Evaluation of Microbiological Water Quality and Coastal Waters Quality Index of Persian Gulf in Bandar Abbas Coastal City, Iran

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ABSTRACT
The goals of this study were to assess the microbiological quality and coastal water quality index (CWQI) in the Persian Gulf alongshore of Bandar Abbas city. Water samples were collected from five different coastal sites in spring and summer seasons. To assess the microbiological quality: *Total Coliforms, Fecal Coliforms, Fecal Streptococci* and *Clostridium perfringens* were measured. Also, eight physicochemical parameters (DO, BOD, TSS, Turbidity, Temperature, pH, Nitrate, Phosphate) were examined for calculating the CWQI.
The mean for microbiological indicators was respectively, 3667, 1055, 50, 211 MPN/100ml. for physicochemical parameters, the average of water temperature was 32 °C, electrical conductivity was 57mmho/cm, the turbidity was 70.7 NTU, pH 8.1, and also the average concentration of phosphate, nitrate, nitrite, and ammonium was 180, 18.2, 4.9, 12.16µmol/L, and the mean of concentration BOD, COD and DO were 4.89, 11 and 6.8mg/L, respectively. In addition, the water quality index for all months and at selected stations was 65.
The results showed that in the most samples the levels of microbiological indicators were exceeded the national standard and guideline values. Also, the computed CWQI showed that quality of water was weak. All the extracted results are closely related to the inlets connected to the sea. These inlets except the Ghadir station will affect the rest of the stations. In general, in low tide, the Bactria index was more than high tide.

Keywords: Microbiological Quality, Water Quality Index, Coastal Waters, Persian Gulf

INTRODUCTION
Environmental pollution is one of the most important problems that these days mankind is facing which has caused serious challenges [1]. This's especially important about of contamination in aquatic environments that easily publish [2]. Today we are witnessing a change in the balance of the quality of water through the discharge of wastewater to the sea. Therefore, the impact of health risks that water users are facing is increasing [3]. The rapid increase in urban population and the development of residential and industrial centres on the margins of the sea and the discharge of sewage and human and chemical waste to them has caused the pollution of coastal waters in recent years. The microbial and physicochemical factors that enter the sea directly or indirectly through untreated urban and industrial sewage can endanger the health of swimmers [4]. Since coastal waters are susceptible to microbial contamination with urban surface runoff or other discharges, they can be used as a means of transmitting microbial pathogenic agents [5]. Each year, about 120 million cases of gastrointestinal disease and 50 million cases of respiratory illnesses are estimated in swimmers exposed to coastal waters contaminated with sewage [6]. Many types of opportunistic and pathogenic microorganisms can enter these natural resources directly from urban sewage systems or indirectly through the body of swimmers due to illness or non-compliance with sanitary rules before swimming, causing skin, gastrointestinal and respiratory diseases [7,8]. Around the world human faecal contamination is the main source of human diseases, as a result, various bacterial indicators have been used to identify faecal contamination in aquatic systems. In between, *Escherichia coli* and *enteric enterococci* have long been used to monitor the faecal contamination [9]. *Clostridium perfringens* is also a complementary index for faecal contamination [10]. These bacteria are more resistant to physical and chemical factors than *coliforms* and *streptococci*, and their spores remain in water for a long time [11].
However, World Health Organization has identified *enterococcus* as a bacteriological indicator for coastal and recreational swimming places on the beaches [12]. These indicator bacteria that are normally found in

sewage or other faecal contamination sources are associated with gastroenteritis in recreational waters [13]. Researches shows that there is a risk of gastrointestinal disease by swimming in seawater containing 10 *Enterococcus* per 100ml. For this reason, microbial monitoring and test of coastal waters and carrying out bacteriological experiments throughout the year or during use of coastal swimming places, analyzing the results and adjusting them to the standards and permissible limits regarding the use of the various bathing is of prime importance [2]. In order to sustainable management of resources, it is necessary to develop the most important issues related to coastal water pollution, identification and corrective strategies. To this end, the water quality index for coastal waters assessment is calculated in this study, which will be useful for the coastal ecosystem. This index provides a simple and concise way to express water quality for a variety of uses such as recreation, swimming, drinking, etc. [14-16].

