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POLLUTION RISKS IN DRINKING WATER DISTRIBUTION NETWORK OF A HEALTHCARE FACILITY IN TIARET, ALGERIA

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ABSTRACT

Water plays an important role in the healthcare field and can become the source of health problems due to microbial or chemical contamination. However, the quality of water used in hospitals has not been well studied in developing world. This study aimed to assess bacteriological and physicochemical drinking water quality at the hospital of Tiaret Town to get insight into any potential health risks due to waterborne diseases. To evaluate water quality of hospital, five sampling sites were determined and water quality parameters were selected for physico-chemical and bacteriological analysis. The analysis results were compared with maximum permissible limit values recommended by World Health Organization (WHO) and Algerian drinking water standards (JORA). The obtained results indicate that, the water temperatures ranged between 18.10 and 18.40 °C. The pH ranged between 7.93 and 7.99. The electrical conductivity (EC) with maximum value of 1149 µS/cm. The HCO_3^- content with a value of 146 mg/l at all sample points. The chloride (Cl^-) values ranged from 114.30 to 115.10 mg/l and sulfate (SO_4^{-2}) values from 189.70 to 197.20 mg/l. The physicochemical analysis indicated that parameters values of the water were far below drinking water standards. The microbiological results show that the microbial load of total germs and fecal coliforms is very important. The levels of total germs at 22 °C and 37 °C ranged between 2 CFU/100 ml to 128 CFU/100 ml and 40 CFU/100 ml to 134 CFU/100 ml respectively, while, the levels of total coliforms and fecal coliforms ranged between 13 CFU/100 ml to 146 CFU/100 ml and 00 CFU/100 ml to 371 CFU/100 ml respectively which indicates the contaminated than the hospital drinking water. The results show that the microbiological qualities of the water generally worsen from hospital taps.

KEY WORDS: Water, Quality, Microbiological, Physico-chemical, Hospital

INTRODUCTION

Water is an essential natural resource in life, water quality decreases because of contamination from bacteria and other pollutants. The bacteriological and physicochemical quality of the drinking water served to the population has been the subject of numerous studies that have shown the health risks and the impact of polluted drinking water on human health. Water quality, including chemical, physical, and biological characteristics, is of great importance also for human lives as it is commonly consumed and used in hospitals and other health care facilities. Bacterial contamination of drinking water promotes the short term spread of fecal diseases and can cause serious illnesses such as typhoid, cholera and diarrhea. Water is of vital importance for both clinical and other areas in hospitals. It's used for drinking, general cleaning, sterilization and gardening and in operating rooms, diagnosis and treatment units, kitchens and laundries in the form of cold water, hot water and vapor (Ozkan *et al*, 2014).

Water quality can also be monitored by a biological index (Raghav *et al*, 2011)or Physico-chemical parameters (Ighalo *et al*, 2020). It is an essential element in the hygiene and functioning of health facilities should be professionally managed in hospitals. Contaminated water supplies affect the growth and nutrition in young children adversely. Specific objectives of this study were to assess physico-chemical and microbiological quality of the water at the hospital during the period 2018-2019 according to World Health Organization guidelines (WHO, 2017a) and Algerian drinking water standards (JORA, 2011).

MATERIALS AND METHODS

Study site and sampling points

The study was conducted in the hospital of Tiaret. It is situated between longitudes 35°23206.9622 ~ 35°22259.2022 N and latitudes 1°18'46.12" ~ 1°18257.0022 E. with a total area about 3.95 ha. This hospital meets the health care needs of the population in the region of Tiaret. In addition, the hospital gathers a large number of health services with different activities.

Water sampling

Five sampling points were chosen (Gastroenterology/infectious, woman service, Pneumo-phthisiology, kitchen). The water samples were collected in 250 ml sampling bottles previously washed with deionized water, rinsed with the sample to be collected from different stations. Then they were transported within 6 h to the laboratory in an ice box at 4 °C until analysis. Then they were carried to the laboratory in an ice box using ice gel packs at 4°C until analysis.

