

ENVIRONMENTAL IMPACTS OF LIQUID EFFLUENTS OF THE ALCOHOL PRODUCTION PLANT ON RIVER KLOU IN LOGOZOHE, REPUBLIC OF BENIN

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Article Received on
29 Dec. 2020,

Revised on 18 Jan. 2021,
Accepted on 08 Feb. 2021

DOI: 10.20959/wjpr20213-19821

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ABSTRACT

The aim of this study is to evaluate the environmental impacts of liquid discharges from the alcohol production industry at Logozohe through a characterization of the physicochemical parameters of its effluents and an assessment of the levels in dry season, of river Klou's water contamination. This river is the receiving environment. For this purpose, thirteen parameters were measured on sixteen sites along the river Klou from the upstream to the downstream of the factory. From results obtained, it appears that nitrogen pollution is high and is reduced to Kjeldahl nitrogen (NTK). Also organic pollution is very important and not biodegradable. This leads to suspicion of the use of synthetic organic solvents in the factory's production processes. This massive organic pollution of the receiving environment on which local residents depend challenges more than one as to water pollution of the factory and its consequences on populations and the future of the river Klou.

KEYWORDS: Water pollution, river Klou, Logozohe, alcohol factory.

I- INTRODUCTION

Day by day, demography and industrial development increase highly by training changes in environment affecting atmosphere, hydrosphere, geosphere and biosphere.^[1] The course for economic growth is so engaged with an important consumption of raw materials, the degradation of living environment with various rejects and many consequences on water resources and human. In contrary to developed countries where industrialization and transfer of technology of factories and enterprises which follow had made people aware of relation between pollution, public health, living environment and by extension has led to a development introducing obligations that are properly organized on the legislative and regulatory level, as well as on infrastructure, training and behavioral level, in our countries, there is still some way to go.^[2] Industrialists therefore take advantage of the absence or application of these rigorous and above all coercive legal provisions to discharge effluents into the environment without treatment. In Logoze (Benin) this is the case of alimentary alcohol production unit. This work aims to evaluate the consequences of this factory's effluents on the river Klou in dry season.

II- MATERIAL AND METHODS

A- Presentation of the study area

The factory and the river Klou are both located in Logoze (Savalou-Benin). From its source and on its way the river has many tributaries.

The study was carried out from February to April 2018 in the dry season to find out the potential and real impacts of effluents on the environment of the area.

The choice of sampling points were carried out by following below criteria:

- For the sites inside to the factory the choice was made according to the circuit traversed by the water in the production process until discharge.
- For the sites located on the wastewater circuit outside of the factory, the choice focused on the key stages of the treatment chain implemented from upstream to downstream of the factory in order to assess water quality before and after plant discharges;
- For the sites located on the course of the Klou river, the choice was made starting upstream (the areas before discharge) downstream of the plant in order to assess the extent of the chemical pollution of the rejections from the production unit concerned.

The coordinates of the investigated sites are listed in table1.

Table 1-a: Geographic coordinates of sites (from ST1 to ST8).

| Code site | ST1 | ST2 | ST3 | ST4 | ST5 | ST6 | ST7 | ST8 |
|-------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Coordinates | 07°53.384'N 002°05.854'E | 07°53.355'N 002°05.846'E | 07°53.359'N 002°05.839'E | 07°53.361'N 002°05.849'E | 07°53.365'N 002°05.852'E | 07°53.376'N 002°06.088'E | 07°53.268'N 002°06.095'E | 07°53.276'N 002°05.986'E |

Table 1-b: Geographic coordinates of sites (from ST9 to ST16).

| Code site | ST9 | ST10 | ST11 | ST12 | ST13 | ST14 | ST15 | ST16 |
|-------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Coordinates | 07°53.243'N 002°06.017'E | 07°53.224'N 002°06.004'E | 07°53.194'N 002°05.996'E | 07°41.625'N 002°02.449'E | 07°41.552'N 002°02.318'E | 07°41.552'N 002°02.318'E | 07°41.806'N 002°02.086'E | 07°47.616'N 002°03.514'E |