United Nations studies have shown that, despite the increase in human facilities, the main activities of coastal tourism are still nature-based. Therefore, it is very important to pay attention to the health of tourists and swimmers in the areas where microbial contamination is in a critical condition [17]. Regarding the importance of coastal water quality assessment to secure the health of swimmers, permanent monitoring of recreational waters is essential. Since the Persian Gulf coast in Bandar Abbas is one of the most important hotspots of coastal tourist attraction in Iran, this study investigates the quality of the waters of these beaches in terms of microbial and physicochemical aspects.

MATERIALS AND METHODS

Study area

The Persian Gulf is a semi-closed marine ecosystem in southern Iran, located between 30° and 24´ north latitude, and 50° and 48' east longitude. Persian Gulf area is 251300 square kilometres and is the third-largest gulf in the world after the Gulf of Mexico and the Hudson Bay in Canada. Bandar Abbas is one of the most important ports in Persian Gulf, in Iran [18]. Bandar Abbas, with an area of 72316 square kilometres, has a very hot and humid climate due to its specific climatic and geographical conditions [19]. Economic and commercial activities in Bandar Abbas have exacerbated the pollution burden and destroyed the sensitive ecosystem of the coastal waters of the region. Part of the economic growth is related to tourism and recreation on the coast of the city. The samples were carried out at the Kapeshkan (K), Plaj (P), Ata (A), Shilat (Sh) and Ghadir (Gh) Beaches (Fig.1). The length of the coastline where the samples were collected is approximately 10 kilometres.

Sample Collection

According to the WHO guidelines, the sampling frequency for coastal and recreational swimming places based on the index of *enterococci* for swimming seasons is 5 samples per season and for non-swimming seasons 3 samples per season. In this study, 2 samples were collected per month. Samples were randomly chosen in spring and summer for 5 months according to the standard method from coastal waters of Bandar Abbas and kept at a temperature of 4 °C in the cold box until reaching the laboratory. The samples were taken at 9:00 PM. In order to conduct physicochemical experiments, a sample was tested at the end of each month. In total, 75 samples were tested.

Microbiological analysis

In this study, *total coliforms, faecal coliforms, faecal Streptococcus, Clostridium perfringens* and *heterotrophic bacteria* were measured based on standard methods. *Total coliforms* bacteria and *faecal coliforms* were carried out (APHA No. 9221B) [20], using Lauryl Tryptose Sulfate Broth medium at presumptive stage and incubation for 24 to 48 hours at a temperature of 35°C, in confirmed phase used from Brilliant Green Bile Broth culture medium for total coliforms and incubation for 24 hours at 35°C, and for *faecal coliforms*, EC Broth medium and placing it in a water bath at 44.5$^{\circ C}$ for 24 hours. Turbidity and gas generation is a sign of a positive test at this stage. Ultimately, complete the *coliforms* determination, done by EMB Agar medium for both bacteria. Colonies with metal polish represent *Escherichia coli* and pink colonies are the symbol of *Klebsiella*. *Faecal Streptococci* were measured by enrichment in a liquid medium (ISIRI; No. 3619) [21]. At presumptive stage, Glucose Azide medium used and incubated culture medium for 48 hours at a temperature of 35°C and then confirmed stage, Esculin Azide Agar culture medium were used and then incubation at 44°C for 48 hours. Blackish brown colonies that spread across the plate represent streptococcus. Catalase test was conducted at the complementary stage using H_2O_2. The presence of oxygen gas indicates that the presence of *Streptococcus* is negative. Measurement of *Clostridium perfringens* was done using aerobic method and dry milk culture medium with litmus [22]. The water sample should be warmed up to15 minutes at 100$^{\circ C}$ before being transferred to the culture medium to eliminate the vegetative form of the bacteria. Incubation was carried out at 35$^{\circ C}$ for 3-5 days. The most obvious sign that the test is positive is to create a whirlwind mode in the test tube. Pour plate method and R_2A Agar culture medium were measured to count the *HPC bacteria* (APHA; No. 9215B) [20]. The incubation was carried out at a temperature of 35$^{\circ C}$ for 48 hours. In this study, appropriate dilution was employed for samples since it was impossible to count the colonies.