Physicochemical analysis of water

Water temperature was measured using a thermometer. pH was measured and electrical conductivity using an electrometric method. Total Hardness (TH), calcium (Ca^{+2}) and magnesium (Mg^{+2}) were determined by the volumetric method with EDTA (Ethylenediaminetetraacetic acid). Chlorides (Cl^{-}) was determined by the volumetric method with dinitrate mercury $Hg(NO_3)_2$. Nitrate (NO_3^{-}), bicarbonate (HCO_3^{-}) and sulphate (SO_4^{-2}) were determined by a colorimetric method using a UV-Visible spectrophotometer.

Microbiological analysis of water

The counts of total germs (Total Aerobic Mesophilic Bacteria) were made by seeding in the surface on the agar medium. The reading was done after 48 hours of incubation at 37 °C or after 72 hours of incubation at 22 °C. For the enumeration of fecal coliforms, the technique of membrane filtration through a ramp filter was used. The membrane filtration technique consisted of passing 100 ml of water samples in sterile funnels using vacuum filtration ramp for each parameter through a cellulosic membrane filter with pores of uniform diameter equal to 0.45 µm. After filtration, this membrane filter was inoculated in a Petri dish containing a standard culture medium specific for each bacteriological parameter. The culture of total coliforms (TC) was carried out on middle Tergitol 7 agar TTC and incubation at 37 °C during 24 hours. The culture of fecal coliforms (FC) was also performed on middle Tergitol 7 agar, with an incubation at 44 °C for 24 hours. The results are expressed as colony-forming unit per 100 ml (CFU/ 100 ml). Total coliform and fecal coliform have been chosen for this study mainly because of their fecal and environmental origin and could also be monitored as an alternative for *E. coli* and as such have been used universally as microbiological indicators of water quality.

RESULTS AND DISCUSSION

Physicochemical parameters

The values of various physico-chemical parameters of the water samples at different services of the hospital are presented in Table 1. In this study, all physico-chemical parameters values of the water were far below drinking water standards. Due to alterations in natural and anthropogenic processes, it is necessary to guarantee its quality so that there is no risk for humans and the environment (Lugo and Lugo, 2018). The average values of temperature recorded oscillate between 18.30 and 18.40 °C.

The recorded temperatures are below 30 °C considered limiting value of (WHO, 2017a) and (JORA, 2011). The mean value of pH was recorded to be varying from 7.93 to 7.99 at different sampling points. The maximum pH was recorded at Service 1 and the minimum at Service 2. The pH values ranged from near neutral to basic values. The increase of water pH may have been caused by the dissolution of the accumulated limestone in the distribution system. Water hospital comes from groundwater. Bicarbonate (HCO_3^{-}) and carbonate (CO_3^{-2}) are the source of water alkalinity. Bicarbonate ions in groundwater derived from the carbon

Table 1. Physical-chemical parameters of water distributed in hospital supply system

Parameters	Service 1	Service 2	Service 3	Kitchen	WHO	JORA
Temperature T (°C)	18.30	18.20	18.10	18.40	< 25	< 25
pH	7.99	7.93	7.95	7.97	9	6.5 - 8.5
EC (µS/cm)	1141.00	1143.00	1149.00	1146.00	2000	2800
TH (°F)	49.70	49.40	49.80	49.30	50	50
Ca^{++} (mg/l)	110.20	111.50	110.00	110.90	200	75-200
Mg^{++} (mg/l)	58.90	59.30	59.10	58.90	150	150
Cl^{-} (mg/l)	115.10	114.30	114.90	114.50	300	200-500
HCO_3^- (mg/l)	164.00	164.00	164.00	164.00	400	200-400
SO_4^{-2} (mg/l)	189.70	191.40	197.20	191.70	400	200-400
NO_3^- (mg/l)	5.48	5.74	5.98	5.79	50	50

(Service 1: Gastroenterology/infectious diseases. Service 2: Woman. Service 3: Pneumo-phthisiology).

