VOL. 7, NO. 12, DECEMBER 2012 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

BACTERIAL LOAD EVALUATION OF WASTEWATER TREATED BY NATURAL LAGOON: CASE OF THE BENI-MESSOUS LAGOON

Driche Mohamed, Abdessemed Djamal and Nezzal Ghania
University of Sciences and Technology Houari Boumedienne, Faculty of Mechanical Engineering and Processes Engineering, Laboratory of Process Engineering -Environment, Bab-Ezzouar, Algiers
E-Mail: drichem@yahoo.fr

ABSTRACT

The wastewater reuse is becoming increasingly important worldwide, especially in irrigation, it depends on the elimination of pathogens. For this, we choose the process of natural lagoon which consists in purifying the waste water by simple flow of the effluent in not very deep ponds where proliferate bacteria, algae and other living organisms, under a surrounding air and in the presence of a solar radiation. This study is based on the estimated removal efficiency of the bacterial load in the natural lagoon of Beni Messous. According to the results obtained, the average number of germs per 100 ml of wastewater after treatment by stabilization pond was 6, 48.10^5 for Faecal coli forms (FC) and 3, 5.10^6 for Total coliforms (TC), 4.10^5 for Escherichia coli and to 7.10^5 for Faecal streptococci (FS), 10^3 for Salmonellas and 33 for Sulfite-reducing bacteria. Decontamination is considered completed when the concentration of germs in the water is below the recommended limit, after comparing, purified water has satisfactory bacteriological characteristics for reuse the effluent in irrigation.

Keywords: wastewater, lagoon, pollution, decontamination.

INTRODUCTION

Algeria counts among the countries with semi arid or arid climate, whose water pollution comes to accentuate the water deficit caused by dryness. Actually, the choice of techniques of wastewater treatment, especially in developing countries, is the natural lagoon because we do not need specialized skills. The lagoons have generally been viewed as an effective and low-cost method of removing pathogens from wastewater (Pearson *et al.*, 1987; Mara *et al.*, 1992). The treatment of wastewater in lagoons exploits the physical and biochemical interactions that occur naturally in aquatic systems to remove pathogens, biochemical oxygen demand (BOD), ammonia, nitrates, suspended solids and phosphates. The primary function of tertiary lagoons in most parts of the world is the removal of pathogenic organisms, the size and number of these lagoons will normally be determined by the required bacteriological. The National Sanitation Office (NAO) has launched several projects including the lagoon treatment plant of Beni Messous. The wastewater treatment by natural lagoon seems to be the best adapted process to the Algerian socio-economic context. When well controlled, it is particularly adapted for the reuse of the purified water in irrigation. This is the context in which it is proposed to assess the bacteriological and physicochemical quality of treated water at the lagoon and explore the possibility of reuse of treated wastewater in agriculture. The bacteriological analysis consists of an enumeration of fecal and total coliforms and, fecal streptococci, Salmonellas, Sulfite-reducing, as well as the research of the vibrios.

MATERIALS AND METHODS

Description of the lagoon

Beni-Messous lagoon is located at 20 km east of Algiers, It is fed by the Beni-Messous river with a 11.5 km length and a mean flow of $0.245 m^3/s$. The sewage treatment plant by natural lagoon consists of four ponds of rectangular lengthened forms. This geometry is presented in Figure-1.

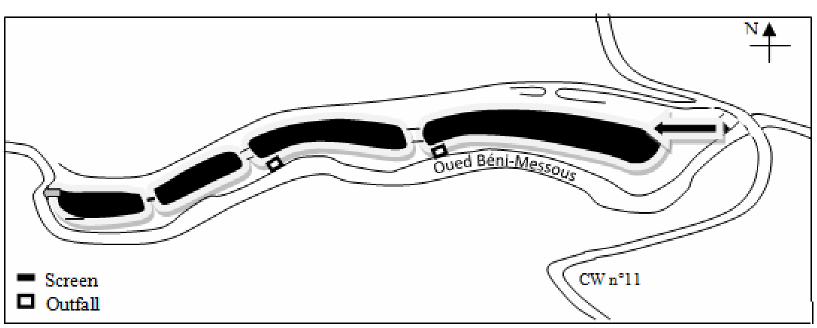

Figure-1. Diagram of the lagoon of Beni-Messous.

