

## Summary

The total number of drinking water samples collected was 378 during the three years (2017-2019). It was noted that the contamination in the studied wells is mainly due to the leakage of contaminated water into the groundwater.

The highest value of contamination in the general in 2017 and 2019 was during April and December as a result of the deterioration of the environmental situation due to the war and the increase in the intrusion of water contaminated with sewage water into the groundwater.

The highest value of turbidity was in well No. 6 with a value of 5.7 (NTU) for the well in April 2017, the highest value of the temperature was C<sup>0</sup> 26.8 for well No. 38 in August 2018, and the highest value for pH was 8.7 in well No. 4 in December 2017, the highest value of EC 2595( $\mu$ S/cm) for well 7 in April 2017.

The highest value of TDS was 1536 mg/L for well No. 4 in April 2019, the highest value for Cl was 369 mg/L in well No. 8 in December 2019, and the highest value for F was 2.7 mg/L for well No. 24 in December 2017, and the highest value for Ca was 217 mg /L for well No. 19 in April 2017, the highest value of Mg was 171 mg/L for well No. 32 in April 2017, the highest value of Na was 395 mg/L for wells No. 7, 27 in December 2019 and the highest value of K was 13.7 mg/L for well No.

40 in August 2017 and the highest value of  $\text{NO}_3$  was 79.8 mg/L for well No. 7 in August 2019, the highest value for Fe was 2 mg/L for wells No. 41 and 1 in August 2017, wells No. 30 and 28 in April 2017, and well No. 14 in August 2019 and the highest value was for T . coliform and F. coliform were 62 cfu/100 and 21 cfu/100, respectively for well No.1 in August 2017.

Significantly and according to the statistical analysis, the mean of the highest values with a significant difference and statistical significance was calculated during the three years of the study and according to the wells, which exceeded the permissible limits in the Yemeni and WHO reference values, where the mean of the highest turbidity value was 5,220 (NTU) for well No. 33 and the mean of the highest temperature value was 26,470  $^{\circ}\text{C}$  for the well No. 38, the mean of the highest value of EC was 2564,330 ( $\mu\text{S}/\text{cm}$ ) for well No.7, the mean of the highest value of TDS was 1510 mg/L for well No.4, which was significant and statistically significant with the Yemeni reference value and not statistically significant with the WHO reference value, the mean of the highest value for  $\text{Cl}^-$  was 365 mg/L for well No.8 where it exceeds the permissible WHO reference value and is within the right reference value allowed, the mean of the highest value of F was 8.08 mg/L for well No. 24, the mean of the highest value of Ca was 206.11 mg/L for well No. 19, the mean of the highest values of Mg was 158.89 mg/L for well No. 32, the highest

mean value of K was 12.95 mg/L for well No. 40, the highest mean of NO<sub>3</sub> was 78,156 mg/L for well No.7, the mean highest value of Fe was 1,543 mg/L for well No. 30, the highest mean value for T. coliform was 53.89 cfu/100 for wellNo. 22 and the highest mean value of F. coliform was 16.56 cfu/100 for well No. 22.

By comparing the results of the three years of the study according to the collection periods, a significant and statistically significant difference was observed in the concentration of contaminants (EC, TDS, Cl<sup>-</sup>, Na, NO<sub>3</sub>, Fe, T. coliform and F. coliform) where the highest mean value of EC, T. coliform was in the first quarter of 2019 as a result of the increase in sewage contamination and the dependence of farmers on sewage water for irrigation in the absence of oversight and in light of the deteriorating situation of the sewage treatment process at that time due to the war, also this may be due to the increase in groundwater withdrawal. And the scarcity of rain, which increases the concentration of contaminants. The highest mean values for F. coliform and Fe were in the second quarter of 2017 due to the intrusion of sewage water with rain water into the groundwater. The highest mean values of TDS and Na were in the second quarter of the year 2019 and the highest mean values of Cl<sup>-</sup> and NO<sub>3</sub> were in the third quarter of 2019 also as a result of groundwater contamination with sewage water containing various chemical and microbial contaminants.

Through the results of the correlation relationship between the obtained results and the depth of the wells and the distance from the source of pollution represented in the sewage channel, where there was an inverse and somewhat high correlation of (0.626) between depth and contamination with T.coliform bacteria, at a significance level less than 0.01, also there was presence of an inverse and medium correlation (0.458) between T.coliform contamination and temperature at a significance level less than 0.01. There was a linear and medium (0.473) correlation between T.coliform and F.coliform at significance level less than 0.01. A medium inverse correlation was between Cl<sup>-</sup> and Fe (0,431) at significance level less than 0.01 and inverse and medium correlation (0.493) was between Mg and the distance from the pollution source at significance level less than 0.01.

