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Measuring the Pollution of Three Main Drinking Water Treatment Plants with Coliform Bacteria in Sharqat District

Zuhair Farooq Ahmed Fartm

General Directorate of Education in Salah Al-din, Ministry of Education, Salah Al-din, Iraq.

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ABSTRACT

The current study encompasses three major drinking water purification projects situated on the left side of Sharqat city, which rely on raw Tigris River water as their water source. The projects are arranged from north to south as follows: Safina Water Project, Lower Asdira Water Project, and Tal Muhammad Water Project. During the study period, we collected samples of raw river water and samples from each sedimentation and filtration process to measure the presence of faecal coliform bacteria, evaluate the effectiveness of these processes in eliminating faecal coliform bacteria, and assess the suitability of the prepared water for drinking and its compliance with international standard specifications for drinking water. The study period lasted ten months, starting in August 2020 and ending in May 2021. Among the most prominent results of the current study are the following: The three project sites exhibited significant similarities in the percentage of unacceptable samples, with two sites reporting a percentage of 60% and the third site reporting a percentage of 70%. The results also revealed significant similarities in the months when the samples were deemed acceptable or unacceptable. For instance, the Tal Muhammad water project saw acceptable samples in December, January, and February, with the Safina and Asdira water projects following suit in March. The Safina and Asdira water projects saw unacceptable samples in August, September, October, November, April, and May, while the Tal Muhammad water project saw them in March.

1. Introduction

Any substances that are foreign to the basic components of water and cause harm to any living organism that drinks it are defined as water pollution. This, of course, will negatively affect the living organisms or render the water unfit for its intended uses. Water pollution has a significant impact on the lives of individuals, families, and society. All life on Earth depends on water, and polluted water can lead to its demise. According to the World Health Organization, more than five million people die annually as a result of unclean and contaminated water [1]. Many pollutants, including sewage water, infiltrate raw water. We must treat this water to remove all pollutants and combat these diseases. Pathogenic strains of E. coli bacteria, which

Corresponding author:
E-mail address: zuhairfarooq80@gmail.com
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cause intestinal inflammation, enter human bodies due to water pollution from sewage. Many countries lack access to clean, drinkable water, leading to a high prevalence of diarrhoea that has claimed the lives of millions of children under five years of age. [2] More than one million people in Yemen contracted cholera in 2017 as a result of drinking water contamination [3, 4]. The process of detecting all these pathogenic germs is time-consuming and requires great effort, leading to a reliance on microscopic organisms whose presence in water serves as evidence of their contamination. The Total Coliform group, a Gram-negative, rod-shaped bacterium, is one of the most prominent bacterial indicators. These facultative anaerobes, which are non-spore-forming, can ferment lactose at a temperature of 37-35 degrees Celsius, producing gas and acid within 48-24 hours. These species include Escherichia coli and Enterobacter spp. [5, 6, 7].

The objective of the study:

The study aims to understand the environmental conditions of drinking water in Sharqat, assess the quality of drinking water initiatives by determining the quality of water that citizens receive, and organize stations based on the water quality generated. The study included other sections, such as comparing the quality of purified water and the water reaching the consumer, which aims to determine the impact of distribution networks on water quality.

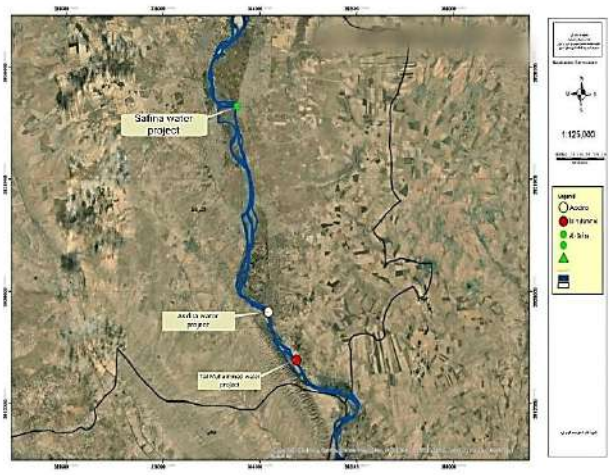

Figure 1. is a map representing the study area.