Dimensions and the characteristics of the lagoons have been determined using a topographic study carried out on the ground with a theodolite resulting measurements are represented in Table-1.

Table-1. Dimensions of the Beni-Messous lagoon.

N° lagoon	**Length** (m)	**Width** (m)	**Depth** (m)	**Surface** (m^2)	**Volume** (m^3)
1	90	310	4	27900	111600
2	62	220	2	13640	27280
3	42	130	1.5	5460	8190
4	25	95	1.5	2375	3562.5

Residence time

The residence time indicates the necessary time for which wastewater has to stay in each basin to allow their purification. The retention time of wastewater in the lagoons was very important in determining the treatment performance; they showed that the increase in residence time increases the mortality rate of bacterial die-off (Oragui *et al*., 1987). The residence time is a factor that could guide the specific development in a natural lagoon; it is a parameter of great importance for the design of lagoons (Cromar *et al*., 1997).

For the calculation of the water residence time in each basin, the flow is considered constant in all the lagoons (laminar flow).

The residence time is calculated from the following relation:

$$Q = \frac{V}{t} \quad (1)$$

Q = mean flow of wastewater entry (m^3/J)
V = volume of the basin (m^3)
t = residence time (day)

The residence time of the various basins is as follows:

1st basin: t = 7 days
2nd basin: t = 2 days
3rd basin: t = 1 day
4th basin: t = 1 day

The total residence time of the lagoon is: t = 11 days.

Sampling

Samples for bacteriological analysis were collected in sterile glass bottles of 500 mL. The samples are transported to the laboratory in an isothermal cooler under a temperature of 4°C. The researched and counted germs are the total coli forms, the fecal coli forms, Escherichia coli and Streptococci fecal, these germs are a sign of a fecal contamination and involve by their abundance the presumption of more dangerous contamination (Rångeby *et al*., 1996). The enumeration method of these germs is the process of the most probable number (MPN) by incubating the samples in a liquid medium.

The determination of the characteristic number (a number of the positive tubes) will allow the establishment of the most probable number by the Table look-up of Mc Grady (Brisou *et al.,* 1980). Enumeration of Sulfite-reducing, vibrio and salmonella was also performed.

RESULTS AND DISCUSSIONS

Study of the pollution origin

The origin of fecal pollution was studied by Haslay and Leclerc (Haslay and Leclerc, 1993) who proposed to evaluate the ratio of the concentration of fecal coliform to fecal streptococcus (CF/SF) to determine the origin of the contamination. The interpretation of this ratio CF / SF is:

-FC/FS < 0.7: the pollution is of animal origin.
CF / SF is between 0.7 and 1 pollution is predominantly animal.
-FC/FS is between 1 and 2: the pollution is of unknown origin (uncertainty in interpretation).
CF / SF ranging between 2 and 4 the pollution is essentially urban and human origin.

The application of the preceding scale, on the computed values confirms that pollution is exclusively human origin (FC/FS >>4), with the exception of a few samples where the ratio FC/FS is greater than 0.7 which means that pollution is of animal origin, mainly due to discharges of breeding stations, runoff and leaching from agricultural land located near the Beni Messous lagoons. The bacteriological analysis is carried out in order to know the concentration variation of germs after the passage of the waste water through the various basins.

Total coliforms (TC)

According to the histogram in Figure-2, the bacterial load of total coliforms shows a maximum at the entrance to the first basin, and then decreases more and more with the direction of flow of water. At the entrance, the average number of bacteria per 100 ml is 140×10^8 and at exit, this number decreased to a value of 3.5×10^6 with an average yield purification of 99.9%.

