Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454

Vol. 21 | No. 3 | pp. 931-940 | 2022

Original Research Paper

https://doi.org/10.46488/NEPT.2022.v21i03.001

Open Access Journal

Risk Assessment of Chemical Pollution of Industrial Effluents from a Soap Production Plant

Zoyem Gouafo Mathurin*(**)†, Talla Pierre Kisito*, Ngapgue Francois*(***) and Médard Fogue*
*University of Dschang, Laboratory of Mechanics and Modeling of Physical Systems, Dschang, Cameroon
**University of Dschang, Industrial Systems and Environmental Engineering Laboratory (IUT-FV), Bandjoun, Cameroon
***Department of Civil Engineering, IUT-FV, Bandjoun, Cameroon
†Corresponding author: Zoyem Gouafo Mathurin; zoyemm@gmail.com

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 24-09-2021
Revised: 02-12-2021
Accepted: 15-12-2021

Key Words:
Water and environmental pollution
Mewou river
Industrial effluents
Soap factory

ABSTRACT

The MEWOU river, which crosses the town of Bafoussam, is one of the main sources of drinking water and irrigation for the populations who live there. It is subject to intense agricultural and industrial activity all along its banks. Soap and refined oil factories generate pollution in the form of liquid effluents which are discharged without any form of treatment. The objective of this study is to assess the impact of soap factory effluent discharges on the quality of the surrounding water. In total, seven samples were analyzed during March, April, and May of the year 2021. The results we obtained were analyzed according to the regulatory requirements recommended by the Directives for the quality of drinking water and the Algerian standard relating to the limit values of the physico-chemical parameters. The results we obtained showed signs of significant pollution in particular: chemical oxygen demand (COD: 125.32-959 mg.L^{-1}), 5 days-biochemical oxygen demand (BOD5: 23-99 mg.L^{-1}), turbidity (2-520 NTU), TDS (130-13430 mg.L^{-1}), Nitrite (4.96-21327.44 mg.L^{-1}) and many other parameters greatly exceed those required by the international standard, we also noted strong pollution with heavy metals: chromium (35.76-1381.08 mg.L^{-1}), lead (0.21 - 2.49 mg.L^{-1}), iron (0.28- 17.82 mg.L^{-1}), and cadmium (0.03-0.19 mg.L^{-1}) which are above the values prescribed by the WHO. These highly polluted effluents released into the natural environment are harmful to the environment, biodiversity, and human health. This state of affairs requires urgent intervention to preserve the ecological balance. Otherwise, it can constitute a risk for public health in the short term by deteriorating the quality of the underground reservoir known as the main source of water supply for neighboring populations.

INTRODUCTION

Water pollution results from the introduction of foreign matter capable of deteriorating the quality of the water in a body of water, thus posing negative effects on human life and health. Industrial effluents represent a point source of water pollution (Awomeso et al. 2010). While strict waste management and control policies have existed for years in developed countries, the implementation of the same model Regulation is struggling to take effect in developing countries like Cameroon, thus making it difficult to assess the current situation or compare and contrast its performance with other places/nations.

Based on a 2005 analysis of global urbanization prospects (INS 2004, ONU 2006) more than half of Africa's population is expected to live in cities by 2030. In Cameroon, 50% of the population lives in cities; The urban population increased from 28.5% of the total population to 52.8% between 1976 and 2003. By 2030, it is expected to reach over 70% of the population. During the same 1976 – 2003 period, the population density in Cameroon increased from 16.4 to 35.7 inhabitants per km2 (INS 2004). In the large urban centers of the city of Bafoussam, the population density per square kilometer is high, the same is true for the cities of Douala, Yaoundé, and Garoua. This increase in the demographic pressure of cities like Bafoussam combined with the increase in population and the intensification of industrial activities makes the issue of controlling industrial effluents even more important.

