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Evaluation of the impact of wastewater in the rural commune of Jmaa Moulblad on the bacteriological water quality of the Grou River (Rabat region, Morocco)

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Abstract

In the region of Rabat, shallow watercourses are currently threatened by the magnitude of urban and industrial discharges, mainly due to its growing demography and the continuous development of the agricultural and industrial sectors. This study aims to evaluate the impact of wastewater from the rural commune of Jmaa Moulblad on the bacteriological water qualityof the Grou River.

In order to measure the pollution levels of this watercourse, our study focused on the enumeration of fecal contamination indicator bacteria such as total coliforms (TC), faecal coliforms (FC) and intestinal enterococci (EI), as well as the detection of salmonella. Water samples were taken by season during the 2016/2017 period at four stations on the Grou River. The results obtained describe a worrying state of the watercourse, particularly at the S_2 station located directly at the mouth of the wastewater of the rural commune of Jmaa Moulblad which is rejected without prior treatment. If protective measures are not taken, the perpetual degradation of the quality of these waters would certainly lead to the loss of this watercourse, which is of paramount importance in the region.

Keywords*: wastewater, bacteriology, contamination, Grou River, Morocco.*

I. Introduction

In Morocco, a country with arid to semi-arid Mediterranean climate, the hydric potential is relatively limited and uncertain [1]. As in all countries, this hydric potential is affected by all forms of pollution, its qualitative status is far from satisfactory [2], especially at the level of the region of Rabat, object of this study. Indeed, population growth accompanied by rapid urbanization causes many disturbances to water resources [3]. The industrialization, the irrational use of fertilizers, and the lack of population awareness towards the protection of the environment, lead as much to an imbalance of the ecosystem and maximize the spread of polluting elements, which can affect the physicochemical and biological quality of the receiving aquatic environments [4]. These pressures on water resources are accompanied by an increasing degradation of their quality [5], and a loss of their self-purification capacity to a large extent [6]. In the region of Rabat, the Grou River plays a very important role in livestock watering, irrigation, bathing and other socio-economic activities of the local population. It also contributes to the supply of the reservoir of the Sidi Mohammed Ben Abdellah dam (SMBA) intended for the production of drinking and industrial water for the entire coastal region ranging from Rabat to the metro pole of Casablanca [7]. However, the intense impression that is exerted on its water resources causes the degradation of their bacteriological quality and the consumption of water contaminated by micro-organisms is the origin of several epidemics [8]. These conditions attract the interest of several researchers. But so far, no study of this kind has been carried out on this river. This study provides an overview of the impact of wastewater from the rural commune of Jmaa

Moulblad on the bacteriological water quality of the Grou River. The main objective of this work is to alert and sensitize local communities of the seriousness of the situation in an attempt to remedy this problem.

II. Material and Methods

II.1. Study site and sampling stations

The Grou River (Figure 1), located on the central Moroccan plateau, is one of the main rivers that feed the reservoir of Sidi Mohammed Ben Abdellah (SMBA) which is dedicated primarily for the production of drinking water. However, this watercourse is particularly affected by pollution due to the daily wastewater discharges. Therefore, for an adequate evaluation of the impact of the wastewater of the rural commune of Jmaa Moulblad on the bacteriological water quality of the Grou River, we have chosen four sampling stations along this watercourse. Are:

- Station S_1: Located upstream, has been chosen as the reference point.
- Station S_2: Located immediately downstream after the confluence zone with the wastewater of the rural commune of Jmaa Moulblad rejected without any prior treatment.
- Station S_3: located 35 Km from S_2, at a more or less sufficient distance to the setting up of the phenomenon of natural self-purification of water.
- Station S_4: is located 30Km from S_3, downstream of the river, at the confluence zone with the waters of the SMBA dam.

Figure 1: Location of the study site (Source: [9]. Slightly modified)

II.2. Sampling and analysis

To enumerate fecal contamination indicator bacteria, such as Total Coliforms (CT), Fecal Coliforms (CF) and Intestinal Enterococci (IE), as well as evidence of the presence or absence of Salmonella in the water of the Grou River, seasonal sampling was carried out during the period (December 2016 - July 2017), according to the filtration method, as it has been described in the Moroccan standard norms [10; 11 and 12]. The water samples were collected in sterile ground-capped vials with a capacity of 1000 ml and transported to the laboratory in a cold cooler (+ 4 °C).