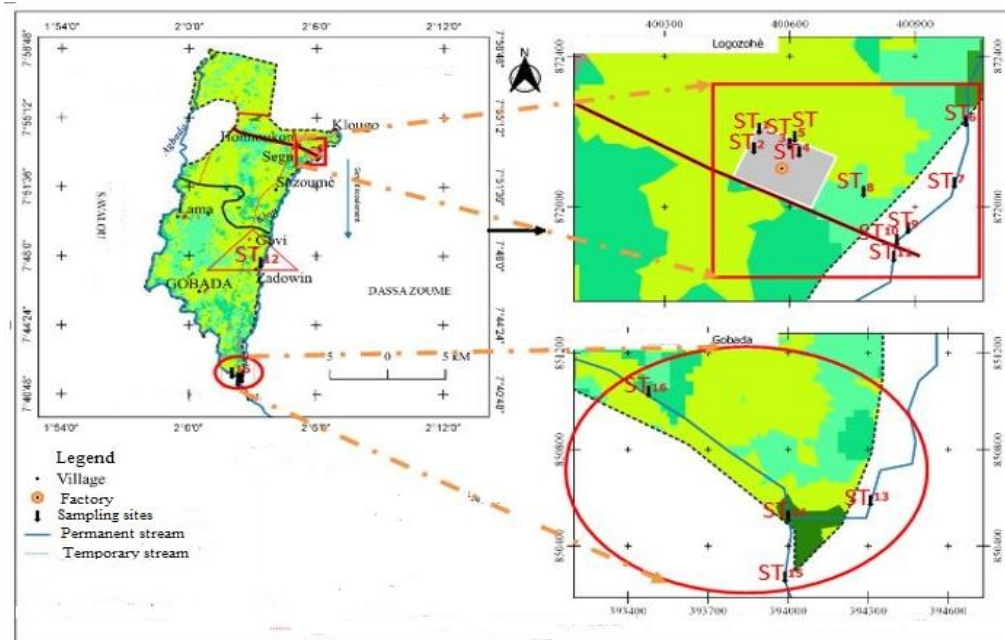


Figure 1: Sampling sites.

B -Sampling collection

All the samples are taken in glasses bottles initially washed and rinsed with the water to be sampled. In addition for in-situ measurements, 1.5L of water are sampled each time in bottle and rinsed 3 times with the water to be sampled before real water sampling. Water samples are afterwards conserved at a temperature of 4°C and analyzed in the laboratory within 48 hours after the sampling.

C- Analysis methods

Temperature, conductivity and pH were measured on situ while water hardness, alkalinity, BOD, COD, NTK, concentrations of nitrate, nitrite and ammonium are researched in water samples by standards methods according to methods of analysis recognized by the French Association for Standardization (AFNOR) [3]. The table below summarizes these methods.

Table 2: Analytical methods used.