Physical-chemical parameters analysis

Parameters considered as physicochemical for measurement are electrical conductivity, turbidity, temperature, nitrate, nitrite, ammonium ion, phosphate, TDS, TS, pH, COD, BOD, and DO. Temperature was measured by a thermometer and a portable device (HACH: USA) was used to measure pH, EC, DO and TDS parameters. Measurement of temperature, DO and pH parameters was conducted at the sampling site. Turbidity was measured by turbidimeter (WAGTECH). Measurements of phosphate, nitrate, nitrite and ammonium were carried out according to MOOPAM standard [23].

Phosphate measurement

According to MOOPAM standard (III.2.8.A), to each of the portions add 1.5 ml of acid-molybdate solution and afterwards, 1.5 ml of the ascorbic acid solution is added only to the 50ml of sample. After 10 minutes, samples containing phosphate become blue. Using a spectrophotometer with a wavelength of 882nm, we measure the absorbance of the samples.

Nitrite Measurement

According to MOOPAM standard (III.2.8.C), 1ml Sulfanilamide reagent and then 1ml diamine added to 50ml of the sample. We allow it, at least 20 to 30 minutes to release Azo pink colour. Then, we measure the absorbance of the samples using a spectrophotometer and a wavelength of 540 nm.

Nitrate Measurement

According to MOOPAM standard (III.2.8.D), Nitrate in seawater is measured using a cadmium column (cadmium clad with copper). In this column, nitrate is reduced to nitrite. For the reduction, optimal pH is 8.5. We mix 25ml of the sample with 25 ml of Ammonium chloride-ammonium buffer solution and pass it through cadmium column. Then, we add 0.5ml of Sulfanilamide and 0.5ml of diamine to the sample. Pink colour is the sign of the presence of Nitrate. We wait for an hour and then read absorbance rate of the sample using a spectrophotometer and a wavelength of 540 nm. The important point in this test is that this method determines the total amount of nitrite and nitrate, so a separate nitrite test should be conducted. Nitrite absorption should be reduced from nitrate.

Ammonium Measurement

According to MOOPAM standard (III.2.8.B), 2 ml Phenol reagent, 1ml buffer solution and 2 ml hypochlorite reagent added to 50 ml of the sample. After mixing, closed the reaction bottles and keep it at room temperature for at least 6 hours in a dark place. Then, we measure the absorbance of the samples using a spectrophotometer and 630nm wavelength.

COD Measurement

COD was measured by standard method (No. 5220C) [21]. Because seawater salinity interferes with the COD measurement, Mercury sulfate was used to eliminate the existing chlorine in the sample. Based on the Standard Method., we can use 1g of mercury sulfate for 50ml of sample to remove chlorine to 2 grams per litre. Since the chlorine of the Persian Gulf on the coast of Bandar Abbas is approximately 40 g/l, we should increase the amount of mercury sulfate to 1.5g for2.5 ml of sample according to the studies conducted by [24].

BOD Measurement

Based on Method Standard (No. 5210B), a glassware with capacity of 300 ml is used to measure BOD [20]. In this study, a dilution method has been used to measure the amount of oxygen needed for biological purposes. Diluted water was prepared to dilute the samples. In this research, seed (wastewater emitted from the initial Sedimentation unit of the urban wastewater treatment plant) was used to help the growth of decomposing microorganisms of organic matter in the sample [20]. To provide the control, distilled water mixed with sodium chloride (38g/l) to respond the salinity of the sea was used [25]. All additives are also used in the control group.

