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Full Length Research Paper

Evaluation of faecal coliform levels in the discharges from the city of El Jadida, Morocco

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In order to assess the fecal coliform contents in the raw sewage from the city of El Jadida, the principal component analysis of these contents coupled with the physicochemical parameters of water (temperature, pH, electrical conductivity and total suspended solids) was carried out. The bacteriological analysis of samples taken at the level of collector SIDI DAWI of the city of El Jadida between May 2008 and June 2010 shows that the effluent were characterized by fecal coliforms contents ranging from 2.22×10^7 and 9.64×10^7 CFU/100 mL with an average of 6.38×10^7 CFU/100 mL. These values were far above the recommended norm by WHO for irrigation water which is 10^3CFU/100 mL. Fecal coliforms have a positive and highly significant correlation with temperature, pH and total suspended solids. Also, poorly significant and negative correlations were observed with electrical conductivity. Among the physicochemical parameters studied, only the electrical conductivity appeared as the parameter to be monitored during the treatment of wastewater to reduce the load of fecal coliforms. A physical treatment is necessary especially for decantation followed by biodenitrification.

Key words: Wastewater, pollution, physicochemical parameters, fecal coliform, El Jadida, PCA.

INTRODUCTION

Raw sewage consists of all waters likely to contaminate the environments in which they are discharged. It contains pollutants and by-products of human use, either of domestic or industrial origin (Asano and Cotruvo, 2004). Sometimes, dirty wastewater drains into surface watersheds and into the sea (Hammer, 1986; Tchobanoglous and Burton, 2003). When this happens, the environment is as much at risk as people.

The pathogens in raw sewage can contaminate ecosystems and thus may cause a health risk for humans and animals.

In Morocco, the state of the environment continues to deteriorate due to the overexploitation of natural resources, air pollution, desertification, climate change and development of the industry (Salama et al., 2013).

In the context of limited water resources, wastewater in Morocco has not only a new limitation of the available resource but also an affront to human health and environmental quality in general.

Pollution by non-purified wastewater also affects the quality of sea water. The composition of wastewater from household can be extremely variable and depends on three factors, which are the original composition of drinking water, the various uses by individuals who can

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Figure 1. Geographical situation of the site of study.

provide a nearly infinite number of pollutants, and finally the users themselves who will reject the organic matter in wastewater (urine, feces) (Salama et al., 2013).

Other studies conducted by Lamghari (LamghariMoubarrad, 2005; LamghariMoubarrad and Assobhei, 2007) on the parasitological characterization of the wastewater from the city El Jadida in Morocco, the impact of partially treated wastewater on coastwater and sediments and on the infantile population of the discharge area showed that pollution detected in the effluent of wastewater as well as at the coast of El Jadida, is in fact a problem for the environment of the city. It is therefore necessary to take preventative measures to minimize this real danger: simple measures such as increasing public awareness about the contamination threats to more serious measures like the comprehensive treatment of wastewater before it is dumped into the ocean.

Our study aimed to evaluate faecal coliform levels in wastewater rejected on the coast from the city of El Jadida between 2008 and 2010 by coupling with physicochemical parameters in Principal component analysis (PCA).

The physicochemical parameters studied are the main growth factors of fecal coliforms in an ecosystem and it is temperature, pH, electrical conductivity and total suspended solids.

MATERIALS AND METHODS

Studied zone

The city of El Jadida is the second industrial pole of Morocco and is located on the Atlantic coast of Morocco between Casablanca (90 km southwest of Casablanca) and Jorf Lasfar (one of the largest ports in Africa) (Figure 1). It covers the area of 2480 hectares, with latitude of 27 m and it has 4 urban districts (Chofqi, 2004).

In August, there was the famous Moussem of Moulay Abdellah Amghar, which attracts over one hundred thousand visitors. It is bounded in the north by the Atlantic Ocean, to the east by the rural commune Haouzia, to the south by the rural commune OueldHcine and to the west by the rural commune MlyAbdellah and the Atlantic

Figure 2. Sampling zone of wastewaters to SIDI DAOUI (El Jadida).

Ocean.

Wastewater sampling

The wastewater that is dumped into the sea comes from domestic origin or a mixture with industrial wastewaters (95 and 5%). Samples of wastewater were collected (one per month) and stored at 4°C (Figures 2 and 3).

