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Research Article

Survey of microbial quality of drinking water in residential places (Motels) of Babolsar coastal zone

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ABSTRACT

Safety drinking water providing is one of the main purposes for community development and improvement. Having a healthy community is related to the safe drinking water. In this study, we surveyed the microbial quality of 50 residential places (motel) located in the coastal zone of Babolsar city. In total, 50 samples were collected from 50 wells .We examined the Total Coliforms ,Ecoli , pH , Turbidity and Free residual chlorine in laboratory of the health network. Most Probable Number (MPN) was done on nine tube cultivation basis and also turbidity test using HACH turbidimeter. Results show that free residual chlorine content in all wells was zero because of failure to install disinfection facilities and the Total Coliforms,HPC, Turbidity,E.coli, pH, 2%,94%,18%,16%,%100, of drinking water samples were desirable levels respectively .Based on the results obtained from laboratory all wells had microbial contamination. In order to provide safe water, it is recommended that the city water supply network is installed by the water and Wastewater Company and the branches are assigned to the motels and additional disinfection facilities should be installed by motel owners.

1. Introduction

Safety and quality of drinking water are always an important public health concern (Abia et al., 2016). The raw water quality can be affected by human or animal activity either within that body of water or within its watershed (Vaziri et al., 2010; verijkazemi, 2019; Bekele and Teka, 2023; Verijkazemi and Jalilzadeh, 2022). According to a report on world development indicators by World Bank, 1.1 billion people globally lack access to potable water with 2.5 billion people have inadequate sanitation facilities. Annually, 4 billion cases of water-related diseases cause 3.4 million deaths worldwide, which is a leading cause of deaths especially in children under 5 years who die of water-related diseases. The situation is much worse in the rural areas of many of the developing nations (World Bank, 2015). According to a report by World Health Organization (WHO) on drinking water in the year 2017, 159 million people depend on water from surface sources like rivers and 423 million take water from unprotected springs linked to transmission of water-related diseases (WHO, 2017). Consumption of such microbiologically unsafe water leads to water-related diseases like typhoid, diarrhea, dysentery, and paratyphoid (Futi et al., 2011; verijkazemi and Yengejeh, 2022). The most significant risks to people's health from drinking water come from microscopic organisms (Naseri et al., 2021; Sarowska et al., 2019) Fecal contamination of

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water is mainly assessed using fecal indicator bacteria such as Escherichia coli and enterococci (Joshua et al., 2020; Ghanavat Amani et al., 2021). Assessing water quality is crucial as it allows for investigations into the causes of pollution and averts likely waterborne diseases,by providing evidence on the risks of human exposure related to different water uses (Giradi et al., 2019) Poor sanitation and food sources are integral to enteric pathogen exposure Comprehensive evaluations of microbial quality of water require survey of all the pathogens that have potential for human infections (Gwimb, 2011). Currently, different microorganisms are being used as the primary indicator to assess water quality (Mugenda, 2003). World Health Organization (WHO) essential parameters of drinking water quality are fecal Escherichia *coli* and total coliforms, chlorine residual, turbidity, pH (Wen et al., 2020).These guidelines are essential determinants to reduce or eliminate the risk of water pollution (WHO, 2016).While the drinking water resources, contaminated with agricultural, industrial, and sewage waste are dangerous and less usable for human consumption and for agricultural purposes (Abera et al., 2018). To date, no studies have been focused on the microbial quality of drinking water in motels of Babolsar so the present study aimed to investigate the microbial quality of drinking water in residential places (Motels) of Babolsar coastal zone and determine the access of tourists to safe drinking water.

2. Materials and Methods

2.1. The study Area

The present study was conducted in Babolsar that is one of the most touristic cities in Mazandaran province. It is located on the southern coast of the Caspian Sea. Since the Babol river passes through the city, both the bank of the river and the beach of the sea form tourist attractions in the city Babolsar's population increased from about 3,500 in 1945 to 11,781 in 1966 and 18,810 in 1976. Babolsar has a humid subtropical climate with warm summers and cool winters. Rainfall may occur at any time of the year but is heaviest in autumn and winter. Babolsar Beach Boulevard, which is a few kilometers, has water branches that this coastal boulevard connect to the sea .It's also called parking. Each of these parking has a good space to sit by the sea and all the residential motels and suites are placed in parking spaces. Fig 1 show the sampling stations are located in Babolsar Beach Boulevard.