In the town of Bafoussam, rivers are one of the main sources of freshwater supply, however, they are also vulnerable to both point and diffuse types of pollution. Wastewater discharges from industries around the town of Bafoussam deteriorate the quality of surface and underground water and soils (Gouafo & Yerima 2013). The effects of water pollution are often different depending on the mode of contamination. For humans, this is done by ingestion, contact, or consumption of contaminated fish from polluted waters. For example, fish contaminated with biogenic elements such as copper and cadmium are highly toxic to humans. The presence of chromium and cadmium makes water unsuitable for domestic and agricultural use due to their toxicity (Kankou 2004).

The presence of toxic chemicals in industrial effluents can pose a threat to human and animal health as well as contaminate water quality (WHO 2008). The objective of this study is to assess the impacts of effluent discharges from soap production on the quality of nearby water by analyzing certain physicochemical parameters of the discharge water leaving this soap factory.

MATERIALS AND METHODS

The physico-chemical parameters analyzed in this study were the following: pH, temperature, turbidity (NTU), Electrical conductivity (μS.cm^{-1}), TDS, calcium, magnesium, potassium, sodium, bicarbonates, carbonate, nitric nitrogen, nitrate, nitrogen ammoniacal, ammonium, nitrite, chlorine, sulphate, sulfur, soluble phosphorus, aluminum, cadmium, copper, chromium, iron, lead, zinc, dissolved oxygen (mg.L^{-1}), chemical oxygen demand (COD) and 5 days of biochemical demand in oxygen, required by national standards, to qualify the sources of pollution with a global view of the chemical quality of the effluents discharged. The analysis of the physico-chemical parameters was carried out at the Soil Analysis and Environmental Chemistry Research Unit, FASA, University of Dschang (Cameroon)

Presentation of the Soap Production Plant (Cameroonian Company of Soap Factory)

This is a large soap production plant located in Bafoussam, Kamkop (in the western Cameroon region). The western region has the city of Bafoussam as its capital. It is located in the mountainous region of West Cameroon, in the Mifi Sud watershed, between 9°30 ‘ and 10°35’ East longitude and between 5° and 6° North latitude. It is at an average altitude of 1450 meters and extends over the highlands of the western mountain range. The expansion of the SCS plant in 2013 also boosted its production to 500 tonnes of refined oils every day. The SCS soap production plant releases a volume of raw polluted effluents of between 80 and 100 m^3/day into the environment

Sampling and Physico-Chemical Analyses

Sampling Conditions

For the results to be valid, special care must be taken when taking a water sample. First, the sample taken must be homogeneous, representative, and obtained without altering its