ARPN Journal of Agricultural and Biological Science

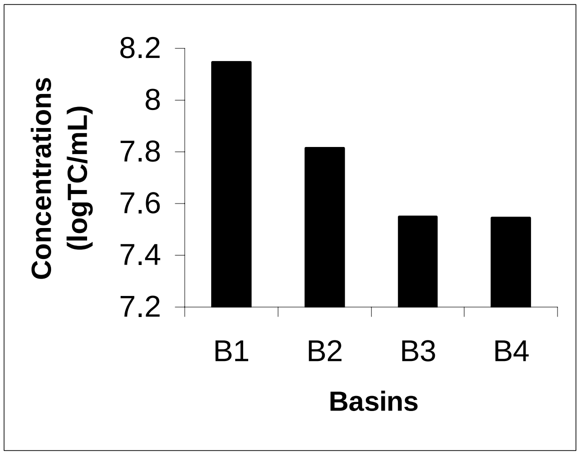

Figure-2. Evolution of the average concentration of total coliforms on the level of the various basins.

Fecal coliforms (FC)

At the entry of the first basin (B1), the average concentration of fecal coliforms is 140×10^8 germs/100mL; the reduction is visible only from the fourth basin (B4) (see Figure-3) approximately 6.48×10^5 germs/100mL with an average yield of 99%.

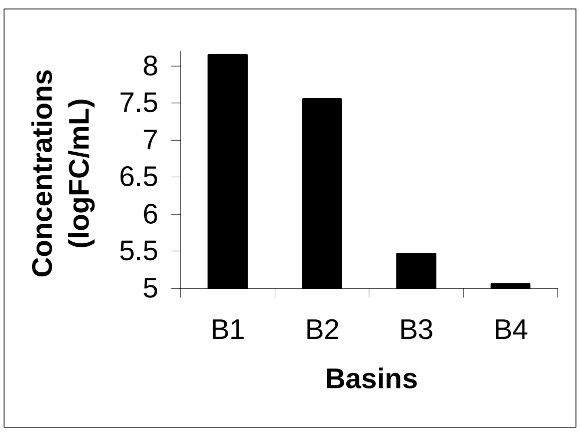

Figure-3. Evolution of the average concentration of faecal coliforms on the level of the various basins.

Escherichia coli (E coli)

For this germ, we remark in Figure-4 that the bacterial load is to the maximum at the entry of the first basin then decreases more and more with the water flow direction. At the entry of the lagoon (B1) the average concentration is 140×10^8 germs/100mL, at the exit, she is of 4×10^5 germs/100mL. The purification average yield is 99 %.

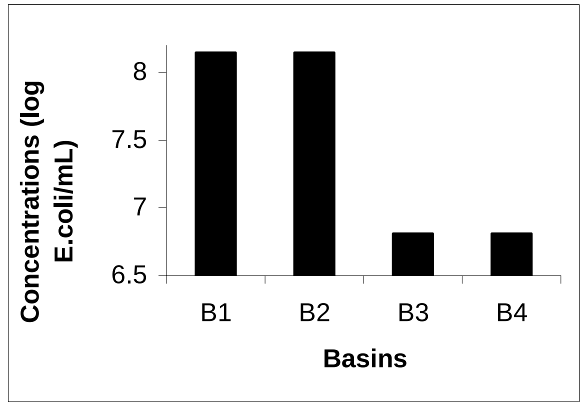

Figure-4. Evolution of the average concentration of E. Coli on the level of the various basins.

Most of the work on pathogen removal in lagoons has concentrated on the removal of the bacterial indicator organisms, E. coli and faecal coliforms, as they can be rapidly and reliably identify and enumerate, but there has been very little works to investigate whether these results will be the same for pathogenic organisms such as viruses and intestinal parasites (Purdy *et al.*, 2010). Vibrio cholera and E. coli survive differently under the same conditions and found that during the summer months, has high temperatures and intense algal activity, resulting in a high pH, the concentration of Vibrio cholera increases, while the concentration of E. coli decreases (Thomas *et al.*, 2012; Kimberley *et al.*, 2003).

The number of Vibrio cholera increases with temperature and the treated wastewater, the correlation between Vibrio cholera and the pH increases significantly (Béla Nagy *et al.*, 2005). The damage to the cytoplasmic membranes of bacteria caused by sunlight could make the germs more sensitive to the effects of other factors such as high pH, by cons Vibrio cholera is more resistant to high pH values, and these germs are less sensitive to sunlight (Masters *et al.*, 2011).