Water Quality Index (WQI)

Nine parameters (nitrate, temperature, Fecal coliforms, phosphate, turbidity, BOD, DO, TSS, pH) were used to determine the water quality index. The sub-index quality variables are used to describe water quality. A method to calculate quality index is math or arithmetic method. Calculation of this index was carried out according to Brown Weight Index in such a way that after obtaining the results of the test, it is registered in the Index Table of Water Quality; and then, using the corresponding tables, we calculate the quality level of each parameter (qi), and multiply this value in the weighting factor (it shows the importance of each test for water quality) (Table.1). The numbers of all the parameters are summed together and the overall quality of the water is determined. The WQI for water quality is in the range of 0 to 100. The obtained result is compared with the relevant scale in the water quality index table and determine the water quality level (Table.2) [26- 28].

The calculation of water quality index by mathematical method is carried out based on the following formula:

$$WQI_A = \sum_{i=1}^{n} w_i q_i$$

Another method used to calculate the water quality index in this study is the multi-dimensional or multiplication method proposed in 1974, particularly, for recreational waters. This estimation method has been presented by NSF. The multiplied water quality index is calculated by formula [26]:

$$WQI_M = \prod_{i=1}^{n} q_i^{w_i}$$

Table 1: Weights for nine water quality variables [26,27]

parameter	Weighing factor (w_i)
Dissolved oxygen (mg/l)	0.17
Fecal coliform (MPN/100ml)	0.15
pH	0.12
BOD (mg/l)	0.11
Temperature (℃)	0.1
Nitrate (µmol)	0.1
Phosphate (mg/l)	0.1
Turbidity (NTU)	0.08
TSS (mg/l)	0.07

Table 2: Descriptor categories for Coastal water quality index

Category	CWQI
Very bad	0-25
Bad	26-50
Medium	51-70
good	71-90
Excellent	91-100

Statistical Analysis

Data analysis was done by SPSS software. To compare the microbial contamination of selected indices, one-way ANOVA, between different sampling sites. Also, Pearson correlation test was used to determine the correlation between variables.

RESULTS AND DISCUSSION

Microbial analysis results

The present study is a microbiological analysis of 50 samples. Table. 3 shows the mean and standard deviation, as well as the incidence of indicator bacteria in terms of MPN/100ml at different sampling sites.

Table 3.: Mean ±standard deviation and range of index bacteria for the different sampling sites (all values in MPN/100ml).

Beach	*Total coliform*		*F. coliform*		*F. Streptococci*		*C. perfringens*	
	range	**M±SD**	**range**	**M±SD**	**range**	**M±SD**	**range**	**M±SD**
Plaj (p)	460-11000	3870±1730	150-1100	863±795	3-92	29±22	11-460	239±202
Shilat (Sh)	92-4600	1909±1790	21-1100	370±286	0-48	19.2±5.9	28-460	98±50
Kapshkan (K)	1100-11000	6385±3050	150-11000	3064±2380	3-460	162±153	48-460	260±142
Ghadir (Gh)	48-1100	462±452	15-1100	178±168	0-75	15±13.7	0-460	186±163
Ata (A)	48-11000	5710±4962	9-2100	802±526	0-75	25-17	48-1100	276±172

The results of the microbial water tests at the studied stations showed that the GH station is the only station that is in good condition in terms of the total coliform. In the case of *faecal coliform*, none of the stations are within the standard range and are contaminated. On the other hand, all of these stations, except the K station, are in very good condition in terms of *faecal Streptococci*. Also, the results of microbial tests at the studied stations in relation to the *Clostridium perfringens* bacteria show that all stations are too infected with this bacterium.

A comparison of the indicator bacteria in the studied stations has been carried out with existing standards (Fig. 2). It's seen that the *total coliforms* in all stations, except Ghadir, was higher than the WHO and EEC standard. The maximum *total coliforms* value at the Kapeshkan Station was 6385 and the lowest in Ghadir was 460/100ml. *Faecal coliforms* is higher than standard in all stations. The highest and lowest rate of *faecal coliforms*, respectively; is for Kapeshkan and Ghadir stations, 3065 and 178/100ml. The highest rate of *streptococcus* found in the Kapeshkan station was 162, and the lowest rate for the Ghadir station was 15/100ml. In relation to *Clostridium perfringens*, the Hawaiian state guidelines have been used. The highest and lowest bacteria counted were Ata and Shilat Station with 276 and 98/100ml (Fig. 2).