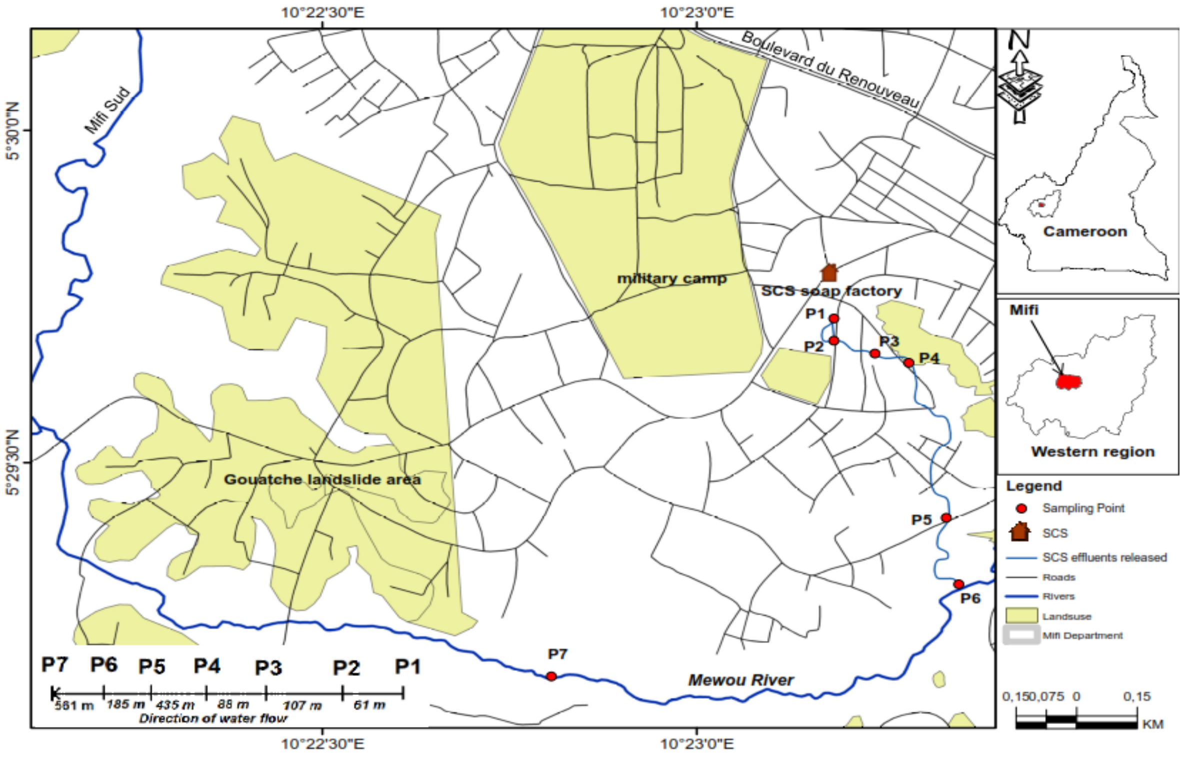

Fig. 1: Partial hydrographic network of the southern Mifi showing the location of the sites of the SCS (Cameroonian company of Soap factory).

microbiological or physicochemical characteristics. (Rodier et al. 2009).

The water samples used for the physico-chemical analysis were taken according to the method described by Rodier et al. (2009) in sterile disposable plastic bottles and stored at + 4 °C, then to be analyzed within 24 h following sampling, with the exception of two parameters, pH and temperature, which were measured on-site.

Samples were taken in the morning, and the used vials were held directly and extended to a depth of 30 to 50 cm from the surface of the polluted effluent of the SCS, a total of 7 samples were collected and analyzed (Table 1).

Physico-Chemical Analyses

All the physico-chemical parameters analyzed were based on the standard methods given by the American Public Health Association (Rice et al. 2017) as follows:

- The temperature and the hydrogen potential (pH) were measured respectively by a thermometer and a pH-meter (Thermo-scientific ORION STAR 225)
- The electrical conductivity was determined using a conductivity meter. The result was expressed in micro siemens per centimeter ($\mu S.cm^{-1}$);

Assessment of Organic Pollution of SCS Effluents

For a better evaluation of the organic pollution of the discharged water, the parameters that indicate biodegradabilities such as the ratio BOD5 / COD, and the coefficient K = COD / BOD5, are of great importance. The use of these characterization parameters is an excellent way to estimate the level of pollution of the raw effluents discharged and also to optimize the physicochemical parameters of these industrial effluents to propose a suitable wastewater treatment method.

Interpretation of Physicochemical Results

Thanks to the analysis of physico-chemical and bacteriological parameters, it is possible to determine the sources and the pollutant load of wastewater. Before being released into the natural environment, they must meet the standards established to protect the receiving environment against pollution. The limit values are given in the Official Journal of the Algerian Republic and by those of (OJAR n.26, 2006, WHO 2008).

Statistical Analyses

The experiment was repeated three times where the results obtained were presented as the mean ± SD, calculated using the MATLAB software from whose representations have been given in the form of curves.

RESULTS AND DISCUSSION

Physico-Chemical Analyses

Temperature

Water temperature is an important factor as it governs the types of aquatic organisms that inhabit it. Its role is, among other things, to dissolve the gases in water, and to separate the dissolved salts, its measurement is necessary. Here the


(a)

(b)

Fig. 2: (a) Effluents released by the Cameroonian company of Soap factory in Bafoussam, Kamkop (Mathurin et al. 2022) (b) one of the meeting areas between the effluents and a watercourse in the town of Bafoussam.