| Parameters | Principle of the method | Reference |
|------------------------------|---|------------------|
| NH ₄ ⁺ | NH ₄ ⁺ ions were sought by formation in an alkaline medium of a compound of indophenol type with phenol and ClO ⁻ in the presence of sodium nitroprusside Na ₂ [Fe (CN) ₅ NO]. H ₂ O ₂ is used as a catalyst. The blue color revealing the presence of indophenol was obtained. The spectrophotometric measurement is carried out at $\lambda = 630$ nm. | NFT90-015-2 |
| NO ₂ ⁻ | The NO ₂ ⁻ ions were assayed with 4-amino-benzene sulfonamide at pH = 1.9 in the presence of H ₃ PO ₄ to form a diazo salt with complexation with dihydrochloride of N-(Naphthyl-1) diamino-1,2-ethane. All this gives a pink color whose intensity is proportional to the NO ₂ content - and measurable at 540 nm | NF EN 26777 |
| TH | Ca ²⁺ and Mg ²⁺ ions were complexed with EDTA at pH 10 in the presence of Eriochrome Black T as indicator. | NF T90-003 |
| TAC | Titration of water sample with acid solution (0.02 N) at pH = 5.4 | NF EN ISO 9963-1 |
| DCO | Oxidation of organic matter in an acidic solution by excess of K ₂ Cr ₂ O ₇ in the presence of Ag ₂ SO ₄ as catalyst and HgSO ₄ to complex the Cl ⁻ ions and determination of the excess oxidant with a solution of Mohr's salt (NH ₄ Fe (SO ₄) ₂ .6H ₂ O) | NF T90-101 |
| DBO | Oxidation of the biodegradable organic material contained in a water sample by natural microorganisms in the dark in amber bottles saturated with O ₂ placed in a thermostatic incubator at 20 ° C ± 2 ° C for 5 days. | NF EN 1899-2 |
| Turbidity | Emission of radiation of $\lambda = 860$ nm in a sample and measurement of the scattered radiation transmitted under the effect of particles in suspension | NF EN ISO 7027 |
| O ₂ dissous | Immersion of a probe consisting of a cell closed by a selective membrane permeable to dissolved O ₂ and containing the electrolyte and two metal electrodes in the water to be analyzed | NF EN 25814 |

III- RESULTS AND DISCUSSION

Table 3: Identification of environmental components impacted by liquid effluents of the factory.

| Phase | Activities | Environmental components | | | | | | | | |
|--------------|--|--------------------------|-------|------|------------------------|-------|-------------------|-----------|--------|---------|
| | | Physical environment | | | Biological environment | | Human environment | | | |
| | | Air | Water | Soil | Wildlife | Flora | Social | Landscape | Health | Economy |
| Exploitation | Used waters reject into the river Klou | - | - | - | - | - | + | - | - | +/- |
| | Maintenance of machines and equipments | - | - | - | - | | | | | |

The matrix of Leopold is used by taking into account the activities of reject of used waters by the factory and the maintenance of whole the machines and equipments. The sign (+) indicates that the impact is positive while the sign (-) indicates a negative impact.

A- Variations of physico-chemical parameters

Table 4-a: Physico-chemical parameters values (from ST1 to ST8).

| Parameter | Sites | | | | | | | |
|---------------------------------|-------|-------|------|------|------|-------|-------|------|
| | ST1 | ST2 | ST3 | ST4 | ST5 | ST6 | ST7 | ST8 |
| Temperature (°C) | 33.8 | 34.2 | 57.7 | 70 | 36.4 | 31.4 | 31.6 | 35.9 |
| Turbidity (NTU) | 49.9 | 26.24 | 11.3 | 1063 | 27.7 | 16.8 | 18.3 | 46.8 |
| Potential of Hydrogen | 6.73 | 6.41 | 6.96 | 3.47 | 5.32 | 6.38 | 6.53 | 6.58 |
| Electrical conductivity (µS/cm) | 276 | 282 | 264 | 4640 | 276 | 203.1 | 187.8 | 841 |

Table 4-b: Physico-chemical parameters values (from ST9 to ST16).

| Parameter | Sites | | | | | | | |
|---------------------------------|-------|------|------|------|------|------|------|------|
| | ST9 | ST10 | ST11 | ST12 | ST13 | ST14 | ST15 | ST16 |
| Temperature (°C) | 34.1 | 29.1 | 33.8 | 27.5 | 26.6 | 27 | 28.5 | 28.5 |
| Turbidity (NTU) | 52.8 | 113 | 95.7 | 15.6 | 7.1 | 3.18 | 7.39 | 4.02 |
| Potential of hydrogen | 6.65 | 6.82 | 7.17 | 6.48 | 7.05 | 6.97 | 6.83 | 6.95 |
| Electrical conductivity (µS/cm) | 1385 | 2133 | 2088 | 346 | 434 | 321 | 353 | 247 |

The Temperature values vary from 26.6°C to 70°C. The difference between the water in the river Klou's temperature and the one of the effluent from the plant just at the point of discharge into the watercourse is 4.4 °C and meet the standards for wastewater discharges in Benin which recommend deviations less than or equal to 5 °C.^[4]

Apart from the values recorded on the sites ST14 and ST16, all the other values obtained for the turbidity are higher than those admissible according to the WHO (5 NTU); this means that the waters of the river Klou are unfit for consumption on most sites. The high value

(1063 NTU) is recorded at site ST4. This value is more than 63 times higher than that recorded for water at the input of the process at site ST6 located in upstream of the plant (pumping source at river level). The value recorded on site ST11 shows also that the factory influences, by its rejects, the quality of the water of the river.