All the extracted results are closely related to the inlets connected to the sea. These inlets except the Gh station will affect the rest of the stations. The K and Sh station are under the influence of the westernmost inlet of the city. Raw urban sewage (3000m^3/day), from a nearby residential town, enters the inlet and pours into the sea. Additionally, the surface runoff of residential buildings adjacent to the sea at the K station also causes high pollution loads on this site. Also, because residents of this area are often engaged in fishing, after the catch; sale and cleaning of fishes do on the beach, and in most cases, the waste is released on the beach, which causes the presence of stray dogs there has been. All of these factors have led to the most contaminated station's parrot station in terms of microbial indicators so that during the 5 months of sampling and among the different stations, the highest values of the measured indicators were related to the K Station. The Sh and A station are also affected by the city's largest inlet, which Imports the effluent of wastewater treatment plant to sea. The lack of proper functioning of the wastewater treatment plant causes the high pollution rate to enter the sea. The Gh station is far from the sewage outlets. According to the results of microbial tests, Gh station is less polluted than other studied sites and seems proper for water recreations. Of course; when the number of swimmers and users of coastal waters increases, consequently; microbial contamination also increases. Water depths on the beach of Gh are lower than those of other sampling stations, that's why used more often for children, that in the event of water contamination, it's a threat to this group. According to the Environmental Protection Agency of Bandar Abbas, sewage treatment plant in Bandar Abbas had poor performance in summer. Most of the sewage went into the sea without treatment, that's one of the main reasons for the high rate of pollution at A station.

Statistical Analysis

ANOVA test showed that there was a significant difference between the microbial indices at the selected sampling stations. This difference was significant for the three indices of *total coliforms* (P-value = 0.002), *fecal coliforms* (P-value = 0.005) and *fecal Streptococcus* (P-value=0.003), and not significant for *Clostridium perfringens* bacteria (P-value=0.23).

Pearson test also showed a significant relationship between *fecal coliforms* and *fecal Streptococcus* (r = 0.89, P ≤ 0.001), as well as between *total coliforms* and *clostridium* (r = 0.48, P = 0.01).

Physicochemical analysis results

25 samples were analyzed for physicochemical analysis. Table.4 shows overall results of conducted analysis during 5 months of sampling. We could see that during spring 2017 the coastal water, varies from 29℃ in April to 35.5℃ in August. Meanwhile dissolved oxygen, among the studied stations, was between 6.05 and 7.36mg/l. maximum biochemical oxygen demand (BOD) is 8.1mg/l and minimum expected is 2.25mg/l. the highest COD measured was 20 and the lowest one is 4.8mg/l. The relationship between TDS and EC in the coastal waters of Bandar Abbas is TDS = 0.77 EC.

Table 4: Statistics description of various parameters for different stations.

Statistics	Temperature (°C)	pH	DO mg/l	EC $\frac{mmho}{cm}$	PO_4 µg/l	NO_2 µg/l	NH_4 µg/l	NO_3 µg/l	Turbidity (NTU)	TDS g/l	BOD mg/l	COD mg/l
N. Sample	25	25	25	25	25	25	25	25	25	25	25	25
Mean	32	8.1	6.8	57	180	4.9	12.16	18.2	70.7	43.4	4.89	11
S. D	±1.56	±0.11	±0.42	±1.09	±123	±3.1	±9.6	±20	±40.3	±0.82	±1.77	±3.4
Minimum	29	7.8	6.05	55.4	29	1	3	3	172	42	2.2	5
Maximum	34.5	8.3	7.3	58.6	431	13	33	83	18	44.9	8	20

Statistical Analysis

Pearson test results show a relationship between physical parameters is as follows: There is a significant and reverse relationship between dissolved oxygen and TDS (r = -0.415, P ≤ 0.05), the relationship between variables of turbidity and water temperature, significant but reverse (r = -0.63; p = 0.001), also we observed a significant relationship between dissolved solids and water temperature (r = 0.469, p = 0.018).