2.2. Sample collection

This cross-sectional study was conducted on 50 samples of drinking water in motels of Babolsar coastal zone to assess the microbial quality within the period of January to march 2017. All motels are situated in nine parkings**.** In this study, we investigated the quality of water from 80 percent motels. The number of the collected samples was determined based on the standard number 4208 of the Institute of Standards and Industrial Research of Iran (ISIRI). The samples were harvested in 100-milliliter sterile bottles with a smooth lid and containing sodium thiosulfate and transferred to the laboratory in hygienic conditions. Total Coliforms, fecal coliforms, turbidity, free residual chlorine, and pH were measured. The samples were measured based on water and sewage testing as mentioned in the book 'The Standard Method',and the free residual chlorine was measured using diethyl-p phenylenediamine pills and a digital colorimetric kit. In addition, pH was measured using Aquatic mark pH meter at the sampling site. To investigate the presence of total and fecal coliforms, the most probable number (MPN) test was applied in three phases of probabilistic, support, and supplementary with various objectives. In the probabilistic assay (phase one), the samples were cultured in lactose broth medium at the temperature of 37 °C for 48 h. Gas production in the samples was an indication of the positive probability of microbial contamination, and the positive samples were incubated immediately and directly on a culture medium (brilliant green lactose bile) at the temperature of 37 °C for 24-48 h. At the end of the cultivation period, gas production in the samples was an indication of the confirmed positive test.14 The Thomas's relationship was applied to calculate the probable number (100 mL) of the coliform and thermotolerant coliforms. In order to identify and count the fecal coliforms (*E.coli*), EC broth culture media were used, which were incubated at the temperature of 44.4 °C after inoculation for 24-48 h. The presence of gas after incubation in the EC broth was a positive marker of the test, confirming the presence of fecal coliforms. Following that, the MPN levels of fecal coliforms were calculated as well. Finally results microbial counts of the investigated water samples were compared with the standars (WHO guidelines for drinking water quality and Iran National Standards 1053 and 1011) (Verhille, 2013). Table 1 show frequency distribution of samples and sampling stations.

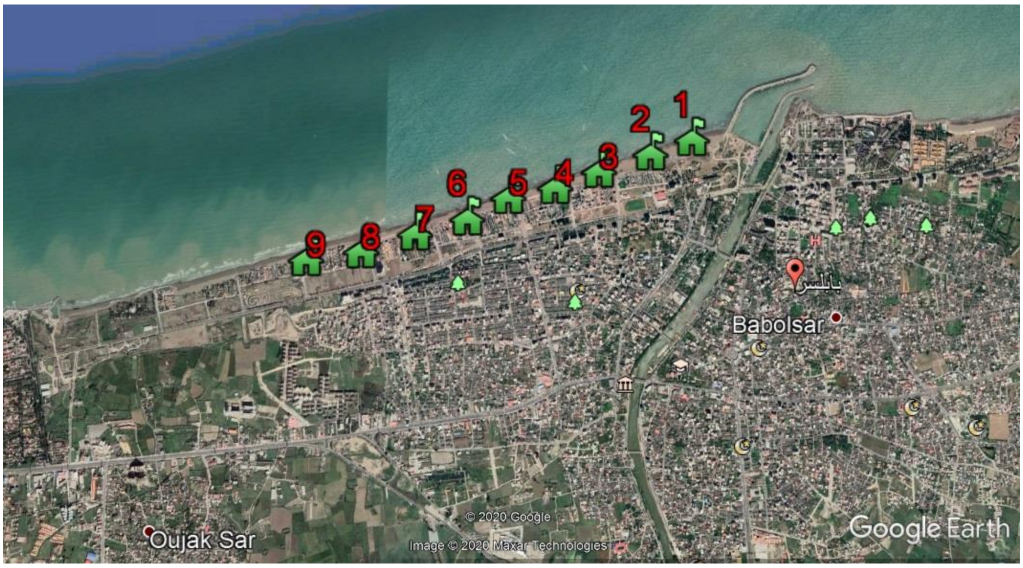

Figure 1. Babolsar Beach Boulevard and nine parkings of sampling stations

Table 1. Frequency distribution of samples and sampling locations

Sampling location	Number of wells	Frequency of wells (%)
The First parking	3	6
The second parking	9	18
The Third parking	8	18
The fourth parking	5	10
The fifth parking	10	20
The sixth parking	8	16
The seventh parking	6	12
The eighth parking	2	4
The ninth parking	1	2
Total	**50**	**100**