Fecal streptococci (FS)

In the Figure-5, we notice that the average concentration of fecal streptococci decreases with the direction of flow of wastewater in the lagoon; this one passes from 140×10^8 to 7×10^5 germs/100mL, with a elimination yield of 99%.

VOL. 7, NO. 12, DECEMBER 2012 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

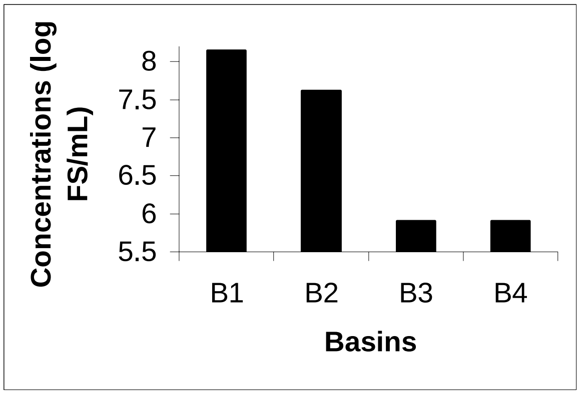

Figure-5. Evolution of the average concentration of fecal streptococci on the level of the various basins.

Salmonellas

According to the analysis made at the entry and the exit of the lagoon, the number of Salmonellas by 100 mL is higher than 1600 germs before the treatment and 1072 after the treatment with a yield of 33% (Figure-6).

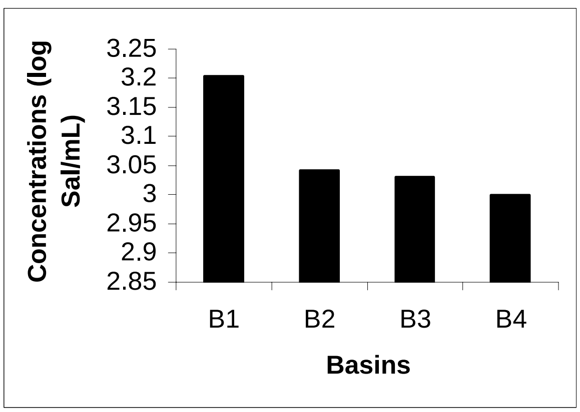

Figure-6. Evolution of the average concentration of the salmonellas on the level of the various basins.

Sulfite-reducing bacteria

The histogram in Figure-7 below, illustrates the abatement of Clostridiums sulfite-reducing, the number of the latter pass of 1650 to 33 by 100 mL and with average elimination yield of 98%. The reduction of the Sulfite-reducing in the second basin can be explained by a certain number of points:

- Anaerobic conditions in the first basin are favorable to the development of sulfite-reducing bacteria,
- On the other hand, the second basin is less deep, it is the aerobic basin, the conditions become unfavorable with these germs, indeed, exhaustion of the substrate, the oxygen presence inhibits the bacteria growth and the germination of the spores (Kimberly *et al.*, 2008).

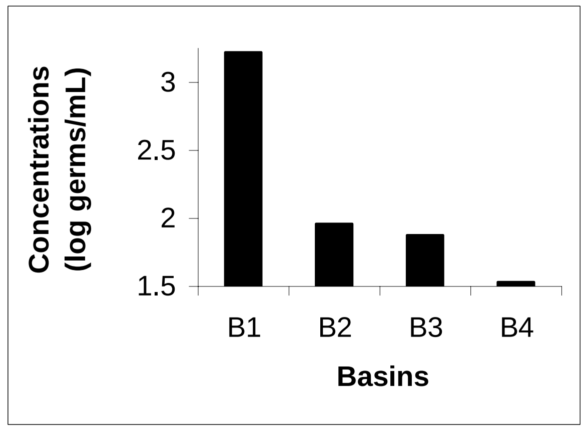

Figure-7. Evolution of the average concentration of the sulfite-reducing bacteria on the level of the various basins.

Isolation and identification of bacterial strain

The isolation and the identification of Enterobacteriaceae are realized by using positive tubes of lactose bouillon S/C and D/C and tubes of VBL and cultures on Hektoen gelose. The obtained results are shown in Tables 2 and 3.