Study venue:

The Tigris River provides raw water to the three drinking water projects located on the left side of Sharqat city, over 90 km south of Mosul city. We selected these projects due to their size and ability to provide potable water to the greatest number of people in Sharqat. The venue is characterised by large areas of agricultural land on the left side of the Tigris River, in addition to the concentration of large numbers of residents on two banks of the river, as well as the presence of industrial activities like the quarries of sand and gravel, as well as grazing cows and sheep near the river, which helps in disposing of their waste near the river water. When floods occur, it will be swept into the river, as well as washing sheep wool and their internal organs in the river, and the presence of drains, household sewage water, and chemical and animal fertiliser waste, which are discharged directly into the Tigris River without treatment, indicating that there is pollution that will affect the Tigris River's water quality as a source for preparing water for purification projects.

The study included two parts, the first concerned with water purification projects and the second with the quality of water that reaches the consumer. We arrange the projects from north to south: the Safina Water Project, the Lower Asdira

Water Project, and the Tel Mohammed Water Project. The projects vary in the quantity of additional materials they require, as well as in other aspects.

in the designs of both the sedimentation and filtration units.

Sample collection locations:

For each of the three projects, we collected monthly water samples from the following locations in sterile plastic bottles with a 250 ml capacity:

1: was taken from the river near the diver.

2: After the process of sedimentation.

3: After the process of filtration.

2. Materials and methods

Isolation and counting of coliform bacteria and fecal coliform bacteria:

The coliform bacteria group consists of Gram-negative, non-spore-forming rods that ferment lactose sugar, resulting in the formation of acid and gas. The natural environment for this group of bacteria is the intestines of humans or animals, so it is taken as evidence of water pollution by faecal waste when present, thus giving the possibility of the presence of pathogenic intestinal bacteria in such water. This underscores the significance of examining the presence of coliform bacteria in water.

(Standard method for reverse colonization using M.P.N.)

The first stage: Presumptive Test:

A series of tubes are inoculated in the form of (3 or four groups; each group contains 3 or 5 tubes) containing Lauryl Broth or Brillint Green Bile Lactose Broth medium with a specific volume of the original water sample (it is preferable that the volume be 100 or 10 or 1 or 0.1, i.e., decimal dilutions), and the tubes are shaken and at 37 °C are incubated for 24 hours, and gas formation is observed at the end of this time. If no gas forms, the tubes remain in the incubator for 48 hours. If gas forms during this period, we consider the result as positive. To keep things clear, the culture medium is seen to be foggy, which means bacteria are growing and fermentation is creating gas in the Dirham tube. This way, the gas bubble that forms in the tube is not confused with any other gas bubble that might be there. [8, 9, 10].

Second stage: Confirmed Test:

A small amount of the culture that gave a positive result in the hypothetical test is transferred to tubes containing Brillint Green Bile Lactose Broth medium using a sterile carrier and incubated at 37°C for 24 hours. Any amount of gas is formed in the tubes, indicating the presence of E. coli bacteria. [8].

Third stage: Complete Test:

Following the confirmatory test, we take a portion of the culture from each tube that yielded a positive result from the previous test and plot it on Endo Agar or E.M.B. Agar medium as soon as the gas appears. We incubate the plates at 37°C and observe typical colonies, either with a center and a metallic green lustre or without it. After 24 hours of incubation, the atypical colonies will appear opaque, eccentric, mucous, and pink. [9, 11].

We calculated the results as shown in [12, 13, 14].

The sample receives the symbol (A) if it contains less than 4 colonies of coliforms/100 ml, making it acceptable and suitable for drinking.

The sample receives the symbol (F) if it has more than 4 colonies of coliforms/100 ml, indicating failure and unsuitability for drinking.