3. Results

The purpose of this study is surveying drinking water microbial quality of Babolsar motels and determination of amount accessibility level in these areas to safe drinking water. The results showed that the amount of free residual chlorine in all cases were in the range zero and the all water samples did not meet the WHO guidelines in terms of free residual chlorine, while pH was within the recommended limits of drinking water standards in Iran.Total Coliforms, HPC, turbidity, E.coli, in 2%, 94%, 18%, 16%, of drinking water samples in this report, were desirable levels respectively and 98%, 6%,82%,84%, o% of samples were undesirable levels. In addition, all samples were infected with fecal coliforms and total coliforms, respectively According to fig 3, the average content of Total Coliforms and E.coli of motels that are located in parking 3, 4 (56 and 35 MPN/100ml) and turbidity (3,5 NTU) were higher than other parkings. The mean of the Total Coliforms and *E. coli* counts at all parkings were more than the international permissible levels recommended by WHO and Iranian standards for drinking water (Table 3) (WHO, 2017). The comparison HPC values in wells showed the average of HPC concentration in motels that are located parking 8, 9 (295 MPN/100ml) was higher than other stations and in parking 9 was the lowest (85 MPN/100ml). Turbidity values in 94% of samples was higher than 5 NTU in the sampled stations. The desirable level less or equal to 1 NUT was recommended by WHO. Turbidity value up to 5 NUT will indicate inadequate efficiency of treatment plant and possibly correlate with increased total coliform bacteria (WHO, 2021) .In similar studies conducted by Amin et al and Hamida et al on bacteriological analysis of drinking water of Peshawar city, Pakistan, most samples were total coliform positive. It was less than national maximum Iran means values (91.42%) and according to WHO and permissible levels. This is somewhat more than national Iranian standards for drinking water, fecal bacteria mean value. The pH values in all of the samples were found within the recommended standards of WHO and Iran National Standards 1053 and 1011 (ranges from 6.5 to 8.5) for potable waters (Amin et al., 2012; Hamida et al., 2006). In this study is showed that only 16% of samples were found to be free of E.coli contamination, while the remaining 84% of samples were positive for contamination and unfit for drinking and 98% and 6% of samples had TC and HPC contamination respectively (fig 5).

Table 2. The qualitative control of motels water located in the coastal zone of the Babolsar city

Sample no.	**Sampling location**	**HPC (CFU/mL)**	**E. coli (MPN/100ml)**	**Total Coliform (MPN/100ml)**	**Turbidity (NTU)**	**Free residual chlorine (PPM)**	**pH**
1	Coastal blvd,Parking 8,9	295	16	35	0.61	0	7
2	Coastal blvd Parking 8,9	214	6	9	3.63	0	7
3	Coastal Blvd. Parking 9	85	11	14	2.22	0	7
4	Coastal blvd .Parking 7,8	275	21	93	1.62	0	7
5	Coastal Blvd. Parking 7,8	180	0	9	0.8	0	7
6	Coastal blvd Parking 7,8	480	11	15	1.24	0	7
7	Coastal blvd .Parking 7,8	25	3	9	0.8	0	7
8	Coastal blvd .Parking7,8	160	3	23	1	0	7
9	Coastal blvd .Parking 7,8	275	6	12	1.4	0	7
10	Coastal blvd. Parking 6,7	142	15	21	2.7	0	7.1
11	Coastal Blvd. Parking 6,7	163	16	26	6.52	0	7.2
12	Coastal blvd .Parking.6,7	151	21	29	1.54	0	6.9
13	Coastal blvd .Parking.6,7	136	14	34	2.6	0	7.3
14	Coastal blvd. Parking 6,7	244	20	27	1.73	0	7.1
15	Coastal blvd Parking. 6,7	221	34	43	3.25	0	7
16	Coastal blvd Parking. 6,7	301	42	93	1.44	0	7.4
17	Coastal blvd Parking.6,7	25	0	0	1	0	7
18	Coastal blvd. Parking 5,6	175	35	64	1.56	0	7
19	Coastal blvd .Parking.5,6	132	16	24	2.25	0	7.3
20	Coastal blvd Parking.5,6	400	27	53	1.44	0	7.2