VOL. 7, NO. 12, DECEMBER 2012 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

Table-2. Biochemical identification of the insulated bacteria (Enterobacteriaceae).

Character \ Group	Enterobacteriaceae				
	Coliforms			Salmonella	
Cells aspect	**Bacillus**	**Bacillus**	**Bacillus**	**Bacillus**	**Bacillus**
Gram	-	-	-	-	-
Catalase	-	-	V	V	/
Gaz production	+	+	+	+	+
Coagulase	/	/	/	/	/
Esculinase	/	/	/	/	/
Oxydase	-	-	-	-	
ONPG	+	+	+	+	+
ADH	-	+	-	+	+
LDC	+	-	-	+	-
ODC	+	+	+	+	-
CIT	-	+	+	-	+
H_2S	-	-	-	+	+
Species name	E. coli	Enterobacter cloaceae	Citrobacter freundii	Salmonella arizonae	Salmonella typhi

V: variable according to the stock

Table-3. Biochemical identification of the insulated bacteria (Vibrionaceae et Micrococcaceae).

Character \ Group	Vibrionaceae				Micrococcaceae (steptococci)
	Aeromonas	Vibrios			
Cells aspect	**Bacillus**	**Bacillus**	**Curved bacillus**	**Curved bacillus**	**Pairs in chains**
Gram	-	-	-	-	+
Catalase	/	/	V	V	-
Gaz production	+	+	+	+	-
Coagulase	/	/	/	/	-
Esculinase	/	/	/	/	+
Oxydase	+	/	+	+	-
ONPG	+	/	+	-	/
ADH	+	/	-	-	/
LDC	-	/	+	+	/
ODC	-	/	V	V	/
CIT	+	+	+	-	/
H_2S	-	-	-	-	/
Species name	Aeromonas hydrophila	V. parahaemolytcus	V. alginolyticus	V. fluvialis	S. faecalis

V = variable according to the stock; ONPG = ORTHONITROPHENYL-b-D-galactopyranoside; ADH = l'arginine dihydrolase; LDC = lysine décarboxylase; ODC = l'ornithine décarboxylase; CIT = citrate de Simons; H_2S = Sulfurous acid

VOL. 7, NO. 12, DECEMBER 2012 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

The research of the Salmonella and the Vibrios is carried out by the qualitative method which comprises 3 steps: enrichment, isolation and biochemical identification by API 20E and API 20NE strips (CEAEQ, 2003.c). Bacteria strain of Streptococcus was characterized by using API 20STRE strips.

CONCLUSIONS

The aim of this study is to evaluate the efficiency of wastewater treatment by natural lagoon, for the bacteriological pollution reduction. The obtained results, at the end of the analyses show that, the average number of the germs in 100 ml of water at the entry of the Beni Messous lagoon was 140×10^8 for the total and fecal coliforms and 140×10^8 for the fecal Streptococcus, 1600 for the Salmonellas and 1650 for the bacteria Sulfite reducing, after treatment the concentrations of germs are respectively reduced to 3.5×10^6, 6.48×10^5, 7×10^5, 1000 and 33 germs/100mL. The yield reached values very satisfactory which can go up to 98% for the germs Sulfite reducing, 97 % for Escherichia coli and 99, 9% for the total and fecal coliforms and 33% for the Salmonellas.

These results comply with those obtained in various works which made it possible to highlight the presence of Salmonellas, sometimes in large number, in the wastewater treated by natural lagoon (Toth *et al.*, 2011; Yue Li *et al.*, 2008; Nanh Lovanh *et al.*, 2009). The concentrations of the pathogenic germs obtained after treatment are lower than the irrigations standards, which presents values lower than 10^7 germs/100mL for the total coliforms and lower than 10^6 for the fecal coliforms (Megan et *al.*, 2012). According to the results obtained, we can conclude that the natural lagoon acts several processes:

- a biological process of purification allowing the organic matter elimination;
- a physical process: the settling allowing the evacuation of the suspended particles towards the sediment on which the various germs are adsorbed, the sunning eliminates most of the germs from contamination.