10 types of the bacteria were isolated from the total number of the collected samples, which were 378 samples. *E.coli* was the most number among the other isolates, where their number was 336 isolates in rate 88.9%, followed by *Enterobacter spp*, where the number of isolates were reached to 262 isolates with rate 69.31%, and 119 isolates of *Pseudomonas aeruginosa* with rate 31.5%. The least number of isolates is for *Vibrio cholera* which was 2 isolates in rate 0.53%.

Heavy metals contamination also appeared in 11 of the wells studied, where cadmium appeared in wells No.1,7,14 and 29, and its

percentage exceeded the permissible limits in the Yemeni and WHO standard limits, and its concentrations in those wells were 0.01294, 0.01687 ppm, 0.00710 ppm and 0.05671 ppm, respectively.

Mn also appeared in wells No.1,2,3,7,14,15,16,22,25 and 33 at concentrations of 0.01655, 0.01626, 0.01620, 0.01621, 0.01652, 0.01619, 0.01638, 0.01615, 0.02128, 0.01794 and 0.01604, respectively, and this concentration were within the permissible limits in the Yemeni specifications and exceeded the WHO standards. Pb element also appeared in 3 wells No. 1,7 and 15 with concentrations of 0.01531, 0.01695 and 0.02337, respectively with concentrations exceeding the permissible limits in the WHO standards and within the permissible limits in the Yemeni specifications.

There was a high and linear correlations between Mn and Cr that was 0.983 at a level of significance less than 0.01, Ni with Cr and manganese was 0.970 and 0.946, respectively, at a level of significance less than 0.01, Cu with Cr, Mn and Ni which were 0.963,0.969 and 0.944, respectively, with a significance level of less than 0.01, Pb with Cr, Mn, Ni and Cu that were 0.809,0.763,0.777 and 0.717, respectively, at a significance level of less than 0.01. Medium and linear correlations of Zn with Cr, Mn, Ni, Cu and Pb were 0.433, 0.447, 0.414, 0.446 and 0.492, respectively, with a level of significance less than 0.01. An inverse and mean depth correlations with Cr, Mn, Ni, Cu and Pb which were -0.531, -

0.526, -0.506, -0.527 and -0.434, respectively, at a level of significance less than 0.01. There was no correlation of distance with the studied heavy metals which may be due to the surface circulation of sewage, which was prevalent in the study area, and also to the farmers dug of ponds containing sewage water adjacent to the drinking water.

Four types of the pesticides appeared in 5 wells No. 1,14,22,3 and 33, which were toclophos, thiamethoxam, cybermethrin and at concentrations 0.0040, 0.0014, 0.0056, respectively.0.000025 and 0.039 respectively.

There was no correlation between pesticide contamination, depth and distance, not even between pesticides that appeared in this study.

In this study, the methods were developed to test drinking water at home with a simple technique, and the simple citizen can conduct this examination to ensure the safety of drinking water from bacterial contamination. This method, in its first and second parts, gave strong and confirmed results.

In this study, a questionnaire was made for the purpose of investigating the health situation and its relationship to the environmental situation and the situation of drinking water in the study area, as well as the extent of citizens' awareness and deficiencies on the part of the government with regard to the water and drinking water sector. Where the majority of the questionnaire sample was from the Beit Al-Helli area with

a percentage of 14.82%, followed by Beit Dughaish with a percentage of 11.95%, and the majority of the studied wells were private wells with a percentage of 82.62%, while government wells accounted for 11.70%. The highest percentage of changes that the citizens noticed in the drinking water was the change in the taste of the water by 63.95% of the other changes. The highest percentage of diseases prevalent in the study area was diarrhea diseases for females in the age group (19-90), followed by kidney and urinary tract diseases for females in the same age group. The least common diseases in the study area were cancer for females in the age group  $\geq 6$ .

The study also showed from the results obtained by going to the health centers that citizens go to in the study area to receive treatment that the most prevalent diseases are diarrheal diseases, followed by kidney and urinary tract diseases, which fully comply with the results of the questionnaire, which definitely indicates the presence of contamination of drinking water that caused diseases as Diarrhea and Kidney disease.