Analytical Methods

Physico-chemical parameters

The pH and temperature of the wastewater samples were measured at the collection site. Electrical conductivity and total suspended solids, were analyzed in the laboratory according to the methods prescribed in AFNOR (French national organization for standardization) handbook (AFNOR, 1999).

Bacteriological parameters

The bacteriological analysis of the various samples of wastewater consisted of an enumeration of the indicator germs for fecal contamination (fecal coliforms, FC) (Salama et al., 2013).

Enumeration of fecal coliforms

Fecal coliforms or thermotolerant coliforms are a sub-group of total coliforms able to ferment lactose at a temperature of 44.5°C.

The most important species of this bacterial group is *Escherichia coli* (*E. coli*) and to a lesser extent some species of the genera *Citrobacter, Enterobacter* and *Klebsiella* (Elmund et al., 1999; Emmanuel et al., 2004).

The spatio-temporal evolution of the abundances of FC was assessed by counting the colonies on yellow-orange Tergitol agar and triphenyltetrazolium chloride (TTC - Tergitol 7). The inoculated Petri dishes were incubated at 44.5°C for 24 h (AFNOR, 2001).

Statistical study

Statistical analysis was based on Principal Component Analysis (PCA). PCA is a data analysis tool that helps to explain the structure of correlations or covariance using linear combinations of the original data. Its use helps to reduce and interpret data in a small scale (Lagarde, 1995; Mayo, 1995). Matrices intermediate correlations, correlations between variables and axes and projection of variables in space axes F1 and F2 were obtained with XLSTAT 2010 software.

For the treatment of data by PCA, we used the variables such as temperature, pH, electrical conductivity, total suspended solids and fecal coliform as individuals and 15 samples taken at the level of collector SIDI DAWI.

Table 2 shows the correlation coefficients between the variables and the first two axes F1 and F2. Figure 4 reveals to us the projection of variables in space axes F1 and F2. The correlation matrices between the variables studied are shown in Table 3.

RESULTS

Qualitative aspect of the effluent of collector SIDI DAOUI

Table 1 shows changing physicochemical parameters (temperature pH, electrical conductivity and total suspended solids) and bacteriological parameters (Fecal Coliforms) studied between May 2008 and June 2010.

The effluent temperature was between 25.1 and 29.2°C. The minimum and maximum pH values ranged from 6.1 to 6.9 respectively. The maximum value of the recorded electrical conductivity was 3.57 mS/cm and the minimum value was 1.52 mS/cm.

The total suspended solids oscillate between a maximum value of 860.4 mg/L and a minimum value of 403.5 mg/L. The bacteriological analysis showed that effluents were characterized by levels of Fecal Coliforms