Table 1: Description of study sites.

Sampling Point	Districts	Characteristics	Geographical locations	
			Longitude	Latitude
P1	Kamkop	Effluent discharge point	10°23’11”	5°29’43”
P2	Kamkop	Furnished, proximity Dwellings	10°23’15”	5°29’41”
P3	Kamkop	Points of contact between a river and effluents	10°23’14”	5°29’39”
P4	Kamkop	Unfinished, nearby dwellings used as laundry point	10°23’17”	5°29’39”
P5	Kamkop	Under a scupper	10°23’20”	5°29’25”
P6	Kamkop	Meeting with the MEWOU river	10°23’21”	5°29’19”
P7	Kamkop	MEWOU river	10°22’48”	5°29’10”

temperature of the industrial SCS discharges analyzed shows a variation from one sampled point to another (Fig. 3). The highest value was recorded for sample P1 (24.8°C) and the minimum value for sample P4 (22.8°C), with an average value for all samples, analyzed equally to 23.61 ° vs. These values are lower than the limit set by the Algerian standard (Table 2).

The effluent temperature varied from 22.9 to 24.8°C. This factor plays a very important role in the solubility of salts and gases (in particular O2) in water as well as the determination of the pH and the speed of chemical reactions. High temperatures induce additional pollution, thus affecting biological cycles (Gueddah 2003) by reducing the activities of dissolved oxygen, which can cause serious sewage disposal problems (Shivsharan et al. 2013). These values are the result of using hot water. The water produced by the pre-rinsing and washing operations is carried out at very high temperatures up to 70°C (Sayad 2015).

Turbidity

The chemical and biological particles in suspension, which are the causes of turbidity, can have implications for both the aesthetics and the safety of the drinking water supply. Alone Turbidity does not systematically represent a direct risk to public health; however, it does highlight the presence of pathogenic microorganisms and is an effective indicator of potentially hazardous events throughout the water supply system, from abstraction to point of use. For example, high turbidity of water sources can harbor microbial pathogens, which can attach to particles and interfere with disinfection; high turbidity in filtered water may indicate poor elimination of pathogens; And an increase in turbidity in distribution systems may indicate flaking of biofilms and oxide scales or the penetration of contaminants through faults such as power outages (WHO 2017).

The effluents studied have turbidity values ranging from 2 to 520 NTU, due to the presence of colloidal materials from palm oil used for soap production. These results are close to those found by (Gouafo & Yerima 2013) which were from 37.4 to 105.5 NTU.

Hydrogen Potential (pH)

The hydrogen potential (pH) of water provides information on its acidity or alkalinity (Rodier 1998). The pH of the industrial effluents studied reveals a high value for sample P3 (13.2), and a minimum value for the sample P7 (7.4); with an average value for all the samples analyzed equally to 10.53; which exceeds the range required by the national and international regulations.

The industrial effluents analyzed were characterized by a hydrogen potential (pH) ranging from 7.4 to 13.2 very alkaline, and located beyond the recommended standard (OJAR n.26 2006, WHO 2008). These variations in pH are

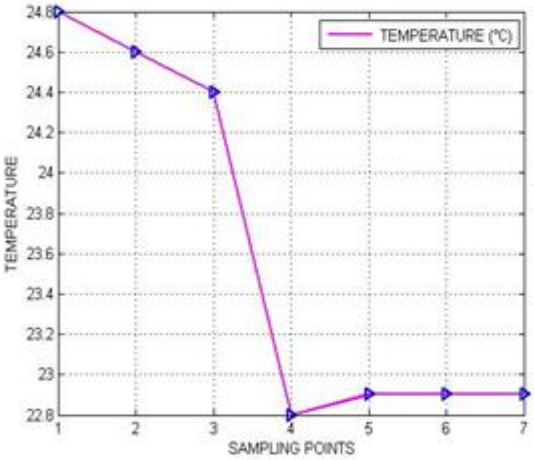

Fig. 3: Average effluent temperature values.