The pH values range from 3.5 to 7.2 with an average 6.44 ± 0.02 . The most low value is recorded at ST4 at the 1st basin receiving the discharge of effluents from the entire production chain to be pumped out. This value is worrying and would be due to the chemical hydrolysis of the must which precedes the enzymatic hydrolysis. However, at ST8, where waste water is discharged after treatment, in the river Klou, the pH value rises to 6.6 and complies with Beninese normative requirements.^[4] The pH of the main effluent discharged into the river respects so the pH range of surface waters.

The electrical conductivity values recorded are ranged from 187.8 $\mu\text{S}/\text{cm}$ to 4640 $\mu\text{S}/\text{cm}$ with an average of (892.30 ± 37.23) $\mu\text{S}/\text{cm}$. Apart on three sites (ST4, ST10 and ST 11), whole the values meet benenese standard wich is 2000 $\mu\text{S}/\text{cm}$.^[4] The high value on the site ST4 are mainly due to the high values of the conductivity of the effluents leaving the factory and those of the sites ST10 and ST11, to a phenomenon of accumulation of the effluents in the river bed in dry season.

Water hardness and alkalinity

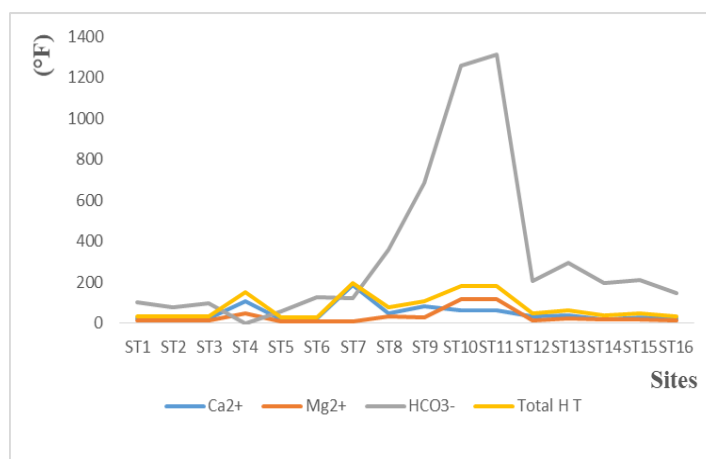


Figure 2: Spatial variation of water hardness.

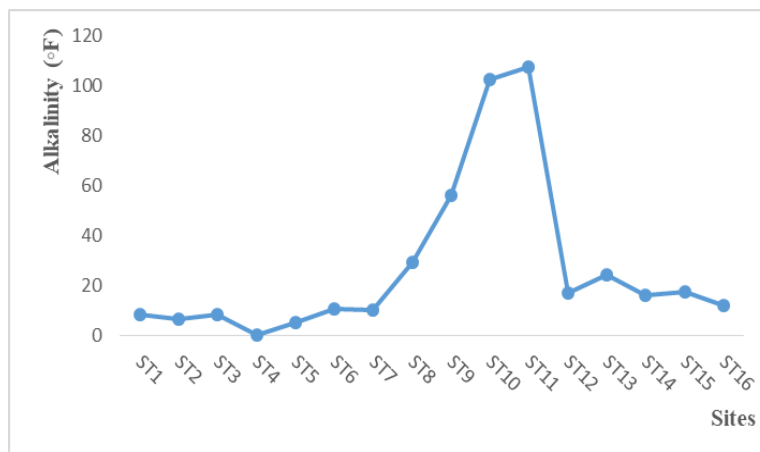


Figure 3: Spatial variation of water alkalinity.

