Evaluation of Microbial or Bacterial Quality of the Drinking Water of Duba Province North Saudi Arabia

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ABSTRACT---- ***This research was conducted to measure the bacteriological contamination of drinking water in Duba Northern Province, Tabuk, Saudi Arabia. 93 water samples were collected randomly which were 30 samples of mineral water bottles representing five brands, 40 samples tap water, 20 sample local desalinated water and 3 samples of agricultural wells water. MacConkey broth was used for counting total coliform and faecal coliforms wheras plate count was used for detection of other non coliform bacteria. The results showed that coliforms were detected in samples taken from local desalinated water, tap and well water at percentages of 60%, 25% and 67% in order. No coliforms were detected in bottled water samples. Fecal coliforms were identified as Klebsiella sp. Streptococcus faecalis. The isolation percentage were 30%, 3.33% and 67% for local desalinated water, tap and well water in order. Non coliform bacteria were isolated from different water samples (local desalinated, tap and well water) and were identified as, P. aerugnosa, Staphyllococcus epidermis, S. aerus. Klebsiella sp. and P. aerugnosa recorded the highest count percentage when compared to the other genera . Among the different resources well water showed the highest bacterial contamination followed by local desalinated and then tap water.***

Keywords— Drinking water, coliform, fecal, tabuk

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1. INTRODUCTION

Water is extremely essential for survival of all living organisms. Over one billion people worldwide have no access to safe drinking water. The quality of water is vital concern for mankind since it is directly linked with human welfare (Peeler et al, 2006). The water quality performs an important role in the human health, animals, and plants. The lack of good quality water supplies leads to the spread of diseases (Howard and Bartram, 2003). Well water is used without being treated in many villages [Al-Otaibi 2009]. In Duba province the consumption of bottled water is very high when compared to tap water. Drinking water from different water resources such as wells and tankers should be pure and free from waterborne pathogenic contaminants such as viruses, parasites, fungi and bacteria. In general, terms, the greatest microbial risks are associated with ingestion of water that is contaminated with human or animal faeces (Atiribom, *et al.*, 2007).

Previous studies in the Saudi Arabia have revealed high occurrence rates of infection with intestinal microbes. Water may be contaminated in many ways and the three main forms of water contamination are physical, chemical and microbial (Fall *et al* 2007). However, microbiological quality is the most important aspect of drinking water with respect to waterborne diseases. For evaluation of water quality total coliform (TC) is used as a parameter giving basic information on microbiological quality of surface waters (WHO, 2008). For more than a century the presence of coliform bacteria in drinking water has been taken as an indication of fecal contamination, and thus of a health hazard (Westrell *et al*. 2003, Ali & Osman 2010). Coliform bacteria are always present in the digestive tracts of animals, including humans, and are found in their wastes. They are also found in plant and soil material of which the most common member is *Escherichia coli (E. coli)* and other subgroups of coliforms including species of *Klebsiella*, *Enterobacter*, and *Citrobacter* (Fewtrell & Bartram 2001, and Viau *et al*. 2011). To clarify this, there is a need for more extensive studies of drinking water in our communities. Moreover, many studies of microbial contamination of water have been carried out at different regions of Saudi Arabian kingdom. Considering the above aspects of water contamination, the present study was undertaken to investigate the drinking water quality of different samples collected from different sources in Duba

province north Saudi Arabia Kingdom. Different tests have been carried out to measure the levels of microbial contamination which include MPN test, total bacterial count, identification of the isolated bacteria and detection the presence of fecal Coliform in order to evaluate the quality of drinking water and consequently its safety and validity for human consumption.

2. MATERIALS AND METHODS

2.1. Sources of water samples

Ninety three water samples were collected from four sources in Duba city which included, governmental sea desalinated tap water (40 samples), bottled water (30 samples), local commercial desalinated water factories (20 samples) and non-drinkable wells water (3 samples). Each sample was collected in a sterile syringe (3ml) of water and were investigated for bacterial contamination**.**

2.2. Sample collection

2.2.1. Governmental sea desalinated tap water sampling

Three-ml. sample was taken from randomly selected households of 5 region in Duba province. Samples were obtained after opening the faucet and allowing tap water to run for approximately 5 minutes. A total of 40 samples of tap water were taken from all 5 areas in Duba. All samples were stored in sterilized tubes prior to analysis in the laboratory at 25-30 ^{o}C.