Table 2: Limits of the physicochemical parameters of industrial liquid effluent discharges from the SCS.

Parameters	Limit	Reference	Physicochemical analysis results		
			Minimum value	Maximum value	Mean ±SD
pH	8,5- 6,5	(OJAR n.26 2006)	7.4	13.2	10.53 ± 2.67
Temperature [°C]	30	(OJAR n.26 2006)	22.9	24.8	23.61 ± 0.86
Turbidity [NTU]	-	-	2	520	201.86 ± 201.83
Electrical cond [µS.cm^{-1}]	-	-	320	19980	9490.00 ± 9054.89
TDS [mg.L^{-1}]	0.2	(WHO 2008)	130	13430	5362.86 ± 4597.07
COD [mg.L^{-1}]	120	(OJAR n.26, 2006)	125.32	959	414.85 ± 259.216
BOD5 [mg.L^{-1}]	35	(OJAR n.26, 2006)	23	99	48.43 ± 26.19
COD / BOD5	-	-	3.79	19.67	9.42 ± 5.22
BOD5 / COD	-	-	0.0508	0.26	0.14 ± 0.07
Calcium [mg.L^{-1}]	-	-	2.4	26.4	7.09 ± 7.98
Magnesium [mg.L^{-1}]	-	-	3.4	10.21	4.93 ± 2.23
Potassium [mg.L^{-1}]	-	-	13.31	26.53	22.02 ± 4.75
Sodium [mg.L^{-1}]	-	-	3.8	452.06	167.46 ± 180.94
Bicarbonates [mg.L^{-1}]	-	-	2135	75640	24948.13 ± 31917.52
Carbonate [mg.L^{-1}]	-	-	6	13134	2250.00 ± 4511.40
Nitric nitrogen [mg.L^{-1}]	-	-	1.12	4814.32	1137.04 ± 1849.77
Nitrate [mg.L^{-1}]	50	(WHO 2008)	4.96	21327.44	5037.09 ± 8194.50
Ammoniacal nitrogen [mg.L^{-1}]	-	-	1.12	4.48	2.56 ± 1.15
Ammonium [mg.L^{-1}]	-	-	3.7	14.78	8.45 ± 3.81
Nitrite [mg.L^{-1}]	3	(WHO 2008)	3,67	15782.3	3727.44 ± 6063.93
Chlorine [mg.L^{-1}]	5	(WHO 2008)	39.05	223.65	112.08 ± 62.79
Sulphate mg L-1 [mg.L^{-1}]	1000 ~1200	(WHO 2008)	1049.6	9725.2	5046.51 ± 3368.62
Sulfur [mg.L^{-1}]	-	-	346.37	3209.32	1665.35 ± 1111.65
Soluble Phosphorus [mg.L^{-1}]	10	(OJAR n.26 2006)	5.64	1700.05	1113.11 ± 692.77
Aluminum [mg.L^{-1}]	3	(OJAR n.26 2006)	0	0.03	0.01 ± 0.01
Cadmium [mg.L^{-1}]	0.003	(WHO 2008)	0.03	0.19	0.10 ± 0.05
Copper [mg.L^{-1}]	0,5	(OJAR n.26 2006)	0	0.04	0.01 ± 0.01
Chromium [mg.L^{-1}]	0.7	(WHO 2008)	35.76	1381.08	717.47 ± 412.30
Iron [mg.L^{-1}]	3	(OJAR n.26 2006)	0.28	17.82	7.13 ± 5.86
Lead [mg.L^{-1}]	0.01	(WHO 2008)	0.21	2.49	0.68 ± 0.75
Zinc [mg.L^{-1}]	3	(OJAR n.26 2006)	0.51	1.98	1.72 ± 1.97
Dissolved oxygen [mg.L^{-1}]	-	-	0.32	1.92	1.10 ± 0.48

strongly influenced by the use of palm oil, chemicals such as nitric acid, and caustic soda (NaOH) in the operations of soap production, cleaning, and disinfection of equipment and facilities. industrial piping circuits, which can influence the pH of the receiving environment (Rodier 2005).