Sample no.	Sampling location	HPC (CFU/mL)	E. coli (MPN/100ml)	Total Coliform (MPN/100ml)	Turbidity (NTU)	Free residual chlorine (PPM)	pH
21	Coastal blvd . Parking 5,6	125	11	23	1.22	0	7
22	Coastal blvd Parking.5,6	150	11	15	1.15	0	7.2
23	Coastal blvd. Parking 5,6	122	27	35	1.25	0	7
24	Coastal blvd .Parking.5	222	20	44	1.52	0	7.1
25	Coastal blvd. Parking 5	100	15	26	0.37	0	7
26	Coastal blvd .Parking 5	412	27	53	2.66	0	7
27	Coastal blvd . 5	250	9	27	1.56	0	7
28	Coastal blvd. Parking 5,6	670	0	4	1.56	0	7
29	Coastal blvd. Parking 4,5	480	0	24	1.09	0	7
30	Coastal blvd 4,5	145	21	44	1.81	0	7
31	Coastal blvd .Parking 4,5	100	39	53	3.27	0	7
32	Coastal blvd . Parking 3,4	600	24	35	3.16	0	6.9
33	Coastal blvd	250	42	75	2.2	0	7
34	Coastal blvd. Parking 3,4	200	35	95	3.02	0	7
35	Coastal blvd. Parking 3,4	260	42	53	4.91	0	7
36	Coastal blvd . Parking 3,4	252	44	64	3.61	0	7
37	Coastal blvd . Parking 3,4	184	20	36	1.81	0	7.1
38	Coastal blvd. Parking 3,4	480	35	75	7.31	0	7
39	Coastal blvd. Parking 3,4	84	0	14	2.68	0	7
40	Coastal blvd . Parking 2,3	181	13	20	1.6	0	7.2
41	Coastal blvd . Parking 2,3	122	9	15	5.1	0	7
42	Coastal blvd . Parking 3	311	26	36	0.8	0	7
43	Coastal blvd. Parking 3	251	16	44	3.53	0	7.2
44	Coastal blvd. Parking 2,3	235	14	29	5.79	0	7
45	Coastal blvd . Parking 2,3	350	11	29	1.65	0	7.1
46	Coastal blvd. Parking 2,3	34	0	9	2.51	0	7.1
47	Coastal blvd .Parking 2,3	14	0	10	1.47	0	7
48	Coastal blvd Parking. 2,3	144	0	21	0.49	0	7.2
49	Coastal blvd Parking. 2,3	400	35	64	0.47	0	7.3
50	Coastal blvd . Parking 2,3	25	3	9	1.4	0	7.2

Table 3. Descriptive statistics on parameters and their Comparison with Iran National Standards

Parameter	N	Minimum	Maximum	Mean	Std. Deviation	Iran National Standards (1053 and 1011)
Turbidity (NTU)	50	0.37	7.31	2.2064	1.54061	maximum allowable: 5 Desirable: ≤1
Total Coliform (MPN/100ml)	50	0.00	95	3428	23.89521	Desirable: 0
E. coli (MPN/100ml)	50	0.00	40	17.32	13.30097	Desirable: 0
HPC (CFU/ml)	50	14	600	221.8400	140.5918	Desirable:500
free residual chlorine CL (PPM)	50	0.00	0.00	0.00	0.0000	maximum allowable :0.5 Desirable: 0.2-0.8
pH	50	6.9	7.4	7.0620	0.11045	maximum allowable: 6.5-9 Desirable: 6.5-8.5

