Seasonal Variations of the Microbiological Parameters of the Quality of Water in Urban Oued Bouishak of the City of Meknes (Morocco)

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Abstract. The objective of this work is to monitor the bacteriological quality of urban wastewater from the Bouishak wadi in the city of Meknes (Morocco). In this study, bacteriological parameters has monitored at three selected upstream-downstream sites (B1, B2 and B3). The sampling has carried out monthly between 10 and 11 h during a period from January to December 2017. The results obtained show that the average concentrations of the various parameters sought are. 9.88 10^6 for the total germs; 8.01 10^6 for total coliforms; 5.92 10^6 for fecal coliforms; 4.98 10^6 for fecal streptococci; 1.54 10^4 for anaerobic sulphite-reducing bacteria and 2.46 $10^5$for Escherichia coli (these concentrations are in colony-forming units per 100 ml) and pathogenic germs such as salmonella and anemic vibrio. The genus Salmonella has detected in July and August at station B1. Their presence at this hot time could be due to human activities. For cholera vibrio, no cases were isolated in the waters of the selected sites. However, this contamination exceeds the standards of Moroccan wastewater discharge. The origin and degree of bacterial contamination are due to the human activities and climatic conditions of the region. In view of the above, the urban waters of Bouishak Wadi are of poor quality.

Keywords: Wastewater · Bouishak wadi · Bacterial contamination · Impact

1 Introduction

To cope with water stress, the reuse of raw wastewater, especially in agriculture, has become an alternative means. Admittedly, the use of this wastewater without any prior treatment constitutes a danger to human health and the natural environment because of their toxic chemical charges and pathogenic microorganisms (bacteria, viruses,

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parasites, etc.) [1–5]. On the other hand, the transmission of pathogenic microorganisms that reside in water is via the fecal-oral route [6, 7]. However, humans can be infected by either the consumption of unsafe water, the consumption of food wiped off by polluted water, or when in contact with recreational water [6, 8]. The reuse of wastewater is therefore a source of waterborne diseases (dysentery, typhoid fever, cholera) [9]. Thus, these epidemics increase the mortality rate in developing countries [10–13]. Therefore, to preserve the good quality of the water, the protection of these natural environments against any urban or industrial pollution is essential. The choice of the water quality study of the Bouishak Wadi has based on their major role in the irrigation of market gardening and oleaginous crops and their use by the population of the Toulal commune. The assessment of bacterial pollution of surface waters involves the search and enumeration of bacteria indicative of fecal contamination such as total germs (GT), total coliforms (TC), fecal coliforms (FC), streptococci fecal (SF), anaerobic sulphite reducers (ASR), Escherichia coli (E. coli) and pathogenic bacteria (Salmonella, Shigella, cholera vibrio …) [14, 15]. An earlier study on the impact of domestic and industrial discharges on the quality of urban water in Bouishak wadi has carried out in 2009 [5]. In the current state of knowledge, no study has conducted on the seasonal variation in the degree of bacteriological pollution of this watercourse. It is in this context that the present study is interesting to:

- monitor the bacteriological quality of Wadi Bouishak urban waters. The follow-up from January to December 2017 has done.
- inspire temporal and seasonal differences and similarities between sampling stations (B1, B2 and B3),
- identify the risks of the impact of human activities on the water quality of this watercourse.

2 Materiel and Methods

2.1 Study Area

The wastewater reuse areas in the city of Meknes are mainly located along the river Ouislan and Bouishak. Agriculture is mainly oriented towards market gardening and arboriculture. The Bouishak wadi is located in the Fez Meknes region, characterized by a semi-arid climate and a relatively low water flow, and used for irrigating the irrigated fields. For a more representative sampling of the watercourse, we have chosen three stations on the Bouishak wadi bed (see Fig. 1). Station B1 is located upstream of watercourses in a zone of great human influence (domestic, industrial and agricultural). Stations B2 and B3 are located downstream from the town of Meknes.

(Table 1) presents the characteristics of the stations studied. The Bouishak Valley has irrigated almost exclusively by raw sewage 93% compared to 25% by mixed water (see Fig. 2).