III. Results and discussion

III. 1. Spatiotemporal variation of total coliforms

The spatial variation of the total coliforms (TC) load shows fluctuations between the different stations of the Grou River (Table 1) and reveals the existence of an increasing gradient from S_1 to S_2 and then decreasing in the downstream direction (Figure 1). This could be explained by the particular conditions of each station and by the direct effect of wastewater from the rural commune of Jmaa Moulblad rejected without any prior treatment, as explained by [1]in the case of Ouislane River influenced by the discharges of the city of Meknes. The temporal evolution of TC throughout the various stations of the Grou River shows very significant seasonal fluctuations (Figure 1). They are numerous during the dry season with a maximum value of 8.5 10^5 UCT/100 ml in S_2 and slightly reduced during the other wet seasons with a minimum value of 1.02 10^4 UCT/100 ml in S_1. This could be explained in the dry period by the decrease of the flow of water accompanied by an increased supply of wastewater and the high temperature which favors the multiplication of many germs. In wet weather, it could be explained by rainfall and runoff that increase the flow of water and decreasing the concentration of the bacterial load

Table 1: Seasonal variation in the concentration of indicator bacteria for faecal contamination (TC, FC and IE) in the waters of the different stations of the Grou River. TC: Total coliforms. FC: Faecal coliforms. IE: Intestinal Enterococci.

Station/Bacteria inUCT/100ml		Seasons		
		Winter	Spring	Summer
TC	S_1	$1,7\ 10^4$	$1,02\ 10^4$	$1,14\ 10^5$
	S_2	$2,8\ 10^5$	$8,5\ 10^4$	$8,5\ 10^5$
	S_3	$2,4\ 10^5$	$6,8\ 10^4$	$7,65\ 10^4$
	S_4	$1,45\ 10^5$	$1,19\ 10^4$	$12,75\ 10^4$
FC	S_1	$3\ 10^3$	$1,22\ 10^4$	$1,36\ 10^4$
	S_2	$2,3\ 10^5$	$4,76\ 10^5$	$11,05\ 10^5$
	S_3	$1,25\ 10^4$	$1,122\ 10^4$	$10,2\ 10^4$
	S_4	$1,28\ 10^4$	$3,23\ 10^3$	$4\ 10^3$
IE	S_1	$5,4\ 10^2$	$5,1\ 10^2$	$7,5\ 10^2$
	S_2	$1,3\ 10^3$	$3,4\ 10^3$	$1,7\ 10^4$
	S_3	$7,1\ 10^2$	$3,4\ 10^2$	$9\ 10^2$
	S_4	$1,2\ 10^2$	$1,7\ 10^2$	$1,6\ 10^2$

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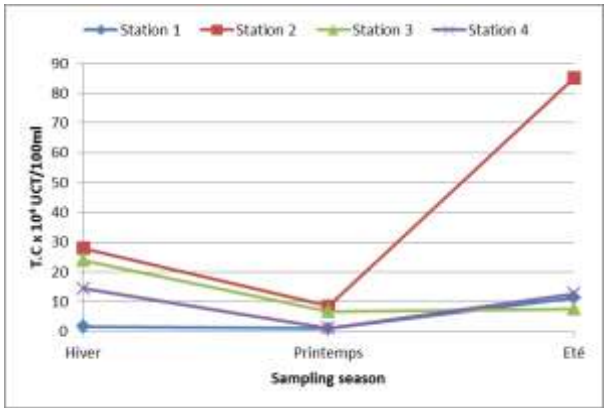

Figure 1: Spatio-temporal variations in the concentration of total coliforms (TC) in the waters of the different stations of the Grou River.

IV. 2. Spatio-temporal variation of faecal coliforms

In general, the spatial variation of faecal coliforms (FC) (Table 1) is reminiscent of total coliforms (TC) and confirms the faecal contamination of the Grou River's waterand reveals the deterioration of their quality. The average value of FC concentration is 0.96 10^4 UCT / 100 ml in S_1, it increases to 6.04 10^5 UCT / 100 ml in S_2, then it decreases while going downstream to 4.2 10^4 UCT / 100 ml in S_3 and 0.66 10^4 UCT / 100 ml in S_4. This shows a significant deterioration of water quality in S_2 located directly to the effect of the untreated wastewater coming from the rural commune of Jmaa Moulblad, then a slight improvement while going downstream in S_3 and in S_4due to the natural self-purifying effect of water as explained by [3]. For temporal evolution, the highest concentrations of FC were recorded during the dry season (Figure 2), with a maximum value of 11.05 10^5 UCT/100 ml in S_2. This is linked to the increased load in wastewater, which promotes the enrichment of the area in germs and rising temperature which plays a key role in the multiplication of FC.

