Coliforms as indicators of efficiency of wastewater treatment plants

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Abstract: Indicator microorganisms are used to evaluate the water quality and in wastewaters the most used indicator bacteria are the total and fecal coliforms. The main objective of the present work was to verify if the treated wastewater had sufficient quality, regarding the chosen parameters, to be discharged in receiving natural waters. In the present work 660 residual water samples from 9 sewage treatment plants located in the Algarve region had been analyzed. The performance of these treatment plants in the removal of fecal and total coliforms was studied. The obtained results showed that 78% of the wastewater treatment plants had levels of removal of faecal coliforms up to 90%, what indicates that they had a proper functioning. Plants that showed very low efficiencies of removal were 22%. The last mentioned plants presented a very high number of coliforms, what could be harmful for the public health if these waters will be discharged at the environment in inadequate sites. Faecal coliforms maximum concentration observed in this study in final effluent was 6.7×10^8.

Keywords: Environment; coliforms; wastewater; faecal pollution; wastewater treatment.

1 Introduction

The main cause of faecal pollution in natural aquatic environments is the discharges of wastewater [1]. Domestic wastewaters is the main source of pathogens in receiving natural waters, and indicator microorganisms must be monitored to prevent outbreaks of enteric diseases, rather than to detect the presence of specific pathogens. Residual water contains millions of bacteria per millilitre of water. Protozoan, fungi and virus are also abundant is these waters [2]. Treatment of wastewater is essential, for further uses, such as irrigation. Wastewater treatment plants had as purpose the removal of organic and inorganic substances, nutrients and microorganisms from residual waters, in order to prevent the degradation of the receiving aquatic systems and to prevent problems related with public health. To reuse wastewater a reliable treatment must be done to meet water with strict quality to protect public health and the environment.

Bacteria numbers can be effectively reduced by disinfection procedures. There are several methods to inactivate microorganisms in water. The most commonly used disinfectants are chlorine, chlorine dioxide, ozone and chloramines.

The most common type of wastewater treatment in Portugal involves a primary treatment succeeded by a secondary treatment that doesn't consider a secondary disinfection phase.

Problems related with water contamination are increasing due to the discharges of non treated water or due to sewage treatment plant working deficiently.

The selection of an adequate treatment depends on the composition of the residual water and nature of the contaminants [3].

In order to protect the human health, there is a need to control the quality of these waters.

Chemical, physical and biological parameters are used for the water characterization.

Biological characterization is done by means of the coliforms enumeration and other bacteria.

In residual waters coliforms are found in high numbers and the methodology for their search is easy to implement.

The most commonly tests used in the water industry are the identification and detection of coliforms and *E. coli* [4].

2 Materials and Methods

2.1 Microbiological parameters

660 samples from 9 sewage treatment plants were analyzed for the enumeration of faecal coliforms. Faecal coliforms (FC), were enumerated by the Membrane Filtration (MF) technique, according to the process described in APHA (1995) [5] and the results expressed in Colony Forming Units (CFU) per 100 mL. Enumeration was done in Agar M. Lauril (Biogerm). For faecal coliforms inoculated plates were incubated at 44±0.5ºC during 24 hours. Confirmation tests were done by oxidase (Difco) reaction and growth in Brilliant Green Broth (Oxoid).

Efficiency evaluation based on concentrations of faecal and total coliforms was calculated in accordance with the following equation [6]:

$$E_{removal} = \frac{C_i - C_f}{C_i} .100$$

E_r – Efficiency of removal
C_i – Concentration of the raw affluent
C_f – Concentration of the final effluent

2.2 Statistical analysis

The quantitative analyses by membrane filtration technique were carried out with three replicates. All data was transformed in decimal logarithms and processed via Microsoft Excel.

3 Results

The results are resumed in Tables 1 and 2 and they showed that 78% of the wastewater treatment plants had levels of removal of faecal coliforms up to 90%, what indicates that they had a proper functioning. Plants that showed very low efficiencies of removal represented 22%.

The wastewater treatment plant referred as one in this study showed an efficiency on the faecal coliforms removal with the highest frequency (69/77). The worst was the one referred as number six, as it showed, an efficiency of removal of 99.8%, just once (1/16).

Considering all the studied Wastewater Treatment Plants, 89.86% of them showed removal efficiency up to 90%.

In raw affluent faecal coliforms maximum concentration observed was 3.9×10^{11} and the minimum concentration was 8.0×10^{4}.

In relation to the final effluent the maximum concentration observed was $6.7\text{x}10^{8}$ and the minimum was zero. Besides the good performance of some of the wastewater treatment plants the final concentration of coliforms could reach very high values, what could be harmful for the public health if these waters will be discharged at the environment in inadequate sites. The decision of the quality of the waters to be discharged in the environment must be accomplished with other parameters such as Biochemical Oxigen Demand (BOD), Chemical Oxigen Demand (COD) and Total Suspended Solids (TSS).

References:

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Table 1 - Maximum, minimum, mean and standard deviation of feacal coliforms for the studied Wastewater Treatment Plant (WTP).

WTP	Raw Affluent				Final Effluent			
	Maximum	Minimum	Mean	Standard deviation	Maximum	Minimum	Mean	Standard deviation
1	3.30×10^{10}	8.0×10^{4}	6.32×10^{8}	3.83×10^{9}	1.0×10^{5}	0	3.89×10^{3}	1.47×10^{4}
2	4.0×10^{9}	1.3×10^{5}	1.34×10^{8}	$6.22x10^{8}$	1.5×10^{7}	$4,0\times10^{1}$	3.89×10^{5}	2.34×10^{6}
3	1.0×10^{10}	2.0×10^{6}	4.02×10^{8}	1.57×10^{9}	3.2×10^{5}	$2,0\times10^{1}$	5.59×10^{4}	7.81×10^{4}
4	3.9×10^{11}	8.0×10^{5}	1.94×10^{10}	7.8×10^{10}	1.2×10^{6}	0	9.13×10^{4}	2.73×10^{5}
5	2.0×10^{9}	1.0×10^{6}	1.99×10^{8}	5.11×10^{8}	4.0×10^{7}	2.5×10^{3}	2.22×10^{6}	7.63×10^{6}
6	6.9×10^{9}	4.0×10^{6}	5.0×10^{8}	1.71×10^{9}	3.30×10^{8}	$1,0\times10^{5}$	2.95×10^{7}	8.06×10^{7}
7	4.3×10^{9}	6.0×10^{6}	2.19×10^{8}	8.90×10^{8}	4.80×10^{7}	$3,0\times10^{1}$	2.22×10^{6}	9.98×10^{6}
8	3.80×10^{9}	1.6×10^{6}	2.15×10^{8}	7.82×10^{8}	6.7×10^{8}	4.0×10^{3}	3.29×10^{7}	1.39×10^{8}
9	8.3×10^{9}	1.0×10^{5}	2.85×10^{8}	1.26×10^{9}	6.40×10^{8}	0	1.69×10^{7}	9.69×10^{7}

Table 2 - Efficiency of the studied Wastewater Treatment Plants

WastewaterTreatment Plant		Efficiency				% Efficiency >90%
		Maximum		Minimum		
		%	Frequency	%	Frequency	
Reference	**N**					
1	77	100	69	99.5	1	100
2	41	100	20	25.0	1	97.56
3	42	100	23	98.9	1	100
4	28	100	22	97.3	1	100
5	36	100	3	75.0	1	94.44
6	16	99.8	1	25.0	1	56.3
7	23	100	7	95.7	1	100
8	23	100	2	52.4	1	69.57
9	44	100	20	20.0	1	90.90
Total	330					89.86