The figure 3 shows partials and total spatial variations of water samples hardness. Among the different variables, only the bicarbonate hardness experienced extreme peaks in ST10 and ST11, the rest of the variables evolve in a sawtooth fashion. Bicarbonates, calcium and magnesium hardnesses are not regulated by standards in Benin. All the maximum levels of both calcium hardness and magnesium recorded are higher but are in agreement with those of groundwater which is very hard in the Hills department (where the study area is located). High calcium hardness for drinking water is generally responsible for kidney stones. The risks are very high for the populations bordering the Klou river who use this resource as drinking water. The lowest value of alkalinity, close to zero is recorded, at ST4. This value is low than the one observed at the same place by another author^[5] in the rainy season. The highest value is registered at ST11. It's noticed that by superposing both figures 2 et 3 water alkalinity is due to bicarbonated ions. According to Hounaho^[5] for the pH ranged between 5.32 and 7.52, conventionnal values of alkalinity are linked to bicarbonated ions. Apart from ST4, the pH values obtained, meet this condition.

Nitrogen pollution

Table 3-a: Variation of nitrogen pollution (from ST1 to ST8).

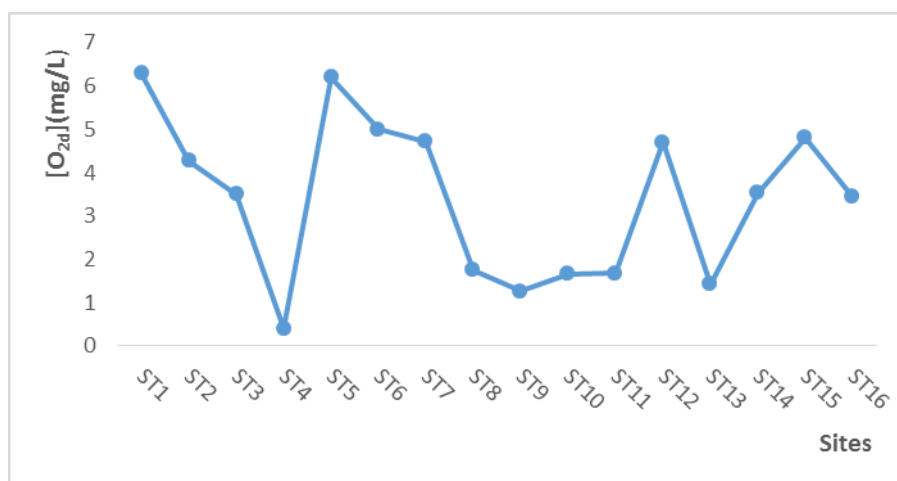
| Parameter (mg/L) | Sites | | | | | | | |
|--------------------------------|-------|------|------|--------------|------|------|---------|------|
| | ST1 | ST2 | ST3 | ST4 | ST5 | ST6 | ST7 | ST8 |
| N-NO ₃ ⁻ | 20 | 7 | 8 | 8 | < 1 | 11 | 7 | 10 |
| N-NO ₂ ⁻ | 0,02 | 0,02 | 1,14 | 1 | 0,04 | 0,02 | < 0.046 | 0,02 |
| N-NH ₄ ⁺ | 0,8 | 1,2 | 2,6 | 350 | 2,6 | 1 | 1 | 4,4 |
| NTK | 0,5 | 0,7 | 0,63 | 24,32 | 2,63 | 0,87 | 1,11 | 0,61 |

Table 3-b: Variation of nitrogen pollution (from ST8 to ST16).