The nature of the work of water purification projects:

The water purification process goes through a few methods, the most prominent of which are sedimentation or collection, filtration, and purification. It is worth noting that there are water impurities that may be suspended or dissolved, such as solid colloids, minerals, or organic materials, and the water may have an odor. The purification steps are listed in the following order:

1- Aeration:

The process releases and eliminates the dissolved gases in the water, leading to the suspension of particles in the water column.

2- Flocculation:

It is worth noting that microorganisms, clay particles, organic materials, and minerals in the water are so small that they do not settle easily because of gravity, so water materials are added for the purpose of collecting, and these materials have the property of collecting which approach and stick of these suspended materials and particles, forming larger and heavier materials that settle easily and fast.

3- Sedimentation:

We keep the water tanks quiet to allow gravity to precipitate the heavy combined particles at the bottom.

4- Filtration:

The process involves passing water through several filters to capture and remove any suspended particles that remain in the water after sedimentation, with the sand and coal layer being considered the most effective for completing these stages.

5- Disinfection:

After completing the previous four steps, the water becomes free of particles and microorganisms. However, substances such as chlorine are added to ensure that any pathogens that may be present in the water are eliminated. After completing the previous step, the resulting water becomes safe and ready to supply homes.

3. Results and Discussion

Faecal Coliform Bacteria

Coliform bacteria are considered one of the most important indicators for knowing if the water is suitable for industrial, domestic, and other uses [15]. The three project sites demonstrated a significant resemblance in the percentage of unacceptable samples (F = failed), which are samples where the number of faecal coliform bacteria exceeded the permissible limit. This was observed in two sites (60%) and the third site (70%), as presented in Table. The results were also very similar when it came to the months when the samples were acceptable or not acceptable. In the Tal Muhammad Water Project, the acceptable months were December, January, and February, followed by March for the Safina and Asdira Water Projects. In the Safina and Asdira Water Projects, the unacceptable months were August, September, October, November, April, and May, followed by March for the Tal Muhammad Water Project. The results indicate a correlation between the number of faecal coliform bacteria and the water temperature and rainfall, with the water temperature being a crucial factor in controlling the growth of pathogenic microorganisms. Researchers have observed a decrease in the number of bacteria in the Tigris River as the temperature decreases [16]. The results revealed that the bacteria in the Tigris River exceeded the permissible limit during the summer, indicating that the water is highly polluted and unsuitable for preparing potable water based on simple traditional methods. The reason for the water pollution in these months is that the area is agricultural and is inhabited by many people for grazing and

swimming, and thus the water will be polluted with livestock waste and human waste. The sedimentation process in the three projects showed low efficiency in removing coliform bacteria. Sedimentation tanks converted 20% of the unacceptable samples into acceptable samples in the Safina project, the most efficient project, while only 10% of the unacceptable samples in the Asdira and Tal Muhammad projects converted into acceptable samples. The reason for this is either the negligence of the workers in these projects, or their lack of awareness about the potential risks of contamination. Because chlorine was added in the first stage of chlorination and solar radiation has an effect on some bacteria, the sedimentation process has to get rid of them. However, sedimentation tanks are not very good at getting rid of coliform bacteria for a number of reasons, such as the fact that the water is only in the tank for a short time.

to remain inside these tanks, and therefore sufficient time must be available for these suspended particles to settle, and this period of time depends on the diameter of these particles and bacteria, whose average diameter is (0.001) mm, and it was found that bacteria need a period of (0.35) hours to be able to settle only one foot [18], and in these projects under study, the period of water remaining was not constant, as it was variable with the amount of water required to be consumed and with the change in turbidity, and in the three projects the period of water remaining in the sedimentation tanks was less than the required period and in some months of the year it was direct due to the residents' need for water as a result of the continuous power outage. Several researchers [16, 19, 20] noted this phenomenon during their study of drinking water filtration stations in Nineveh and Salah al-Din Governorates. The filtration process was found to be below the required level. In the Tal Muhammad water project, 30% of the unacceptable samples were converted into acceptable samples, and in the Asdira water project