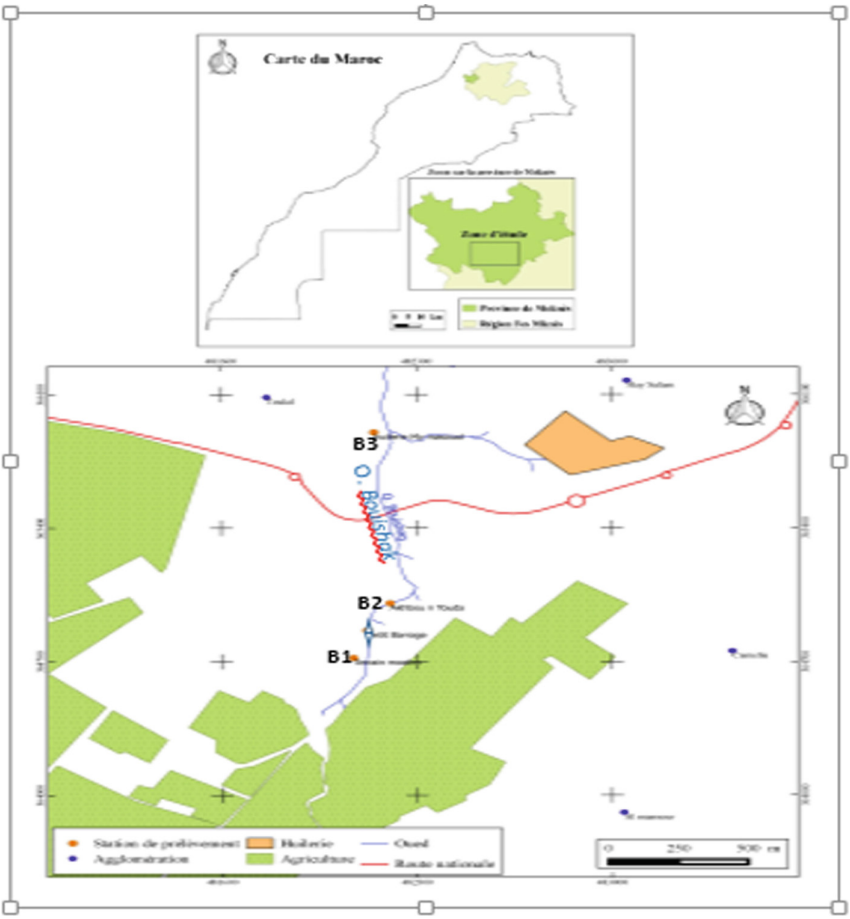

Fig. 1. Geographical location of the city of Meknes and its cutting Administrative

Table 1. Lambert coordinates of the various stations studied

	Station	Type of pollution	Lambert coordinates		
			Latitude	Longitude	Altitude
Water Bouishak river	B1	Domestic, agricultural and industrial	482120,6	364713,8	488
	B2	Domestic, agricultural and industrial	482205,4	365004,5	481
	B3	Domestic, and industrial	482202,5	365900,2	458

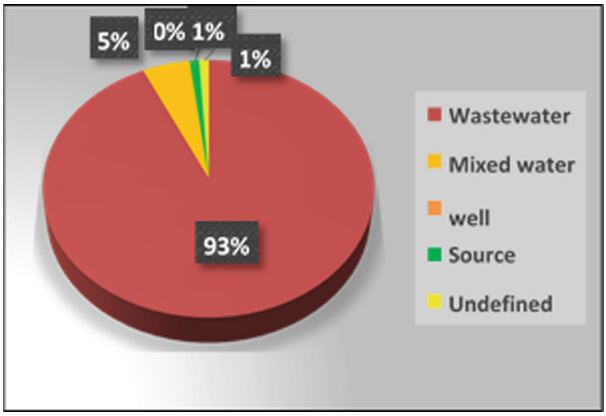

Fig. 2. Different types of irrigation water for Bouishak wadi (RADEEM, 2003)

2.2 Bacteriological Analyzes

The bacteriological analysis consists of determining the qualitative and quantitative quality of the bacteriological parameters of the waters of this watercourse. Monthly samples has taken at the surface of the water in 500 ml sterile glass vials and transported in a cooler at ±4 °C to the management and development laboratory of the Meknes Faculty of Science. The bacteriological analysis of the samples taken has determined by the membrane filtration method. This concentration technique has performed after making a range of dilutions (10^{-1}, 10^{-2}, 10^{-3} …). Filtration has carried out on a cellulose ester membrane with a porosity of 0.45 µm. Different culture media has used depending on the type of bacterium sought. For the detection and enumeration of total coliforms and fecal coliforms, TTC-Tergitol lactose agar has used. While fecal streptococci are isolated and enumerated on the agar medium of Slanetz and Bartley [15]. Salmonella has tested according to the Moroccan standards: 03.7.050 NM [16] of the year 1995. Isolation of Shigella and Salmonella has performed on Salmonella-Shigella agar. Confirmation of presumptive colonies was obtained by Gram staining and some standard biochemical tests [17].

3 Results and Discussions

The variation of the bacterial load in Bouishak wadi water has studied according to two parameters: a time factor represented by the seasons and a space factor represented by the different sampling stations located on the riverbed. The microbiological study of the waters of Bouishak Wadi revealed a significant bacterial contamination, well above the standards of the WHO (1989) [18] (>1000 FC/100 ml) with regard to the direct rejection in the environment. These waters has classified as of poor quality according to the Moroccan classification. Similar works by several authors [19–22] have concluded these results. The bacteriological analysis of raw wastewater at the different stations (B1, B2, B3) during the 2017 monitoring period (see Fig. 3, 4 and 5) showed

significant differences for all groups of organisms: total germs (GT), total coliforms (TC), fecal coliforms (CF), fecal streptococci (SF), sulfite-reducing anaerobes (ASR) and Escherichia coli (E. coli).