| Parameter (mg/L) | Sites | | | | | | | |
|--------------------------------|-------|-------------|--------------|------|------|------|------|------|
| | ST9 | ST10 | ST11 | ST12 | ST13 | ST14 | ST15 | ST16 |
| N-NO ₃ ⁻ | 8 | 8 | 8 | < 1 | < 1 | 1 | 1 | 1 |
| N-NO ₂ ⁻ | 0,04 | 0,06 | 0,04 | 0,46 | 0,16 | 0,12 | 0,08 | 0,1 |
| N-NH ₄ ⁺ | 5,4 | 8,4 | 9,4 | 1,2 | 1,8 | 1 | 1,2 | 1 |
| NTK | 5,46 | 18,3 | 19,93 | 1,17 | 1,54 | 1,09 | 0,95 | 1,09 |

The table 3 shows that nitrate contents in the samples are low apart on ST3 and ST4 where the values are high. The same remarks are made for nitrites on all the sites except on ST3 and ST4 where the measures are higher than standards (0,6mg/L) of Republic of Mali for waste waters.^[6] The contents of ammonium are also lower than the standards (≤ 15 mg/L) of Mali Republic except on ST4 (raw wastewater reception basin from the plant). The NTK higher values are recorded (highest than beninese standards) on sites ST4, ST10 et ST11. These contents are more high than those recorded by Hounanho^[5] on the same sites in rainy season. These high NTK values would result from the high concentrations of the plant's effluent but also from the fact that the current campaign was carried out in the dry season during which the plant is in full operation and discharges large quantities of pollutants into the water of river. The measurement of NTK represents the sum of the contents of NH₄⁺ and organic nitrogen. In view of the above, we note that the strong nitrogen pollution is essentially organic.

Variations of dissolved oxygen contents in the samples

**Figure 4: Spatial variations of dissolved oxygen.**

Dissolved oxygen concentrations vary widely. The very low dissolved oxygen content of ST4 is normal because it characterizes the availability of dissolved oxygen in the raw effluent in a

hot state and very loaded with organic matter. The value recorded in ST6 is also justified by the fact that it represents the availability of dissolved oxygen in the Klou river in the initial state (control). On the other hand, the dissolved oxygen concentrations obtained in ST8, ST9, ST10 and ST11 are low because these sites would be under the influence of the factory effluent.

Biochemical Oxygen Demand (BOD)

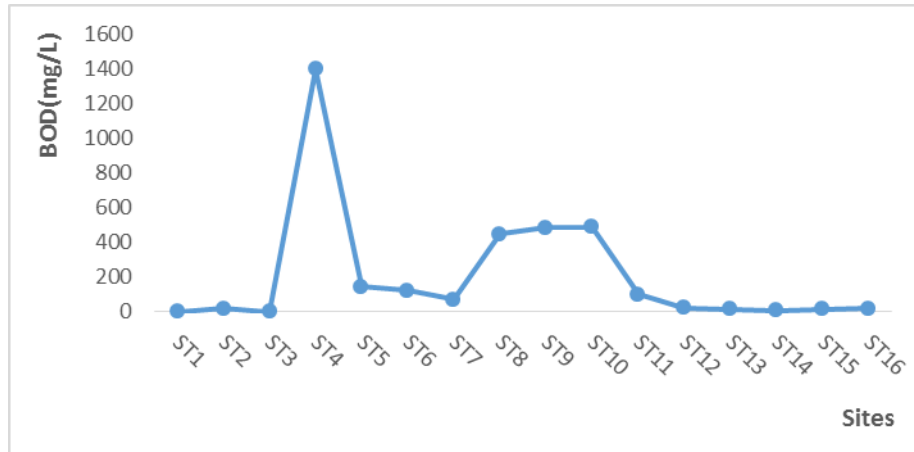


Figure 5: Spatial variations of BOD.

The figure 5 shows a peak at ST4 and above-average values at ST8, ST9 and ST10. The values taken by the BOD are between 3 mg O₂ / L and 1400 mg O₂ / L. BOD makes it possible to assess the biodegradable organic matter content of a receiving environment through the dissolved oxygen cost to be paid to eliminate this pollution. Benin's industrial wastewater discharge standard sets a limit of 100 mg of BOD / L of wastewater discharged. The highest values recorded are well above this standard at the ST4, ST5, ST6, ST8, ST9 and ST10. At ST6 the BOD value should normally be low. However, the high value recorded is due to contamination of water at this level by residues (spent grain) from agricultural areas in the rainy season. Likewise, the high value obtained at ST10 comes from the accumulation of biodegradable organic matter on this site which is an accumulation zone of it, coming from various horizons (factory, agricultural areas, etc.). From the twelfth to the sixteenth site, the recorded values are lower than the Benin standards. This observation makes sense because the water samples were taken from the river whose waters are in strings and therefore do not receive organic pollution from the factory continuously in the dry season.