Only 10% of the unacceptable samples in the Safina Water project underwent conversion into acceptable samples, compared to 20% in the project. The reason for this is due to the low efficiency of the filtration process in the projects, which is caused by the failure to add the appropriate dose of chlorine, or sometimes not adding it at all due to a lack of awareness among some of the workers in these projects. Additionally, there is a lack of awareness among a section of the population, who in some cases ask the workers not to add chlorine to the water entering the projects, claiming that it causes a strange smell in the drinking water. In addition to that, there are the long periods of time that separate each washing process for the sedimentation and filtration tanks. Due to the low efficiency of these projects, the water from water purification projects has been contaminated with faecal coliform bacteria for several months, indicating a lack of compliance with Iraqi and international drinking water standards.

Table 1. Results of colon bacteria examination evaluation during the study period at different stages of filtration.

failure percentage	2021					2020					Filtering stages	Projects
	May	April	March	February	January	December	November	October	September	August		
%60	F	F	A	A	A	A	F	F	F	F	Raw water	Safina water project
%40	F	F	A	A	A	A	A	A	F	F	After sedimentation	
%30	F	F	A	A	A	A	A	A	A	F	After filtration	
%60	F	F	A	A	A	A	F	F	F	F	Raw water	Asdira water project
%50	F	F	A	A	A	A	A	F	F	F	After sedimentation	
%30	F	F	A	A	A	A	A	A	F	A	After filtration	
%70	F	F	F	A	A	A	F	F	F	F	Raw water	Tal Muhammad water project
%60	F	F	F	A	A	A	A	F	F	F	After sedimentation	
%30	F	F	F	A	A	A	A	A	A	A	After filtration	

F= Failed Not suitable for drinking

A= Accept Potable Sample Failed

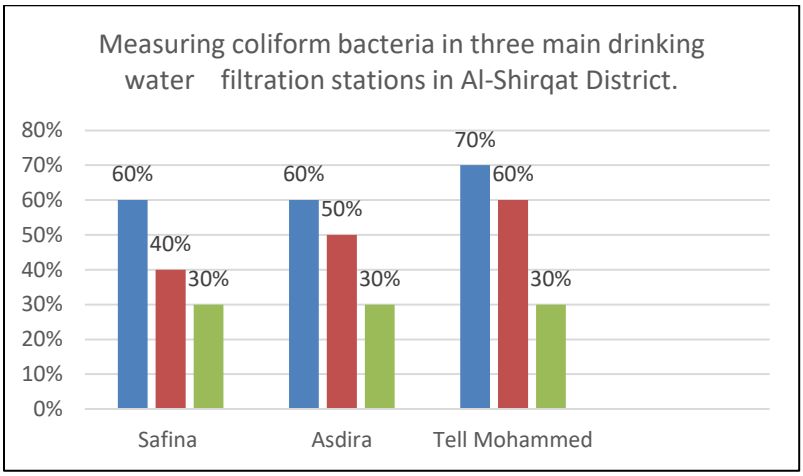

Figure 2. The percentage of removal of coliform bacteria in the various filtration stages for the projects under study

4. Conclusions and Recommendations

1. Despite the presence of faecal coliform bacteria and a wide variation in the sedimentation basins' removal efficiency, the Tigris River water in the study area is a good source for producing drinking water using traditional filtration projects.

2. Educating people responsible for water purification in water projects through special seminars and training them scientifically for the purpose of increasing their expertise, as well as conducting periodic tests of station water to determine its suitability for human consumption.

3. Removing the violations of water pipes, maintaining them from breakage and damage, cleaning them continuously, conducting periodic cleaning operations for networks, ensuring the quality and quality of existing sewage networks, and establishing new networks covering the neighbourhoods of cities, districts, and suburbs.

4- We must raise the efficiency of the stations mentioned in this study by conducting detailed studies for each station separately in cooperation with the departments of these stations to reduce the disadvantages of each station as well as its obstacles, as every station, as is known, has its own conditions.

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