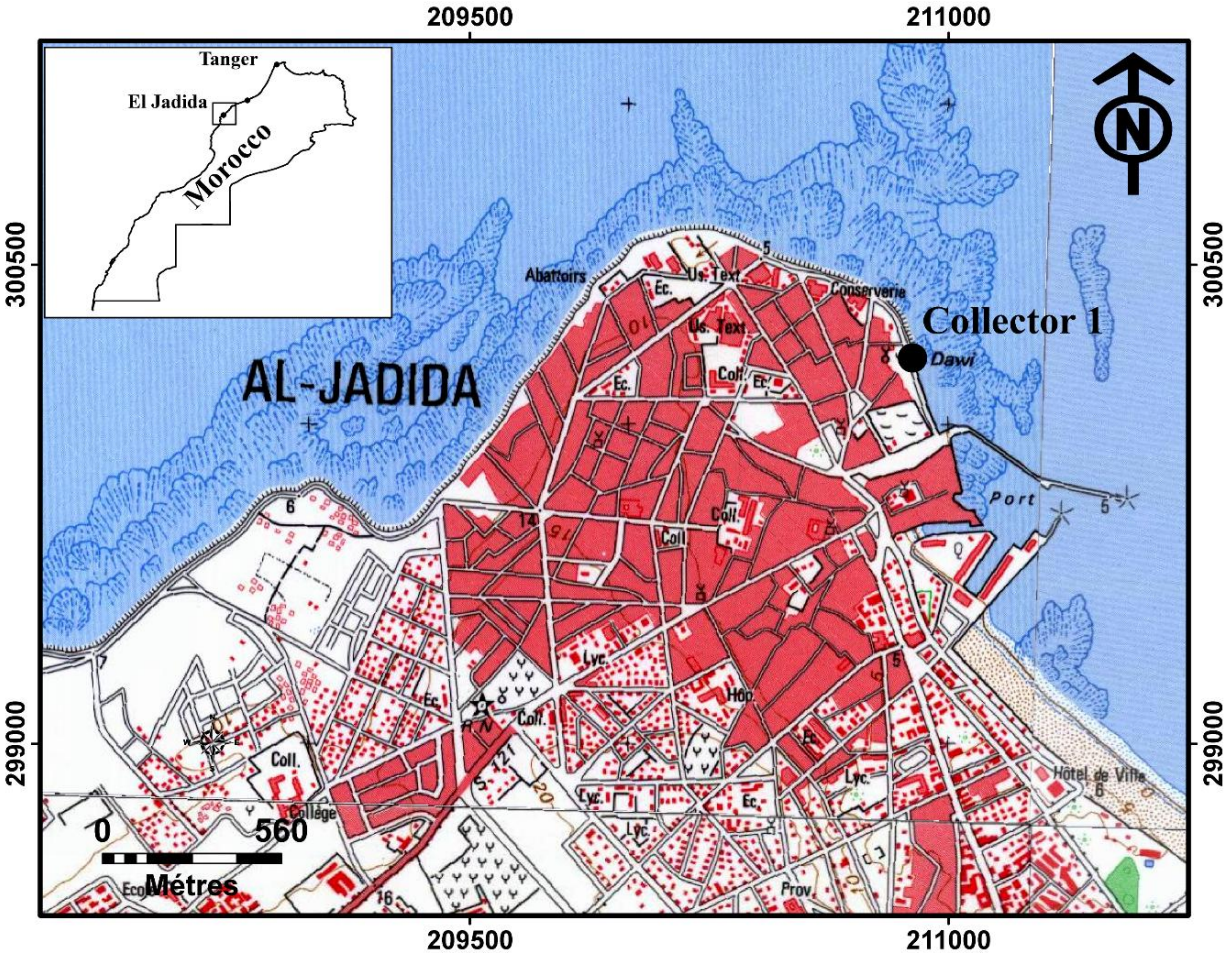

Figure 3. Location of sampling sites in study zone: Collector 1 (SIDI DAWI collector) (Salama et al., 2012).

Table 1. The average values of physicochemical and bacteriological parameters of raw wastewater in the collector SIDI DAWI.

Parameter	Maximum	Minimum	Average	Standard deviation
T (°C)	29.20	25.10	27.20	1.12
pH	6.90	6.10	6.30	0.25
EC (mS/cm)	3.57	1.52	2.13	0.83
TSS (mg/L)	860.40	403.50	677.61	143.82
FC (CFU/100 mL)	9.64×10^{7}	2.22×10^{7}	6.38×10^{7}	2.12×10^{7}

Table 2. Correlations between variables and the principal axes.

Parameter	F1	F2
T (°C)	0.860	-0.165
pH	0.735	0.432
EC	-0.386	0.895
TSS	0.922	0.103
FC	0.950	0.078