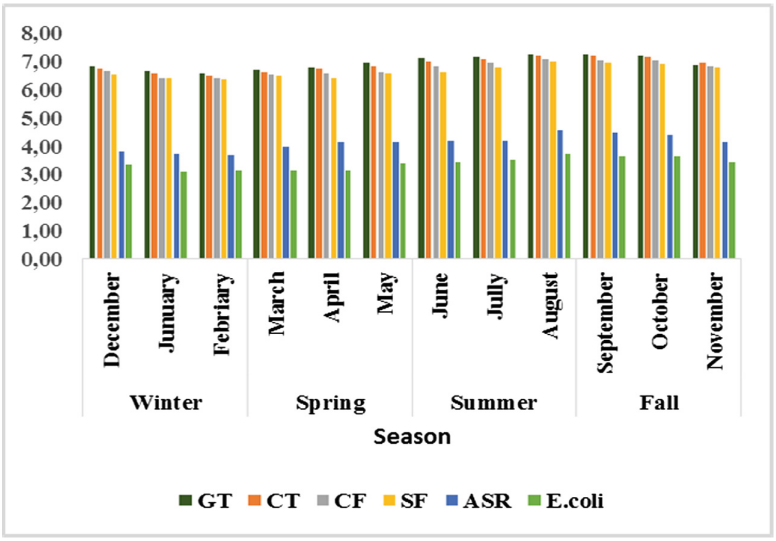

Fig. 3. Seasonal and monthly variation of total germs (GT), total coliforms (TC), fecal coliforms (CF), fecal streptococci (SF), sulphite-reducing anaerobes (ASR) and *Escherichia coli* (E. Coli) at the level of station B1.

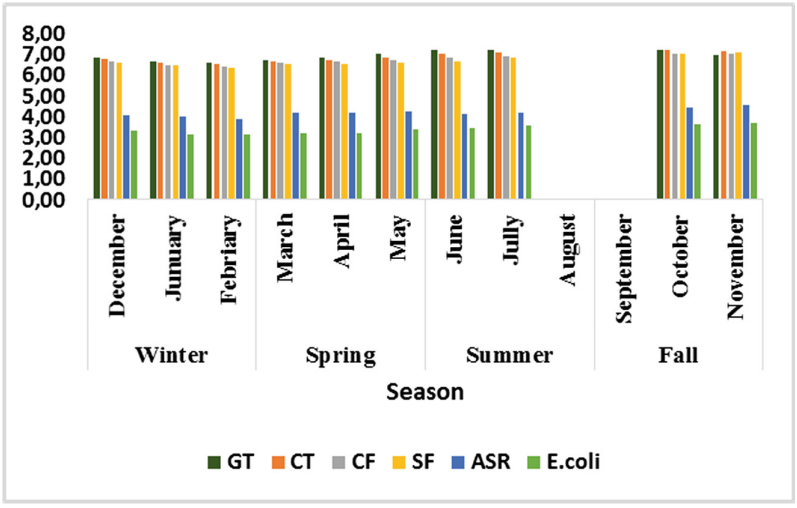

Fig. 4. Seasonal and monthly variation of total germs (GT), total coliforms (TC), fecal coliforms (CF), fecal streptococci (SF), sulphite-reducing anaerobes (ASR) and *Escherichia coli* (E. Coli) at the level of station B2.

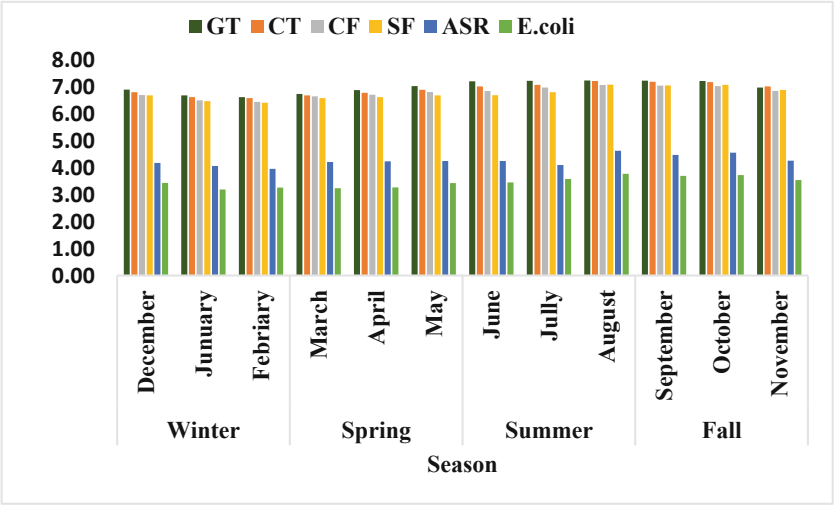

Fig. 5. Seasonal and monthly changes in total germs (GT), total coliforms (TC), fcal coliforms (CF), fecal streptococci (SF), sulphite reducing anaerobes (ASR) and *Escherichia coli* (E. Coli) at the level of station B3.