2.2.2. Commercially available bottled mineral water sampling

One bottle of each different sized commercial preparations (33, 6.0, 1.5, and 5.0 liter bottles) were selected randomly from 5 different grocery stores in Duba. A total of 30 samples of bottled mineral water were taken. All samples were stored at room temperature (25-30^{o}C). In the laboratory, each bottle was adequately shaken then, a sample of three milliliter was taken from each sample using sterile syringe for microbiological analysis, properly labeled and recorded.

2.2.3. Local commercial desalinated water factories sampling

Bottles from local factories in Duba were selected randomly then each bottle was shaken and a sample of 3ml was taken by sterile syringe. A total of 20 samples of bottled water were taken. All samples were stored at room temperature (25-30 ^{o}C)

2.2.4. Well water sampling

Well water samples were collected from different wells scattered throughout villages in Duba region. Water was allowed to run for several minutes before taking the samples, 3 ml of water samples were collected in sterile syringe from each well.

These representative samples were then examined to assess their bacteriological characteristics and suitability for potable purposes [Koneman *et al* (1992)]. American Public Health Association (APHA) (1998)].

2.3. Bacteriological studies

2.3.1. Most Probable number (MPN) Method

One ml of each sample was inoculated separately in a tube containing 5ml of MacConkey broth (three replicates for each test). Samples were incubated at 37°C for 48 hours to observe the lactose fermentation at each set and the bacterial growth. Another method for bacterial Colony-forming Units (CFUs) per milliliter was carried out on agar plate media.

Bacterial identification was conducted using the API system of bacterial identification after the required 24 to 48 hours of incubation. Morphological characterization was done using binocular light microscope to ensure Gram-negative and the bacterial shapes. To differentiate between fecal *E.coli* and other *E.coli*, cultures were incubated at 44°C (in water bath) for 24 hours.

2.3.2. Identification of different bacterial Isolates in water samples

Bacteria isolates of morphologically different colony types were selected from plate count agar and cultured on MacConkey agar medium to differentiate between lactose fermented bacteria and non- fermented one by the colony colour. Then the positive lactose fermented bacteria were grown on bile esculine agar media to determine whether the bacterial colony belong to *E. faecalis* or non *faecalis.* The non-lactose fermented bacteria were cultured on nutrient agar media and the colony colure was observed.

2.3.3. Biochemical Characterization:

Different biochemical tests were carried out for identification the bacterial isolates and these include : Gram staining, catalase test and oxidase test according to William *et al.*, 2001) and also endospore staining, and production of acid from glucose according to Abualdahab and Gorani, 1983.

The Oxidation/Fermentation (O/F test) test was also carried out as described by William *et al.*, (2001). Two tubes of Hugh and Liefson's medium were inoculated with fresh cultures, one tube was covered with sterile paraffin oil and the other was left open. Incubation was carried out at 37°C for 24-72 hours. Growth in both tubes was observed (positive result in the first tube due to fermentation metabolism while growth in the open tube only was recorded as oxidative metabolism) as described by (William *et al.*, 2001).

3. RESULTS

Coliform group was detected by production of acid and gas on the MacConkey broth media. Results of the tested samples showed that, no coliforms were detected in any of the bottled water samples of the current study (Table 1). However, the percentage of coliforms detected was 60% in local desalinated water, 25% in tap water samples and 67% in well water samples. The total coliform number in well water was greater than in tap water and local desalinated water.

Table 1. percentage of coliform bacteria collected from different water sources in Duba rural areas, Saudi Arabia

Water samples	**Total number of samples**	**percentage of coliform group**%
Bottled water	30	0.00
Local desalinated water	20	60
Tap water	40	25
Well water	3	67

No faecal coliforms were detected in bottled water but they were detected in other tested samples with different percentages. Well water recorded the highest percentage of fecal coliform (33%), then local desalinated water (30%) and tap water samples were 6.67 % (Table 2).

Table 2. Fecal coliforms counts/100 ml water samples collected from different water sources in Duba rural areas, Saudi Arabia

Water samples	**Total number of samples**	**percentage of coliform group**%
Bottled water	30	0.00
Local desalinated water	20	30
Tap water	40	6.67
Well water	3	33

Table 3 showed the distribution of the different coliform subtypes on the tested samples. The highest distribution percentage were recorded by two subtypes, *Klebsiella* sp. and *P. aerugnosa*. The distribution percentages, of *Klebsiella* sp. were 6.67%, 33% and 10% while the *P. aerugnosa* percentages were 6.67, 33% and 20% from tap water, well and local desalinated water in order. The rest of coliform subtypes were *Staphyllococcu epidermis*, *S. aureus*, Streptococcus *faecalis* which were detected only in two samples, local desalinated and well water (Table 3).