dioxide (CO_2) in the atmosphere, carbon dioxide in the soil and the dissolution of carbonate rocks such as limestone and dolomite (Hussain *et al*, 2021). The pH levels in the samples collected inside the hospital building were always within (Flouchi *et al*, 2021) optimum range (6.5 – 8.5). Electrical conductivity (EC) of water is also an important parameter for water quality because it is a useful indicator of mineralization and salinity in samples. The values of experimental samples ranged from 1141 to 1149 µS/cm at the studied stations. The maximum EC was measured at service 3; this might be due to the chlorination of tap water or problems related to water containers. The minimum value was measured at service 1 (Table 1). The average values of conductivity recorded at the water of hospital were far below drinking water standards considered limiting value of (WHO, 2017a) (200 µS/cm) and (JORA, 2011) (2800 µS/cm). For the water samples analyzed, the highest total hardness value at hospital was found to be 49.80 °F (French Hardness) in service 3, while the lowest value was 49.30 °F in the hospital kitchen. The nitrate nitrogen (NO_3^-) values in the hospital water ranged from 5.48 to 5.98 mg/l. The value of manganese was measured as 59.30 mg/L in service 2 and the lowest value was 58.90 mg/l in service and hospital kitchen. The lowest calcium (Ca^{+2}) value in was 110.20 mg/l at the service 1 and the highest level was found to be 111.50 mg/l at the service 2. In terms of (HCO_3^-), the value was determined as 146 mg/l at all sample points. The chloride (Cl^-) values in the hospital water ranged from 114.30 to 115.10 mg/l and sulfate (SO_4^{-2}) values in the hospital water ranged from 189.70 to 197.20 mg/l. The results show that all physicochemical parameters determined including temperature, pH, electrical conductivity, total hardness (TH), Ca^{+2}, Mg^{+2}, Cl^-, HCO_3^-, SO_4^{-2}, and NO_3^- are within the recommended standard limits (WHO and JORA) for these contents in drinking water.

Microbiological parameters

The values of various microbiological parameters of the water samples at different services of the hospital are presented in Table 2.

Total germs

With regard to total germs at 22 °C, it can be noted that they are values relatively higher at service 3 and kitchen 128 UFC/100 ml and 114 UFC/100 ml respectively (Fig.1), while the lowest concentration was observed in service 1 (2 UFC/100 ml) and service 2 3 UFC/100 ml. The results of total germ count at 37 °C show relatively higher val-ues at kitchen (134 UFC/100 ml) compared to service 1 (53

Table 2. Microbiological parameters of water distributed in hospital supply system

Germs	Kitchen	Service 1	Service 2	Service 3	WHO/JORA
Total germs at 22 °C	114	2	3	128	100/100ml
Total germs at 37 °C	134	53	64	40	100/100ml
Total coliforms CFU/100 ml	146	13	48	41	0/100ml
Fecal coliforms CFU/100 ml	371	00	3	00	0/100ml

(Service 1: Gastroenterology/infectious diseases. Service 2: Woman. Service 3: Pneumo-phthisiology).

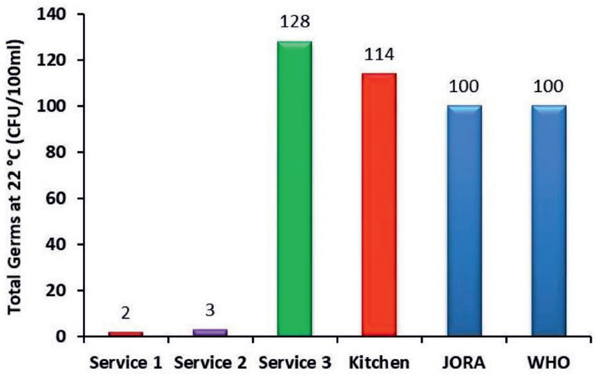

Fig. 1. Values of total germs at 22 °C in different water sampling points in hospital