Also we found a meaningful correlation between microbial indices and physicochemical parameters such as: total coliforms and temperature, (r = -0.54, p = 0.005), between clostridium and BOD (r = 0.62, p = 0.001) and between total coliforms and BOD (r = 0.69, p ≤ 0.001).

Coastal Waters Quality Index results

Water quality index is calculated by important physicochemical parameters. Table.5 shows the results of Coastal waters quality index calculated by arithmetic and multiplicative Methods. The water quality index (by Arithmetic Method) was satisfactory at all stations except Kapeshkan; while the calculated value by multiplicative method refers to medium water quality at all stations, except at Ghadir station. On one hand, the higher numbers at the Arithmetic Method might be considered as a cover for the actual quality of water and, on the other hand, the low numbers obtained by multiplicative method might be considered to exaggerate the water quality. Nevertheless, according to our findings [14], multiplicative quality index is preferred over the Arithmetic method for coastal waters, therefore, we proceed with the multiplicative method as the basis for determining water quality.

Table 5: Comparison of Tow water quality indices in different stations

Station	WQI_A	Quality of water	WQI_M	Quality of water
P	71	Good	65	Medium
SH	72	Good	67	Medium
K	69	Medium	60	Medium
GH	75	Good	71	Good
A	71	Good	63	Medium

Table.5 presents the highest quality index to be 71, at Ghadir station and has good water quality while the lowest quality index is related to Kapeshkan station that is 60 and shows medium quality water at this station.

Nowadays, the *Enterococcus* group is monitored as an index for faecal contamination in recreational seawaters, [12]. Compared to *enterococci*, *Clostridium perfringens* are more resistant to environmental factors such as sunlight and high temperatures [29]. And this bacterium is a suitable index for tropical waters of the Persian Gulf like warm shores of Bandar Abbas; it is primarily used to evaluate the quality of the Persian Gulf recreational waters in Iran. According to the guidelines of the World Health Organization (WHO) and the European Economic Commission (EEC) concerning microbial quality of seawater for swimming, the total number of *faecal coliforms* and *faecal Streptococcus* is 100/100ml. In relation to *Clostridium perfringens* bacteria, no guidelines have been issued for standards. In a survey conducted by Erin K Lipp in Florida in 2001, according to a study done in Hawaii in 1985, the *Clostridium perfringens* bacteria limit is considered to be 50 CFU/100ml [30]. Also, the study by the Curiel-Ayala in Mexico in 2012 that uses the *Clostridium perfringens* bacteria has been used in the Hawaiian State Standard (2000) to compare with the results. The proposed amount for these bacteria in Hawaii is 5 CFU/100 ml [6].