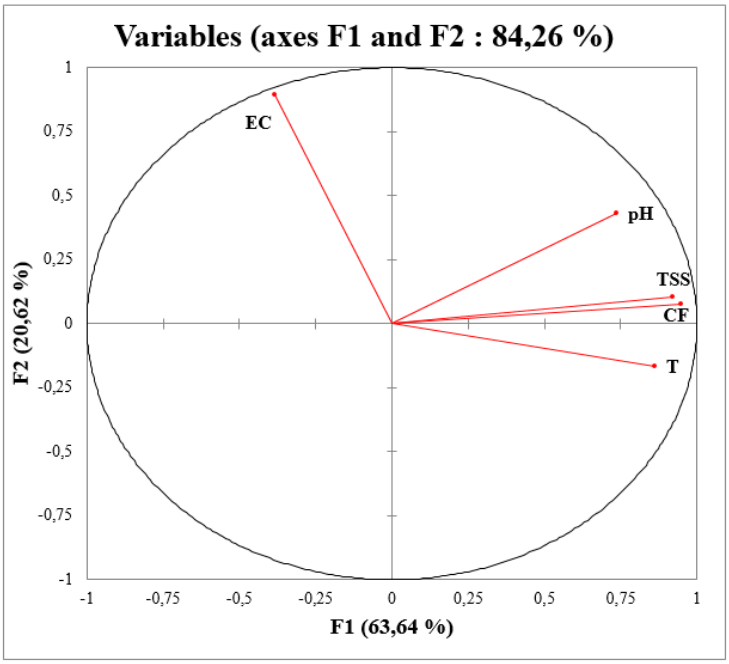

Figure 4. Projection of the variables in the space of the axes F1 and F2.

Table 3. The inter-elementary correlations matrix.

Variable	T(˚C)	pH	EC	TSS	FC
T˚C	1				
pH	0.592	1			
EC	-0.429	0.006	1		
TSS	0.660	0.564	-0.233	1	
FC	0.704	0.608	-0.276	0.990	1

ranging from 2.22×10^7 and 9.64×10^7 CFU/100 mL with an average of 6.38×10^7 CFU/100 mL.

DISCUSSION

The projection of the variables in the space of the axes F1 and F2 showed that parameters fitted at a probability of more than 84.26%. The probability of factorial design is acceptable (Athamena, 2006).

The axis F1 is formed by the temperature, pH, total suspended solids and fecal coliform. The axis F2 is formed by electrical conductivity (Table 2 and Figure 4).

The axis F1 corresponds to a disorder effluent (concentrations of TSS are very high) due to the degradation of organic matter. The latter are considered as vectors of pollution because many pollutants, including heavy metals are absorbed by these particles.

A highly significant positive correlation was observed between fecal coliform, temperature and pH (Table 3). The temperature and pH had a very important role in the solubility of the salts and especially gas.

The recorded temperatures at the effluent was below 30 (JORA, 1993) and 35°C considered as the limit value of direct discharge into the receiving environment (MEMEE, 2002).

These results confirm the work of Mayo (1995) who showed that the increase in pH affected the abundance of fecal coliforms that is to say, the basic pH led to a net decrease in the survival of fecal coliforms.

Another highly significant positive correlation was observed between fecal coliform and TSS (Table 3). The TSS takes into account all the colloidal materials, insoluble minerals or organic solids. Suspended particles included silt, clay, organic matter, inorganic fine particles and microorganisms (Santé Canada, 2003; Schnitzer and Kahn, 1972).

The most important effect of TSS, related to health is

probably its ability to protect bacteria and virus against disinfection solutions or heat, if exposed a too short time (Hudson, 1962). The microbial load of fecal coliforms is very important at the level of the effluents of the collector SIDI DAWI. This bacterial load exceeded that recommended as maximum by WHO for irrigation water, which is of the order 10^3 CFU/100 mL (WHO, 1986).

A negative and weakly significant correlation was observed between fecal coliforms and electrical conductivity (Table 3). The electrical conductivity is probably one of the simplest and most important for the quality control of wastewater. It reflects the overall degree of mineralization and it provides information on the salinity. These results confirm the work of Chedad and Assobhi (2007) which showed that salinity is a factor causing stress which undergoes bacteria of fecal pollution in the salty middle, where the bacteria must establish the osmotic balance between the external middle and its cytoplasm.

Conclusion

The bacteriological analyses show that the effluent collector of the city of El Jadida is characterized by levels of fecal coliforms ranging from 2.2×10^7 to 9.64×10^7CFU/100 mL. The statistical results show that fecal coliform have a positive and highly significant correlation with temperature, pH and TSS, and conversely negative and weakly significant correlations with the electrical conductivity.

Among the physical parameters studied, only conductivity proves a convincing parameter in wastewater treatment to reduce the load of fecal coliform. In the field of quality control of water, the conductivity measurement proves a compelling setting for the treatment of wastewater. Use wastewater for agricultural purposes also reduces the pressure on the environment, but there are factors that must be considered, including the presence of pathogens. The treatment of raw sewage is essential to limit the potential impacts of such activities on the environment and the health of producers and consumers.

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