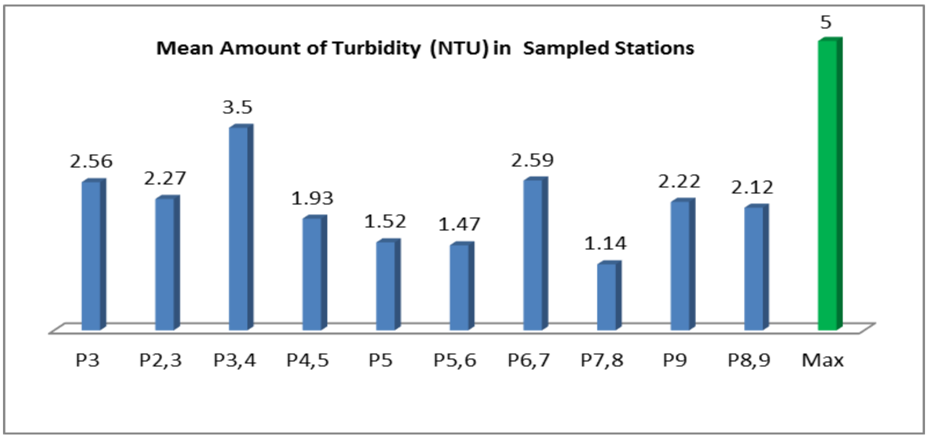

Figure2. Mean amount of Turbidity (NTU) in sampled stations

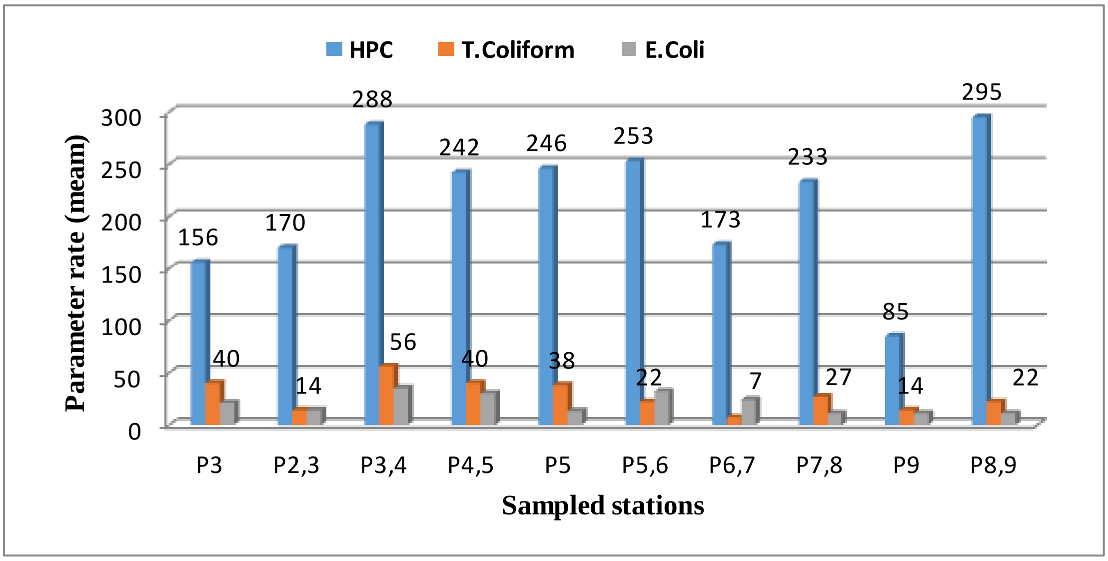

Figure 3. Mean of microbial parameter rates in sampled stations

