaminate level (MCL).

Based on the above discussions in the present research, officials recommended a study of the novel technique of Nano-filtration besides deploying conventional methods for removal of volatile organic compounds in the consumable waters.[23-33] They also recommend to lower the dominant application of chlorine for disinfection of swimming pool waters, and instead, to use ozone gas (O3) as the main powerful disinfectant to reduce THMs formation.[24,32] Chlorine can be added as the supplementary disinfectant as much as 0.5 ppm per liter. Although ozone also leads to generation of its own by-products but the amount of these products is negligible compared to that of chlorine.

To eliminate these harmful chemicals, it is recommended that rapid absorption method should be applied using "granular activated carbons", and due to their strong affinity to pH, higher pH values should be used for removal of halogenic chemicals formed in water.[33-38] Furthermore, for evaluating the total value of trihalomethanes in different sections, Fujiwara reaction method or *Pyridine* reaction method should be used to measure the resulting color by Spectrophotometer in 550-Nanometer.[39,40]

Through recommendations of the present study, the needed measures are expected to be seriously taken for elimination of hazardous trihalomethane compounds in consumable waters after production and before entry into water supply system distribution and consumption centers.

Consequently, residual chlorine content of swimming pool waters should be continuously assessed by the swimming pool officials, health and environmental health inspectors with the seasonal conditions. Also, extensive scientific research are needed to be done concerning disinfectant by-products (DBPs) in swimming pools by the water and wastewater companies as well as national health, medical schools, and environmental health experts.

Limitations of the Study

Convenience sampling makes it possible to study factors associated with trihalomethanes, but limits the generalizability of the results since the sample may not be entirely representative of the all public swimming pools in Iran. In the present study, we did not have access to information about the seasonal temperature for possible impact on THMs levels in swimming pools water due to cost and study period. Also, due to the low number of outdoor swimming pools (12 %) in this study, statistical analysis was not conducted to stratify and compare them to indoor ones related to THMs concentration after water chlorination. This study focused on public swimming pools, lacking information of private ones due to difficulty to access this information. Another limitation is the strategy used for sample selection in different seasons. These potential source of limitations should be considered when analyzing the association between THMs formation and variables related to chlorine compounds regarding the amount of disinfectant, effectiveness of type of disinfectant, not measurable unknown natural factors related to THMs formation prior to chlorination process and different conditions compared with others.

Strengths of the Study

Several strengths of our study are worth mentioning. To the best of our knowledge, this study is the first of its kind in Fars province. In comparing validity and reliability of the data in this study with previous ones, the finding of this study is more precise, valid and reliable due to application of diverse advanced laboratory experiment and statistical outcomes by manipulating appropriate method of sample and data collection. Slow and gent method of collection, extraction, preservation and retaining constant quantitative and qualitative conditions of water samples in Teflon-lidded glass bottles is among the important strength features of the current study. Moreover, due to extremely high volatility and instability of trihalomethane compounds, the results of the samples were immediately analyzed on the same day of sampling based on the temporal standard for checking the accuracy of tests.

Moreover, our findings indicated high level of THMs in Fars swimming pools, in comparison with maximum contaminate level guidelines, 1.2-times higher than Iranian national standard and 3-folds higher than international standard; exposure of long term of this halogenic substances may be potential hazardous.

The above mentioned exposure may results in adverse health consequences such as cancer and genetic mutation in Fars province population and others. In addition, the findings point to the need for further research focusing on benefits in enhancing Fars people living conditions. In particular, we hope our study will stimulate research into consumption waters (drinking and swimming pool), since this is an essential aspect of wellbeing in Fars or even Iranian communities.

Conclusions and Future Implications

Our data clearly demonstrated a mutual association between trihalomethanes concentration and chlorine compounds after consumable water chlorination (Fars swimming pools). In addition, early recognition, control and prevention of the formation and augmentation of trihalomethanes may be beneficial for public. Although further prospective research are needed to investigate this possibility, it may be effective to investigate and eliminate these potentially hazardous, carcinogenic substances by public health experts in consumable waters after production and before entry into water supply system distribution and consumption centers which merits continued attention.

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Conflict of Interest: None declared

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