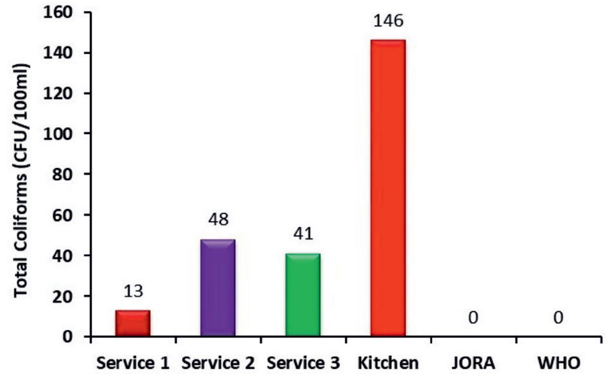

Fig. 3. Variations in values of total coliforms in different water sampling points in hospital

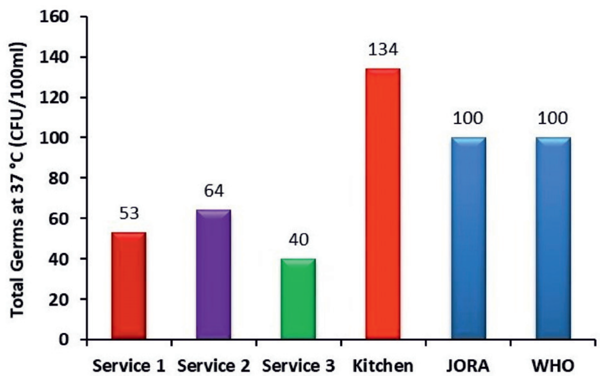

Fig. 2. Values of total germs at 37 °C in different water sampling points in hospital

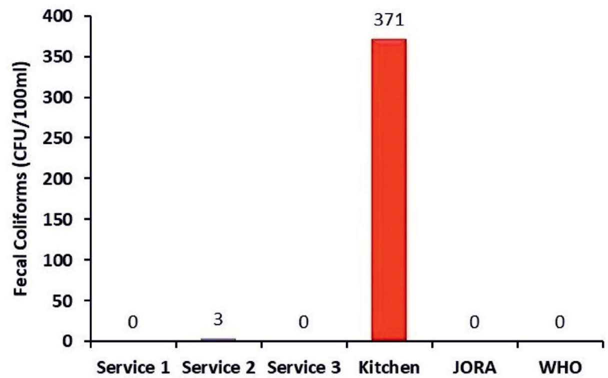

Fig. 4. Variations in values of fecal coliforms in different water sampling points in hospital

UFC/100 ml), service 2 (64 UFC/100 ml) and service 3 (40 UFC/100 ml) (Fig.2) which indicates the contaminated than the hospital's drinking water.

Water can carry many germs, sometimes causing serious infections in patients and health professionals, and drinking water should normally be free of bacteria (Flouchi et *al*, 2021). Water contamination not only occurs during processing but also due to how and where they were stored, the microbes in the water can proliferate to an amount that can become pathogenic. Drinking water can be polluted at any point in the chain from the source to household container and polluted water, in turn, can carry several waterborne pathogens (WHO, 2017a). Transmission routes for waterborne infection are typically through inhalation, aspiration, ingestion, or contact from a wide variety of water sources and potentially an even wider variety of equipment (Maynard and Whapham, 2020). However, based on the nature of the processes in the hospital the water demand on each area and unit is different. Also, the storage of water leads to a deterioration of its quality because of its contamination in their reservoir.

Total and fecal coliforms

Fig.2 shows that the total coliforms (TC) concentrations are higher in kitchen (146 CFU/100 ml), compared to other sites. While the low-est concentration was observed at service 1 (13 CFU/ 100 ml). The highest value in terms of fecal coliforms was determined as 371 CFU/100ml in the hospital kitchen, the lowest value was 0 CFU/100ml in the service 1 and 3 (Fig.3 and 4).