We find that of the 50 water samples analyzed in the present study, the contamination rate is above permissible limit for *faecal coliforms* and *streptococci* samples, which were respectively, 36 (72%) and 5 samples (10%). To observe *Clostridium perfringens* index, Hawaiian State has proposed (≤5 CFU/100ml). While our test results are based on MPN Units. The precision of the CFU unit is higher than that of MPN, technically it is not much different than MPN, and therefore we can apply this guideline without concern. Hence, according to the Hawaiian State guideline, 46 samples (92%) are above limit. In the months of June and August when most of the sampling was carried out in high tide, the lowest number of microbial indices was counted and in April, due to low tide, the highest level of contamination at all stations was measured. The relationship between seawater tide and the level of microbial indices have been proven by various studies. Solo Gabriele and *et al.* 2010 in Florida, has also reported the highest levels of microbial activity at the time of the low tide [31]. In April, following an increase trips and subsequently increase number of swimmers and the use of recreational waters, the highest level of contamination was measured this month. This analysis is similar to the study conducted in 2007 by Sunderland *et al.* in the United States [7]. The high level of indices in April and its low level in August can be associated with water temperature and the amount of sun rays killing microbial factors. Also, the presence of a large number of fishing boats and at further distances, cargo ships around sampling stations has caused oil and lubricant waste to enter the water and create turbidity that reduces the penetration of sunlight in water and prevents its effect on pollutants. Because the sun's rays play a crucial role in the destruction of pathogenic bacteria. In the study conducted by Lado Kranjcevic and *et al*. 2017 in Croatia, the highest concentration of faecal indices was recorded in the early morning due to lack of sunlight [32]. Also, the results of the research carried out by Mattioli and *et al*. 2017 in the United States confirm that sunlight causes the breakdown of microbial indices such as *Enterococcus* and *E. coli* [33]. In the research conducted by Sukumaran and *et al*. 2016 three indices of *E. coli*, *faecal Streptococci* and *heterotroph* were used to evaluate the microbial contamination of Andaman coastal waters in India. The results indicate an increase in faecal bacteria in the beaches where human activities are done there [34], which is consistent with the results of the research conducted on the beach of Kapeshkan. The study carried out by Sakellari and *et al*. 2015 in Greece emphasized that the highest amount of *Enterococcus* and *Escherichia coli* measured on the coast were at the junction of the inlet with sea [35], that this inlet contained treated sewage from the treatment plant which is inconsistent the present study. The study of Curiel-Ayala *et al.* in 2012 on the coast of Mexico showed that 44.4 percent of the studied water had an over-standard *enterococcus* compared to the Persian Gulf waters on the coast of Bandar Abbas, the contamination of the bacteria on the coast of Mexico has been much higher [6]. In a study by Henglin in the Hawaiian coast in 2013, on the *enterococcus* surface in the water and sandy seas, the results showed high levels of *enterococci* as a faecal index in coastal sand [36]. This issue is related to the present study. In July, due to the high wind speed, the sea was heavily wavy, causing mixing and floating sand in the water. The results of this study indicated a high level of *faecal Streptococcus* in July and on sandy beaches of Bandar Abbas (Kapeshkan, Ghadir and Shilat beach).

In relation with water quality index, among several indices, Brown's weighted index is employed to determine the quality of the waters of the Persian Gulf in Bandar Abbas. To determine the quality of the waters of the Persian Gulf in Bandar Abbas. This index is calculated by arithmetic and multiplicative methods. The advantage of using Brown's index is that it is a general index and ignores the type of water used and therefore can be used for different types of water [37]. In the study, Muthulakshmi and *et al*. 2013 conducted a research to evaluate Indian Coastal Water Quality Index. This study consists of 8 parameters (dissolved oxygen, pH, BOD, temperature, suspended particles, turbidity, nitrate and phosphate) to calculate quality index [26]. In this research, the best method for calculating water quality index is arithmetic method. According to study by Ashok Lumb and *et al*. 2011 arithmetic method, despite its simplicity, does not enjoy the necessary sensitivity, and the most appropriate method for calculating the water quality index has been introduced the multiplicative method [14].

CONCLUSION

In general, based on the findings of the microbiological tests of research, and the comparison of the mean of the *total coliforms*, *E-coli*, *HPC bacteria* and *faecal streptococci*, as well as the *Clostridium perfringens* bacteria with existing standards, it can be concluded that the microbial indices of the coastal waters of Persian Gulf in Bandar Abbas at all stations under study, except Ghadir Beach, is above the permissible limit. Of course, it should be noted that the main bacterial index in recreational water is *faecal streptococci*, which this Bactria in all of the studied swimming places was standard and only at the Kapeshkan station in the two months of July and August was above the limit. However, cannot to ignore the contamination caused by *total coliforms*, *E. coli* and *heterotroph bacterias*. Also, the presence of *Clostridium perfringens* bacteria in coastal waters of Bandar Abbas, which has been proposed in numerous studies as a complementary index for faecal contamination, also; shows the contamination of these recreational waters.

By summing up the results of physicochemical tests in the form of a water quality index, it can be said that the quality of coastal waters of Bandar Abbas is in the Medium range.

ETHICAL ISSUES

Ethical issues have been observed by the authors.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests.

AUTHORS' CONTRIBUTION

All authors equally help to write this manuscript.

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