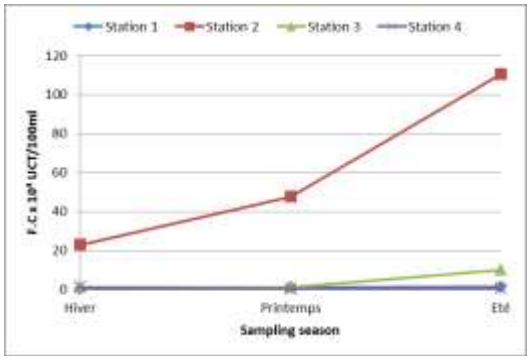

Figure 2: Spatio-temporal variations in the concentration of Fecal Coliforms (FC) in the waters of the different stations of the Grou River.

V. 3. Spatio-temporal variation of intestinal enterococci

The spatial evolution of intestinal enterococci (IE) shows that the lowest concentrations were recorded in the S_1 and S_4 stations with respectively 5.1 10^2 UCT/100 ml and 1.2 10^2 UCT/100 ml (Table 1), while the highest concentrations were recorded in the other stations, especially in S_2 with a maximum value of 1.7 10^4 UCT/100 ml. This corresponds to an increasing gradient from S_1 to S_2 and then decreasing downstream to S_3 and S_4. These results confirm those obtained in this study and are consistent with other studies [13; 14 and 15]. For the temporal variation of intestinal enterococci (IE), the highest concentrations were recorded in summer (Figure 3) because this period is characterized by a decrease of water flow and by an increase in the contribution of the wastewater while the other seasons of the year are characterized by a slight decrease of the concentrations. This could be explained

by rainfall and runoff that increases the flow of water and decrease the concentration of the bacterial load as pointed earlier. This in fact is in contradiction to what was demonstrated by [16] at the Ziz River.

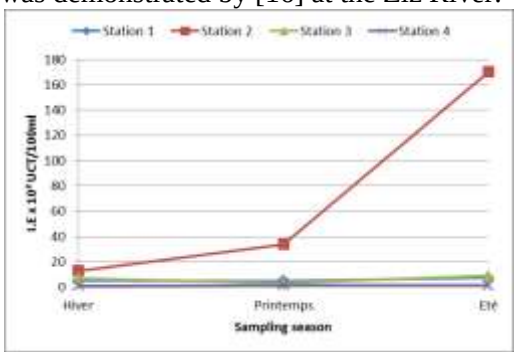

Figure 3: Spatio-temporal variations in the concentration of Intestinal Enterococci (IE) in the waters of the different stations of the Grou River.

III. 4. Spatio-temporal monitoring of salmonella

With regard to pathogenic germs (Salmonella), their isolation presents a great difficulty due to their very small presence in the waters on the one hand, and the coexistence of an accompanying faecal flora and their difficult survival on the other [17]. The results obtained in this study (Table 2) show that they were detected only in summer at the S_2station. This could be explained by the fact that in summer the flow of water from the Grou River has been reduced, which makes the bacterial load high in the S_2 station receiving untreated sewage from the rural commune of Jmaa Moulblad. The probable existence of these pathogens in other stations in the undetectable viable state would call into question the cultivation techniques used as has been shown in other similar works [18; 19 and 14].

Table 2: Seasonal monitoring of the presence and absence of salmonella in the waters of the different stations of the Grou River.

Presence or Absence of Salmonella/Station		Seasons		
		Winter	Spring	Summer
SAL	S_1	-	-	-
	S_2	-	-	+
	S_3	-	-	-
	S_4	-	-	-

III. 5. Global analysis

The spatio-temporal evolution of the three fecal contamination indicators, Total Coliforms (TC), Faecal Coliforms (FC) and Intestinal Enterococci (IE),of the Grou River allows us to identify three sectors:

The first sector represented by the S_1 station, characterized by the lowest values in TC, FC and IE, oscillates between 5.1 10^2 UCT/100ml and 1.1410^5 UCT/100ml. These values reveal a faecal contamination probably due to the discharges that this watercourse receives throughout its course before having reached this level and/or to the agricultural activities carried out all along its bed like animal farming. The higher the animal density, the higher the concentration of faecal coliforms [20]. The second sector represented by station S_2, characterized by the highest values in TC, FC and IE, oscillating between 1.3 10^3 UCT/100ml and 11.05 10^5 UCT/100ml, testifies to a direct contamination due to untreated wastewater from the rural commune of Jmaa Moulblad. The third sector represented by the two downstream stations S_3 and S_4, located at 35 km and 65 km from S_2 respectively more or less sufficient distances to the establishment of the phenomenon of natural self-purification of water. The values obtained in this sector oscillating between 1.2 10^2 UCT/100ml and 2.4 10^5 UCT/100ml reveal a decrease in the concentration in the upstream-downstream direction; testify to a natural self-purification of the water. But, that is not perfect because of a probable contamination of human and/or animal origin. As a result, the bacterial load of the downstream part of the Grou River can originate from wastewater and/or agricultural activities through the use of feces from animals in agriculture as fertilizer in the cultivated areas at the edge of their beds. According to the literature, faecal pollution is related to the quantitative ratio of Faecal Coliforms to Intestinal Enterococci (FC/IE) [21]. When this ratio FC/IEis greater than 4, the pollution is essentially human (wastewater discharge). When it is less than 0.7, the origin of the contamination is animal. In the agricultural sector, livestock waste is the main source of bacteriological contamination of water [22 and 23]. When the FC/IE ratio is between 0.7 and 1 the origin of the pollution is mixed (human and animal), but predominantly animal. In our case, the calculation of the FC/IE ratio is always greater than 4 in all stations (Table 3), which means that the origin of faecal pollution is essentially human: wastewater discharge. These results confirm those

obtained through the use of the Standardized Global Biological Index (IBGN) technique [24].

Table 3: Calculation of theratio FC/IEin the four stations at the Grou River

Station/Bacteria inUCT/100ml		Seasons		
		Winter	**Spring**	**Summer**
FC	**S_1**	$3\ 10^3$	$1{,}22\ 10^4$	$1{,}36\ 10^4$
	S_2	$2{,}3\ 10^5$	$4{,}76\ 10^5$	$11{,}05\ 10^5$
	S_3	$1{,}25\ 10^4$	$1{,}122\ 10^4$	$10{,}2\ 10^4$
	S_4	$1{,}28\ 10^4$	$3{,}23\ 10^3$	$4\ 10^3$
IE	**S_1**	$5{,}4\ 10^2$	$5{,}1\ 10^2$	$7{,}5\ 10^2$
	S_2	$1{,}3\ 10^3$	$3{,}4\ 10^3$	$1{,}7\ 10^4$
	S_3	$7{,}1\ 10^2$	$3{,}4\ 10^2$	$9\ 10^2$
	S_4	$1{,}2\ 10^2$	$1{,}7\ 10^2$	$1{,}6\ 10^2$
FC/ IE	**S_1**	5,55	23,92	18,13
	S_2	176,9	140	65
	S_3	17,6	33	113,3
	S_4	106,66	18,94	25

Conclusion

The results of the bacteriological analyses of the Grou River's water obtained during this study, show very significant spatio-temporal variations. Spatially, Station S_2 has the highest amounts of micro-organisms compared to other stations in the Grou River. This could be explained by the direct effect of untreated wastewater from the rural commune of Jmaa Moulblad. In terms of time, the bacterial load is very important in summer compared to other seasons of the year. This could be explained by the decrease in the flow of water accompanied by an increased supply of wastewater, and by the thermal factor which plays a very important role for the majority of pathogenic and fecal germs that tolerate temperatures that exceed 37 °C in summer. Also, this can be explained by the precipitation and runoff that increase the flow of water by decreasing the concentration of bacterial load in winter and spring. The presence of salmonellae responsible for water-borne infections at station S_2 confirms the impact of the intensification of wastewater discharges and describes a worrying situation of the state of this watercourse. Therefore, this situation poses a threat to the inhabitants of the region who use this water daily in most of their activities. To remedy this problem, we recommend a pre-treatment of wastewater before being discharged into this watercourse, and the implementation of a planning and sustainable management planof the Grou River watershed.

References

[1] J. El Addouli, A. Chahlaoui, A. Berrahou, A.Chafi, A.Ennabili, *Larhyss Journal*., 09 (2011) 21-33.