Coliforms are routinely found in natural environments, as some of them are of telluric origin, their presence in drinking water must at be considered as a threat or indicative of microbio-logical water quality deterioration. Total Coliform bacteria are used as an indicator of other pathogenic bacteria mainly because their presence in water sample indicates environmental contamination and presence of water borne diseases bacteria (Nicholson et *al*, 2017). (TC) are Gram-negative bacilli; aerobic and anaerobic optional. These are indicators that reveal the possible presence of bacteriological contamination and this at indicates chlorination has not been done properly, which in turn implies pathogenic bacteria contamination of the drinking water. The presence of total coliforms does not imply fecal contamination but indicates other sources of contamination that should be analyzed to decide the route the organisms are entering the water system (Ajumobi and Olayinka, 2014).

Coliforms are the indicators of contamination by fecal matters and are therefore routinely carried out by many public health officers to ascertain the quality and potability of water to ensure prevention of further dissemination of pathogens. Any potable water may be contaminated microbiologically due to insufficient sanitation and unhygienic practices (Wright *et al*, 2004). The presence of microorganisms isolated from different hospital water sources indicates a potential risk to human health, especially for the immunocompromised patients suffering from serious diseases (Arroyo *et al*, 2011). High values of fecal coliforms in hospital water are direct evidence for fecal contamination and the occurrence of waterborne diseases. When control of the microbiological safety of water systems cannot be achieved throughout the system by maintaining temperatures, additional control strategies should be considered to reduce the risk of waterborne infection (Maynardand Whapham, 2020). The water use varies depending on different utilizations, and according to the health care units for which it is intended (Flouchi *et al*, 2021). *E. coli* are present in the intestine of men and animals and are released into the environment in fecal material. The high levels of fecal coliforms could be explained by the poor protection of these water points and infiltration of surface water. Gastrointestinal diseases transmitted through water are one of the factors that perpetuate the cycle of poverty, as most of the time they result in diarrhea that, in turn, results in dehydration, malnutrition, and low intellectual development (WHO, 2019). However, although microbial contamination is high, especially in the hospital kitchen. A high count of fecal coliforms in drinking water is direct evidence for fecal contamination and the occurrence of waterborne diseases. Fecal contaminants going into the water supply could lead to a serious form of water contamination leading to the transmission of enteric pathogens such as *Salmonella spp*., *Shigella spp*., *Vibrio cholerae*, and *E. coli*. These pathogens are usually found in human and animal feces and could possibly reach the sources of community water supply through leaching or other means such as improperly treated sewage (Bennett *et al*, 2018). If indicator microorganisms are observed in a substance, it designates the presence of fecal contamination and therefore, pathogenic micro-organisms might be present in that water. Commonly used strategies include the use of physical engineering measures such as filtration and pasteurization and/or chemical measures with the use of biocides (Maynardand Whapham, 2020). Therefore, necessary protection measures should be taken as related to planned usage of the water in hospital. Hospitals need to ensure that the water supply is adequate as per the requirement. Diseases related to contaminated water are a major burden on human health and improved quality of drinking-water provide significant health benefits (WHO, 2017b). Water quality encompasses physical, chemical and biological properties that are supposed to be in line with the required specifications (Agensi *et al*, 2019).

CONCLUSION

Water is an essential element in the hygiene and functioning of health facilities. This study assessed the quality of the hospital water in Tiaret (Algeria) as measured via physical-chemical and microbiological parameters. The present study concluded that the values of the physico-chemical parameters of water sampled in the hospital supply system were always within WHO guidelines standards and Algerian regulation. Also, results obtained from this study indicates the pollution tendencies of the hospital water, attributable to high levels of total germs, total coliforms and fecal coliforms, this at indicates chlorination has not been done properly, which in turn implies pathogenic bacteria contamination of the water. All water samples from the hospital internal water distribution system of different sampling points fail to comply with the WHO or national standards for bacteriological drinking water quality in terms of total germs and coliforms. Thus, the hospital water should be treated before use to avoid water-related diseases that can have harmful effects on humans.

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