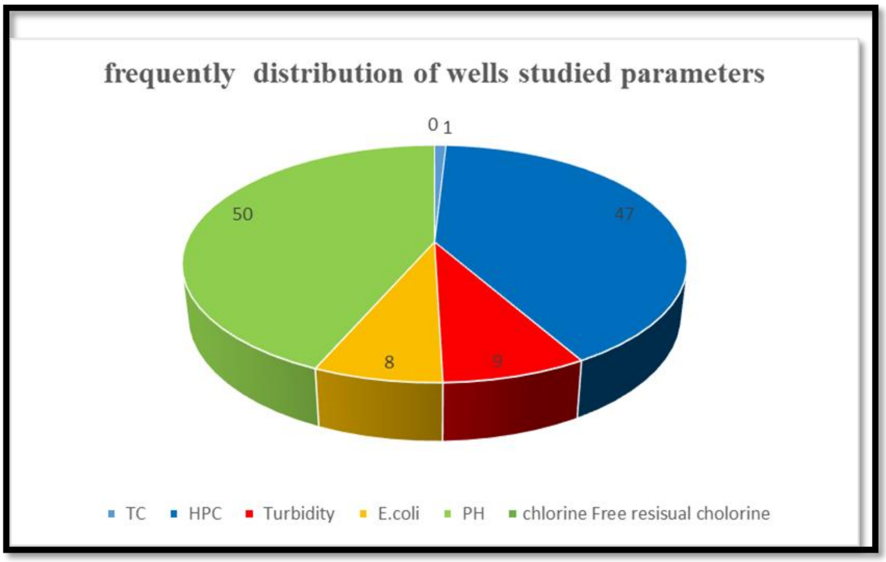

Figure 4. The frequency distribution of wells studied parameters

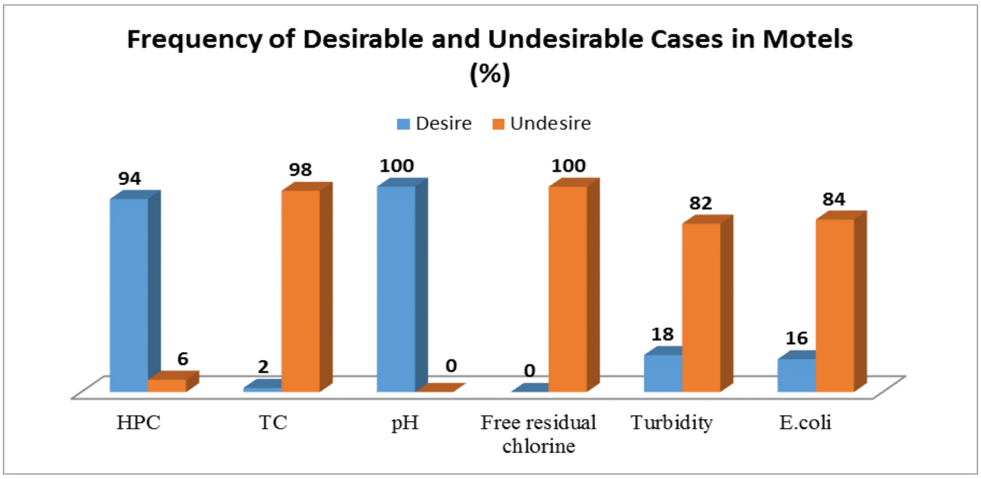

Figure 5. The percentage of the desirable and undesirable studied parameters in water of motels.