Table 3. Distribution percentages of bacterial isolates in different water samples in Duba city, Saudi Arabia

Bacterial Isolates	**Water Samples**				
	Distribution Percentages %				
	Bottled water	**Tap water**	**Wells**	**local desalinated**	**Total %**
Klebsiella sp.	0.00	6.67(2)	33(1)	10(2)	49.6
P. aerugnosa	0.00	6.67(2)	33(1)	20(4)	59.7
Staphyllococcus epidermis	0.00	3.33(1)	0.00	15(3)	18.33
S. aerus	0.00	3.33(1)	0.00	10(3)	13.33
Streptococcus faecalis	0.00	0.00	33 (1)	15(3)	38

4. DISCUSSION

In this study, The presence of coliform group at the tested water samples may be attributed to contamination of the hoses used by humans, including farmers and livestock owners; and the exposure of these delivery hoses to dust storms (Pritchard 2007). Fortunately there is no coliform bacteria detected in bottle water samples in the present study. These data confirmed that bottled water is suitable for human use. In Riyadh Nounou *et al*. 2013 tested different water sources, (bottled water, tap and well water) for the presence of total and faecal coliform bacteria and he concluded that bottled water samples were free from any contaminants, while, tap and well water were contaminated with coliform group and

their contamination percentages were 11%, 30% respectively. Faecal coliform (87.9%), and fecal streptococci (57.6%) were detected in 33 well water samples in Khamis Mushait Governorate, Southwestern Saudi Arabia which were tested by AlOtaib 2009. The result of the present study revealed that the well water is contaminated more than the other sources. This is expected since these wells do not receive any disinfection treatment before consumption in suburban areas. Previous workers (Knappettet *et al*. 2012, Saatti and Faidah 2013 and Levy et al. 2012) have indicated that dust storms and livestock activity in the vicinity of surface wells increase microbial levels and bacterial input. Moreover, the absence of microbial contamination in some of the wells tested may be attributed to the fact that the high salinity of water in some of the wells examined may have hindered proliferous bacterial growth in spite of the eminent contamination cited above (Abdel Magid *et al*. 1984, Al-Redhaiman & Abdel Magid, 2002).

Our study revealed that tap water and local desalinated water recorded higher levels of bacterial contamination in many samples than the national and international guideline values (WHO. Guidelines for Drinking Water Quality 2011). Abu-Zeid *et al*. found that 30% of 20 samples from house tanks for tap water and 6.67 of 40 samples for desalinated water showed contamination. We suggest that water contamination obviously take place during storage in house reservoirs or during transportation, and was possibly implicated, that when water from sources were tested in the present study the result obtained that it was free from water borne pathogens, this indicated that the water gets more contaminated at the point-of-use than at the source. This could be a result of biofilm growth in the household tanks (Obiri-Danso *et al*. 2003). The use of roof tanks for water storage is a common practice in all regions in Saudi Arabia. The lack of cleaning contribute in water contamination. In many previous studies, diarrhea was strongly associated with the cleaning of water tanks (Jensen *et al*. 2004 and Cabral *et al*. 2010). To maintain the quality of drinking water in roof tanks as received from the source, it would be necessary to implement effective awareness and educational programs.

The study of the bacteriological quality of the samples of drinking water revealed that *Pseudomonas. aerugoinosa*, and *Klebsiella* spp. accounted for 50% of all strains isolated. These genera are pathogenic, and their isolation might be important because of their contribution to water-borne infections.(Cabral 2010). Furthermore, the presence of *Staphyllococcus* aureus and *S. epidermidis*, in water samples from tap and desalinated local water is an indication of hand contamination and inoculation from the human skin. (Saatti and Faidah 2013, Mashat 2010). The contribution of bare hands and fingers to the contamination of drinking water has been emphasized in many previous studies (Saatti and Faidah 2013, Mashat 2010). The presence of faecal coliforms (*Klebsiella* species) is an indicator of serious public health risks (Evans *el al*. 1981).

5. CONCLUSION

Since in the current study the bottled water is found free from water borne bacteria this is an indication that it is sufficient for human drinking purposes. Desalinated water might be contaminated during its transportation from the desalination plant to the consumer or during storage in a house reservoir. Well water showed increases in the detected bacteria; followed by tap water. Contamination of tap or well water may occur during storage in the house reservoirs or from the wells' delivery hoses. Bacteriological contamination of water samples between the source and point-of-use in Duba city is widespread and highly alarming. Public tankers should be thoroughly washed regularly, and chlorine levels monitored. Safer household water storage and treatment is recommended to prevent post collection contamination. In addition, this study highlights the importance of the awareness and educational programs for residents on the effect of polluted water on public health.

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