The average concentrations of the lowest bacteria has recorded at station B2: they are 9, 88 10^6; 8,01 10^6; 5,92 10^6; 4,98 10^6; 1,54 10^4; 2, 46 10^5, respectively for GT, CT, CF, SF, ASR and E. coli. The averages representing the downstream station B3 are as follows: (GT 11, 28 10^6); (CT 9.52 10^6); (CF 7.07 10^6); (SF 6.52 10^6), (ASR 2.06 10^4) and (E. coli 3.26 10^5). Whereas the bacterial concentrations observed at the upstream station B1 are the following: (GT 10.04 10^6), (CT 8.93 10^6), (CF 6.44 10^6), (SF 5.15 10^6), (ASR 1, 59 10^4) and (E. coli 2,71 10^5). Similar results has been observed by other authors, notably El Addouli et al. [5] on the water quality of Bouishak Wadi; EL Ouali Lalami et al. [23] on the quality of surface water in the city of Fez in Morocco; as well as Aboulkacem et al. [24] on the quality of the waters of Boufakrane wadi in Morocco [20]. Throughout the study and at all stations, the concentration of SF is lower than that of the GT, CT and CF groups. The average charges of SF are of the order of 1.59 × 104; 1.54104; 2.06 104 respectively at stations B1, B2 and B3. These results are consistent with previous work [25–27]. In contrast, fecal streptococci are characterized by a greater affinity for the decantable fraction in soils, rivers and runoff [28, 29], also influenced by abiotic factors in the natural environment [30, 31]. Microbiological analyzes of effluent discharged into Bouishak river reveal a high density of Escherichia coli. This clearly confirms fecal contamination. Certainly, among the markers of water pollution and controls fecal the results of our research show that bacteriological analysis of water from Bouishak wadis has more polluted during the dry season than during the rainy season (Fig. 6).

Fig. 6. Spatio-temporal variation of the desired germs (CFU/100 ml)

In addition, anthropogenic activity, the physical properties of the environment and the climatic context are the main factors of degradation of water quality. Seasonal variations of bacteria indicative of contamination can be explained either by the influence of changing climatic conditions or by the characteristics of the sewer system that influence the nature of the effluents (industrial and/or domestic). Indeed, the sampling season has an influence on the chemical and bacteriological concentrations of water [32–35]. On the other hand, the rise in water temperature is a direct consequence of an increase in the number of pathogens in the dry period [36].

The concentration of all isolated shoots is lower in December, January and February, during which time the precipitation rate is higher. This decrease in the concentration of germs has be explained by the dilution of water by rain. While a significant increase appears during the month of April 2017. In this context, several studies have highlighted the increase in bacterial load in the dry season compared to the rainy season [34, 37]. Our results show that there is a correlation between time and

space of the variation of indicator bacteria from fecal contamination. Other studies have confirmed that spatio-temporal variation is the main factor controlling the bacteriological quality of water [25–27]. The results of the Salmonella bacteria research has detected in July and August at station B1, their presence at this summer period should have due to the variability of human activity. However, sources of Salmonella contamination are infected human and animal wastes (15). The dry season appears to be at risk due to the elevated bacterial load during this time. On the other hand, other similar works have mentioned the absence of the salmonella genus [5, 24, 38–40]. In addition, other studies suggest that these pathogenic bacteria may retain their pathogenicity in the viable non-cultivable state [41–43].

4 Conclusion

The present work is part of the monitoring of the bacteriological quality of the Bouishak wadi, which receives discards without any prior treatment, and the distribution of indicator germs and pathogens. The results of the bacteriological analyzes showed a spatial and temporal variability of the contamination indicator bacteria (GT, CT, CF, SF, ASR, and E. coli) this could been related to the characteristics of the sewerage network. The density of fecal germs varies from upstream to downstream and from one season to another and the values recorded far exceed the water standards for irrigation. Therefore, these waters should not have used for irrigation of vegetable crops in the region. Irrigation by these polluted waters is a danger for agriculture. This results in a need for urgent intervention to rehabilitate the site. The illegal discharge of sewage from collectors into waterways is a major ecological problem that must been taken into consideration. It is therefore, recommended that the installation of treatment plants for water treatment should be established before discharge in all ways. Alternatively, to set up separate channels to collect the effluents.

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