4. Discussion

The presence of bacteria is important in terms of controlling the processes of water refinery and analyzing the engineering methods associated with appropriate refinery and distribution of water, health, and aesthetic issues of water. In this study all microbial counts were exceeded the international allowable levels Data. The main reasons of well pollution of motels were Lack of proper sanitation of wells Influence of natural and artificial factors, transfer surface water to the wells, the Lack of proper disposal of human wastewater and water network breaking. Residual chlorine of drinking water in all wells were not in 0.2-0.8 mg/l because of lack of disinfection process and lock of water disinfection accessories such as UV and Liquid and gas chlorinator. According to the World Health Organization (WHO), the recommended limits of pH and free residual chlorine in drinking water are 6.5-8.5 and 0.2-1.5 mg/L, respectively (WHO, 2021). In total, the free residual chlorine in 100% of the samples was not within the allowed range by the WHO for drinking water, (Table 3). Moreover, if the free chlorine residual was within the range of 0.2-0.8 mg/L, which could decrease the growth of total coliforms in drinking water as these bacteria are highly sensitive to free residual chlorine (Verhille et al., 2013). Furthermore, the drinking water samples with higher free residual chlorine concentrations had lower contamination rates with coliforms (0.2 mg/L of free residual chlorine or 0.5 mg/L of chloramine) (Blokker et al., 2016). However, the excessive release of residual chlorine may lead to the formation of disinfection by-products in the water distribution networks (Lu and Zhang, 2005). In a study in this regard, Lu and Zhang evaluated the influential factors in bacterial growth in distribution network, reporting that when the free residual chlorine content was less than 0.5-0.7 mg/L, the risk of microorganisms and their growth in the network was higher. In addition, the increased concentration of free residual chlorine led to the reduction of bacterial growth (Lu and Zhang, 2005). In the mentioned research, approximately 8% of the samples had higher turbidity than the allowed limit of the WHO (5NTU). Turbidity could be used as an indicator to identify incoming contaminants and the hydraulic issues in drinking water distribution systems. The increased turbidity of drinking water distribution networks could protect microorganisms against disinfectants to promote the growth and multiplication of pathogens, while reducing the effectiveness of water disinfection. Moreover, turbidity provides the power supply of these networks, thereby facilitating their movement (Shakya et al., 2013). According to WHO and Iranian standards for drinking water, fecal bacteria indicators must not be detectable in any 100 ml sample but in according to fig 5, 84% and 98% of the samples were infected with fecal and total coliforms, respectively (WHO, 2017; ISIRI, 2009) The findings of Jalilzadeh *et al*. regarding the heterotrophic and coliforms of old and new drinking water distribution networks indicated that the combination of coliforms in the old drinking water distribution network consisted of 31% fecal coliforms and 69% other coliforms, while in the new network, these values were 4% fecal coliforms and 96% other coliforms (Jalilzadeh et al., 2016). According to the results obtained by Thani *et al.*, 83.4% of the samples were infected with total coliforms, and 60% were completely infected with fecal coliforms (Thani et al., 2016). On the other hand, the findings of Chaidez *et al.* in Mexico city demonstrated that 43% of the drinking water samples were completely infected with total coliforms, while 26% were infected with fecal coliforms (Chaidez et al., 2008). In the case of large supplies, where sufficient samples are examined, fecal coliform must not be present in 95% of samples taken and caused total and fecal coliforms increase in the drinking water In 49 some of these areas was fair or poor. The highest numbers of total coliform and fecal *E. coli* recorded parking water in parking 3,4 were 95 MPN/100mL and 44 MPN/100 mL, respectively while the lowest numbers were zero CFU/100mL (Table 1). So it is necessary samples fecal coliforms were positive in this period in Iran drinking water standards optimum and Maximum Permissible Levels for turbidity are 1 and 5 NTU respectively. According to national guidelines, the mean values for drinking water turbidity in motels of babosar city was not good. We found that distribution systems and also lack of chlorine due to breakdown of chlorination system have the main effect in microbial pollutions of wells. It is necessary to prevent of secondary pollution in the wells water. The frequently distribution of desirable wells for parameters HPC, Total Coliforms, E.coli, Turbidity and pH were 47,1 ,8,9 and 50 respectively (Fig 4) So all drinking water supply wells have microbial contamination. According to a report on drinking water quality by Osiemo and et al show, *E coli* concentrations and TC exceeded the WHO drinking water guidelines of 0 cfu/100 mL and all drinking water at abstraction and point of use for Marigat residents are microbiologically contaminated and therefore pose serious health risks to consumers of such water. Thus, it is need for public health awareness campaigns on household water management to curb incidences of water-related diseases. Public health practitioners at county and national levels need to ensure that households have adequate access to potable water and improved sanitation Osiemo et al., 2019). Water similar observations have been made in another study by Seino et al, on bacterial quality of drinking water stored in containers by boat households. The concentrations of *E coli* and TC were much higher in the households that relied on sky-plasts and clay pots as their main water storage containers (Seino et al., 2007). In similar studies conducted by Fadaei and sadeghi the importance of regular monitoring of groundwater and surface water sources are emphasized (Fadaei and Sadeghi, 2014). All wells, in this study contained total coliform indicator bacteria which were in excess of WHO and Iran recommended guidelines for drinking water. Improper disposal of human wastewater and directing surface water to wells and poor maintenance are the main causes of wells contamination. Some solutions are suggested for the use of health officials and water and Sewage Company managers in order to satisfy consumers with safe drinking water. These suggestions include the following;

1. Installation of water disinfection facilities and their continuous control
2. Construction of urban water pipeline network in the coastal area for drinking consumption.
3. Establishment of water storage tanks in order to supply water in peak consumption.
4. Regular and continuous washing and disinfection of water tanks located in motels.
5. Supervision and control of water treatment plant installations installed in motels.
6. Proper collection, treatment and sanitary disposal of wastewater in these motels.

Conflicts of interest

The author declare that there are no conflicts of interest.

Refereces

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