Chemical Oxygen Demand

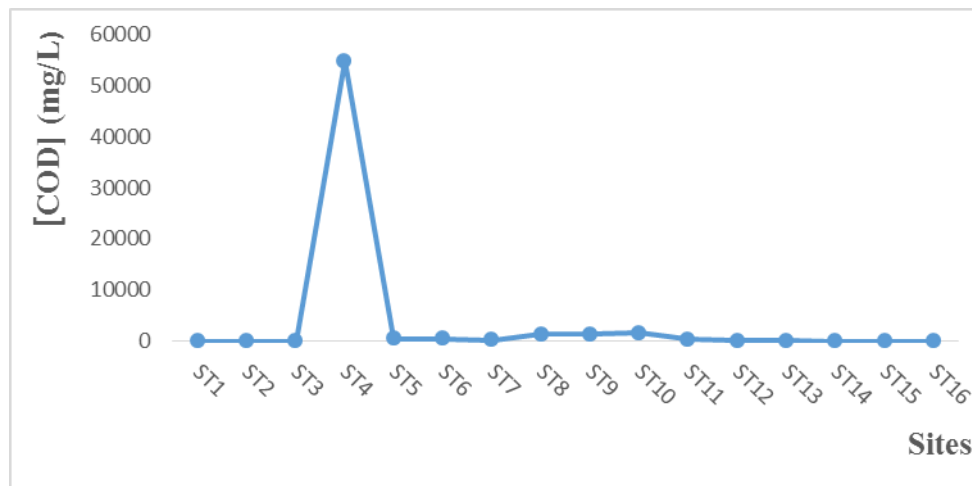


Figure 6: Spatial variations of COD.

The beninese standard requires a maximum daily COD release not exceeding 300 mg / L. This limit is largely exceeded from ST4 to ST11, except at ST7. At these points the BOD5 is also high except at ST11, where its value is close to the limit. This finding suggests that the effluent released by the plant into the stream is mainly loaded with non-biodegradable organic matter. This type of pollution is very damaging to the receiving environment because it is a source of loss of biodiversity in the stream and of foul odors that are harmful to local residents, without forgetting the health risks.

Variation of BOD/COD ratio

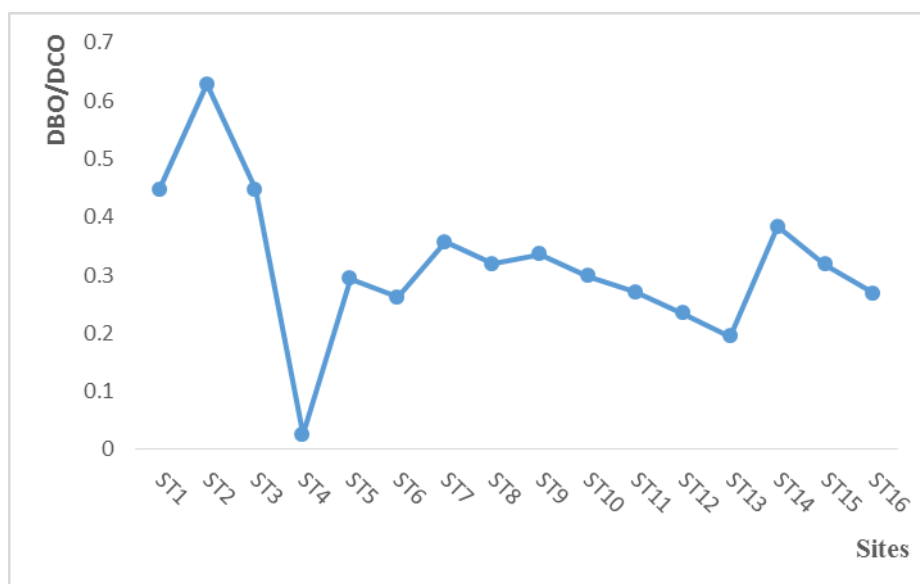


Figure 7: BOD/DCO ratio variations on the sites.