The Beni Messous natural lagoon appears as a very significant technique in wastewater treatment. It generates in fact, a nearly complete removal of organic matter and a satisfactory reduction of germs of fecal contamination and pathogens by the germicidal action of sunlight. This technique is essential because it allows the valorization of the effluents purified for agricultural and aquacultural ends, on the one hand, and by the quasi total absence of equipment consumers of energy on the other hand.

REFERENCES

Béla N. and Péter Z.s. 2005. Enterotoxigenic Escherichia coli in veterinary medicine. International Journal of Medical Microbiology. 295(6-7): 443-454.

Brisou J.F. and Denis F. 1980. Techniques de surveillance de l'environnement maritime. Edition Masson.

Centre d'expertise en analyse environnementale du Québec. 2003. c. Dénombrement des Salmonelles; méthodes par tubes multiples. MA 700-Sal-tm 1.0, Ministère de l'Environnement du Québec. p. 19.

Cromar N. J. and Fallowfield H. J. 1997. Effect of nutrient loading and retention time on performance of high rate algal ponds. J. Appl. Phycol. 9: 301-309.

Haslay C. and Leclerc H. 1993. Microbiologie des eaux d'alimentation. Tech. et Doc. Ed. Lavoisier.

Kimberley C., Chandra M., Anna C. and Christopher K. 2003. Pollutant removal from municipal sewage lagoon effluents with a free-surface wetland. Water Research. 37(12): 2803-2812.

Kimberly L. Cook, Terence R. Whitehead, C. Spence and Michael A. Cotta. 2008. Evaluation of the sulfate-reducing bacterial population associated with stored swine slurry. Anaerobe. 14(3): 172-180.

Mara D.D., Mills S.W., Pearson H.W. and Alabaster G.P. 1992. Waste stabilization ponds: a viable alternative for small community treatment systems. J. Inst. Wat. Environ. Manag. 6(1): 72-78.

Masters N., Wiegand A., Ahmed W. and Katouli M. 2011. Escherichia coli virulence genes profile of surface waters as an indicator of water quality. Water Research. 45(19): 6321-6333.

Megan E.G. and Stefan S. 2012. Microbiological assessment of river water used for the irrigation of fresh produce in a sub-urban community in Sobantu, South Africa. Food Research International. 47(2): 300-305.

Nanh L., John H.L., Kimberly C., Michael R. and Karamat S. 2009. The effect of stratification and seasonal variability on the profile of an anaerobic swine waste treatment lagoon. Bioresource Technology. 100(15): 3706-3712.

Oragui J.I., Curtis T.P., Silva S.A. and Mara D.D. 1987. The removal of excreted bacteria and viruses in deep waste stabilization ponds. Wat. Sci. Technol. 19: 569-573.

Pearson H.W., Mara D.D., Mills S.W. and Smallman D.J. 1987. Physico-chemical parameters influencing fecal bacteria survival in waste stabilization ponds. Wat. Sci. Technol. 19(12): 145-152.

Purdy C.W., Clark R.N. and Straus D.C. 2010. Determination of water quality variables, endotoxin concentration, and Enterobacteriaceae concentration and identification in southern High Plains dairy lagoons. Journal of Dairy Science. 93(4): 1511-1522.

Rångeby M., Johansson P. and Pernrup M. 1996. Removal of faecal coliforms in a wastewater stabilization pond system in Mindelo, Cape Verde. Wat. Sci. Technol. 34(11): 149-157.

Thomas A. Casey, Terry D. Connell, Randall K. Holmes and Shannon C. Whipp. 2012. Evaluation of heat-labile enterotoxins type IIa and type IIb in the pathogenicity of enterotoxigenic Escherichia coli for neonatal pigs. Veterinary Microbiology. 159(1-2): 83-89.

Toth J.D., Aceto H.W., Rankin S.C. and Dou Z. 2011. Survival characteristics of Salmonella enterica serovar Newport in the dairy farm environment. Journal of Dairy Science. 94(10): 5238-5246.

Yue L., Min X., Fanlong K. and Jie L. 2008. Reduction of Salmonella in dairy waste through anaerobic lagoon and constructed wetland. Journal of Biotechnology. 136, p. S661.