

Summary

The global concern for water quality is focused on bacterial indicators; therefore, it is a better way for future indicator systems to do the same by considering other bacteria as water quality indicators and reevaluating the indicator limit value associated with the present water quality situation. Concerns about the safety of drinking water are growing in Yemen as a result of potential microorganism exposure. To increase water quality, it indicates that Yemen needs to establish a stricter and more complete indicator system and strongly enforce water quality standards. Particularly in Sana'a, where the presence of a large number of IDPs has put additional strain on the city's capacity and lowered the quality of its water, it's essential to identify the gaps in the Yemeni water quality indicator system so that improvements can be made to the system in the future.

A few studies on microbial quality tests were performed in Yemen; however, most of them were limited to bottled water and boreholes. Therefore, to the best of our knowledge, there have been no previous published studies conducted in Yemen that addressed the bacterial quality of hand-dug well water.

The main objectives of this research are to examine the bacterial quality of water and qualitatively analyze some physio-chemical parameters of hand-dug well water samples, (which are drawn from shallow aquifers and have a relatively large diameter, making them highly susceptible to contamination) in the study area to identify the best bacterial indicator. This will subsequently help generate a more successful water quality monitoring system in the future to improve the drinking water quality in Sana'a, Yemen.

This study was performed to compare the efficiency of two methods for bacteriological analysis of drinking water, the most probable number

(MPN) and membrane filtration (MF), to detect the presence of bacterial indicators in the water. According to Yemen's Standardization and Metrology Organization, heterotrophic plate count is also used for total heterotrophic bacteria (THB) count enumeration. Some new bacterial indicators that have not been used before were introduced into the study area to check for the presence of other fecal contaminants using various selective media that were recommended for such a study, in addition to the prevalence of various waterborne pathogens. Furthermore, some physicochemical parameters of the water samples were analyzed.

Water samples were collected twice from 53 drinking hand-dug wells during the dry and rainy seasons in Sana'a City, Yemen, 2021–2022.

The overall results showed that 37.5 out of 53 samples (71%) were unsatisfactory, whereas the prevalence of *Citrobacter* (62.3%), *Pseudomonas aeruginosa* (57%), and *E. coli* (50%), was higher than that of other isolated bacteria. In addition, there was a higher prevalence of TC and *P. aeruginosa* in the dry season than in the rainy season, while there was a higher prevalence of *E. coli* and FS in the rainy season than in the dry season.

The statistical analysis showed differences in the percentage contamination of drinking water samples taken from one sample depending on the method type. There was a significant difference in the mean score of FC and FS between the MPN and MF in favor of the MF, as the results were directly obtained by counting. Contrary to this, there was no significant difference in the mean score of *C. perfringens* and *P. aeruginosa* between the MPN and MF.

Moreover, a statistical analysis showed that there was no correlation between the physicochemical parameters and the bacterial indicator of

drinking water from hand-dug wells in both rainy and dry seasons, except for water temperature, nitrate, phosphate, BOD, and COD, which are evidence of water contamination with human waste and have a good correlation with bacterial activity.

The result showed that *P. aeruginosa* was the most isolated indicator from the studied wells, and this is indicative of its contamination.

As the results showed, we found that the MF method provided more thorough and accurate results for detecting bacterial concentration, leading us to the conclusion that the use of several fecal indicators would provide a better resolution of fecal contamination than when a single indicator is used. Consequently, it is necessary to include a number of pathogenic or opportunistic organisms as indicators of health risks related to drinking water, one of which may be *P. aeruginosa*.

The study also showed that the weakness of the sanitation infrastructure is the most important factor in the pollution of the water from manual wells, especially the presence of cesspools, torrential rains, and people throwing garbage near the wells. Perhaps the spread of diarrheal diseases, contamination leaks, and the spread of waterborne diseases such as the cholera pandemic are concentrated in the northern part of the city and the city center.

Key words: Drinking hand-dug wells, Indicator bacteria, Membrane Filtration (MF), Most Probable Number (MPN), *Pseudomonas aeruginosa*, Sana'a city.