The BOD / COD ratio varies between 0.02 and 0.62. Almost all of the water in the Klou River is not biodegradable. Only the water from ST2 (water from the river that has undergone treatment within the plant) is biodegradable with a BOD / COD ratio > 0.5 ie 0.62. The waters at ST1, ST3, ST7 and ST14 are difficult to biodegrade with selected bacterial strains. This state of affairs can be justified by the fact that the Klou river being in a strongly agricultural area where the use of synthetic pesticides is very widespread, the runoff water having leached freshly sprayed agricultural areas drained pesticide residues into the area. The stream, making it refractory to biodegradation. This non-biodegradability of the water was greatly enhanced by the effluents from the plant with a BOD / COD ratio of 0.31. These results agree with the work of Hounaho^[5] in the rainy season.

CONCLUSION

This study made it possible to characterize the liquid effluents from the Logozohe alcohol manufacturing plant and to assess the levels of contamination of the Klou river which is their receptacle, through the determination of the physico-chemical quality parameters of the water. From the results obtained, it emerges that turbidity, electrical conductivity, BOD, DCO, BOD / COD, salinity, total hardness (TH), NTK, oxygen contents dissolved at the level of the main effluent and the Klou river do not meet the standards of drinking water quality and industrial wastewater discharge in the Republic of Benin. The entire portion of the river studied is polluted to varying degrees. The organic pollution of the effluent released from the factory into the stream is not remarkably biodegradable. This type of pollution is very damaging to the receiving environment because it is a source of loss of the biodiversity of the stream, of foul odor emanations and of health risks detrimental to residents. Likewise, the calculation of the BOD / COD ratio revealed that almost all of the water pollution in the Klou river is not biodegradable except for that taken upstream of the alcohol manufacturing process where it undergoes preprocessing. In fact, the pollution recorded as a result of the plant's activity in the dry season is noted locally for this study at ST4, ST8, ST10 and ST11. Solving the problems associated with this industrial pollution requires the establishment of a complete treatment system with particular emphasis on the biological component and the discharges of which must comply with Beninese standards and WHO guidelines.

REFERENCES

1. Dieme D. Physicochemical characterization and study of the toxic effects on BEAS-2B lung cells of particulate pollutants from the city of Dakar (Senegal). Doctoral thesis from the Littoral-Côte d'Opale University, 2011.
2. Guissou I P, Toe A M, Sondo B K, Ouedraogo JB. Management of chemical risks in the Bobo-Dioulasso and Banfora factories. Nomenclature of products and chemical risks and proposal of a prevention strategy. Burkina Faso, 2001.
3. Rodier J, Legube B, Merlet N. Water analysis. 9th edition, 2009.
4. Decree N°2001-109 of April, 4th 2001 setting the quality standards for wastewaters in Benin.
5. Hounaho S G F. Environmental impacts of industrial discharges from the food alcohol production plant on the aquatic ecosystem of the Logozohe river klou: Case of liquid effluents. Professional master's thesis at the National Water Institute at the University of Abomey-Calavi, 2017.
6. Djermakoye H. Physico-chemical, bacteriological characteristics and impact on surface water and groundwater. PhD thesis from the University of Bamako, 2005.
7. Hougbo S, Padoue A, Nonvignon GA, Gérard JR., Aime Z, Bodounri Y, Moderan TR, Jacques F. Study of the chemical and bacteriological quality of water resources in Hozin, district of the commune of Dangbo in Benin. *International Journal of Chemical Studies*, 2018; 6(1): 146–160.