[2] A. Chahlaoui, P. Cugny, S. Lek, A. Zaid, M. Ramdani,*Bulletin de la Société d'Histoire Naturelle. Toulouse.*, 133 (1997) 71-76.

[3] K. Arifi, L. Tahri, A. EL Abidi, F.Z. Hefiane, S. Elblidi, A. Yahyaoui, M. Fekhaoui, *E3S Web of Conferences*., 37 (2018b) 01008.

[4] R.M.Mulliss, D.M.Revitt, R.B.E.Shutes, *Water Sci. Technol*., 36 (1997) 195-199.

[5] J. Alibou,Impacts des changements climatiques sur les ressources en eau et les zones humides du Maroc. CERSHE (Centre D'Etude et de Recherche sur les Systèmes Hydrauliques et Environnementaux). Ecole Hassania des Travaux Publics (EHTP),2002, pp. 1-39.

[6] D. A. Emeka, *Jordan Journal of Biological Sciences*., 5 (1) (2012) 47-54.

[7] R. Delhi, F. Benzha, A. Hilali, M. Tahiri, A. Kaoukaya, L. Baidder, H. Rhinane, J.P. Hangouet, *ScienceLib*., 4 (2012) 2111-4706.

[8] F.J. Angulo, S.Tippen, D.J.Sharp, B.J. Payne, C.Collier, J.E.Hill, T.J.Barret, R.M.Clark, E.E.Geldreich, H.D.Donnel, D.L.Swerdlow,*American Journal of Public Health*., 87 (4) (1997) 580-584.

[9] A.Qninba, M.A.El Agbani, M.Dakki, A.Ben Houssa,*Bull. Inst. Sci*., 12 (1988) 149-156.

[10] NM 03.7.003-2005: Qualité de l'eau - Recherche et dénombrement des Escherichia coli et des bactéries coliformes. PNM ISO 9308-1.

[11] NM 03.7.006-2006: Qualité de l'eau - Recherche et dénombrement des entérocoques intestinaux. PNM ISO 7899-2.

[12] NM 03.7.050-1995: Méthode de mise en évidence des salmonelles dans l'eau. PNM ISO 7875-1.

[13] Rm. Fernandez-Alvarez, S. Carballo-Cuervo, Mc. Rosa-Jorge, Lecea J. Rodriguez-With, *J. Appl. Bacteriol*., 70 (1991) 437- 442.

[14] A.Chahlaoui,Biological hydro study of the wadiBoufekrane (Meknes), Environmental impact and health. Thesis of state. FAC. Meknès,1996, pp.234.

[15] C. Hunter, J.Perkins, J.Tranter, J.Gunn,*Res. Toilets*., 33 (17) (1999) 3577-3586.

[16] M. Ouhmidou, A. Chahlaoui, A. Kharroubi, M. Chahboune, *J. Mater. Environ. Sci*., 6 (2015) 1663-1671.
[17] L.Tahri,Diagnose écologique de de l'estuaire de Bou-Regreg: impact des rejets sur les differentes composantes de l'écosystème et évaluation des risques sanitaires. Thèse de doctorat Fac. Sci. Kenitra, 2010, pp174.
[18] A. Aboulkacem, Hydro study biological comparative of the wadisBoufekrane and Ouislane with the crossing of the town of Meknès (Morocco), Environmental impact and health.Doctorate national. FAC. Sci. De Meknès,2007, p.159.
[19] P. Wales, B.Baleux,*Scitoilets. Technol*., 25(1992)105-114.
[20] M. Patoine, *Revue des sciences de l'eau*., 24 (4) (2011) 421-435.
[21] A.F.Borrego, P.Romero,Study of the microbiological pollution of a Malaga littoral area II. Relationship between fecal coliforms and fecal streptococci.VIejournéeétud. Pollutions, Cannes, France, 1982, pp.561-569.
[22] E. Geldreich, W. Litsky, *Critical Reviews in Environmental Science and Technology*., 6 (1976) 349-369.
[23] A. Maul, M.A. Dollard,J.C. Block,*Journal Français d'Hydrologie*., 13 (38) (1982) 141-156.
[24] K. Arifi, S. Elblidi, A. Serghini, L. Tahri, A. Yahyaoui, M. Fekhaoui, *J. Mater. Environ. Sci*., 9 (4) (2018a) 1343-1356.