Electrical Conductivity (EC)

The electrical conductivity of water is a direct indicator of its salinity. This is an essential factor to follow when considering the reuse of wastewater for irrigation (agricultural fields) (Shilton 2006). A maximum value of the electrical conductivity of the effluents was recorded for the sample P4 (19980 µs.cm^{-1}), and a minimum value of 320 µS.cm^{-1} for the sample P7 (Fig. 6), with an average value for all the samples. samples analyzed equally to 9490 µS.cm^{-1} (Table 2).

The ability of water to conduct an electric current corresponds to its conductivity, which is an indirect measure of the ionic content of the water. In reality, dissonant measurements of an environment highlight the existence of zones of pollution, infiltration, or mixing. (Ghazali 2013). The electrical conductivity of the industrial effluents studied was between 320 and 19980 µS.cm^{-1}, which can be explained by the mineral composition of the soap and also by the use of NaOH. These values were higher than those cited by (Gouafo & Yerima 2013), for industrial effluents from the SCS, with turbidity values ranging from 355 to 1859 µS.cm^{-1}.

Total Dissolved Solids Content (TDS)

Total Dissolved Solids (TDS) is the parameter used to describe inorganic salts and very small amounts of organic matter that are present in the water. The main building blocks are essentially cations, anions, potassium, hydrogen carbonate, magnesium, sodium, potassium, carbonate, chloride nitrate, and sulfate (WHO 2008).

The TDS parameter of the effluents analyzed showed a significant Variation from one sample to another (Fig. 7), where the highest value indicated a TDS content of 13430 mg.L^{-1} for sample P2, and content in the lowest TDS was equal to 130 mg.L^{-1} for sample P7. The mean TDS value of all samples analyzed was 5362.86 mg.L^{-1}.

Nitrate Content (NO_3^-)

Nitrate concentrations in surface water can change rapidly due to surface runoff, uptake by phytoplankton, and denitrification by bacteria, but groundwater concentrations generally show relatively slow changes (WHO 2008). The nitrate

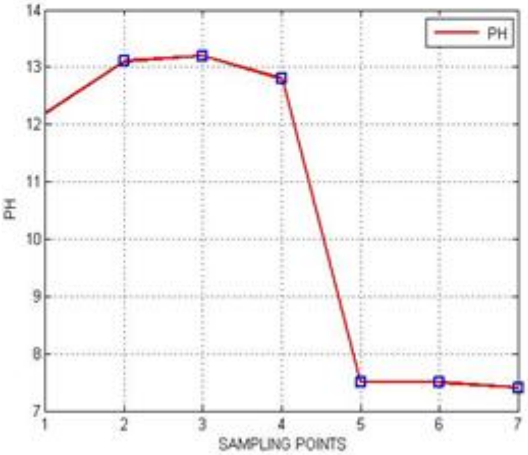

Fig. 4: Average pH values of effluents.

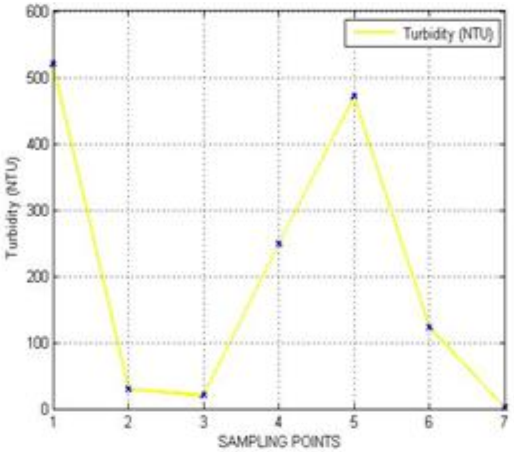

Fig. 5: Average effluent turbidity values.

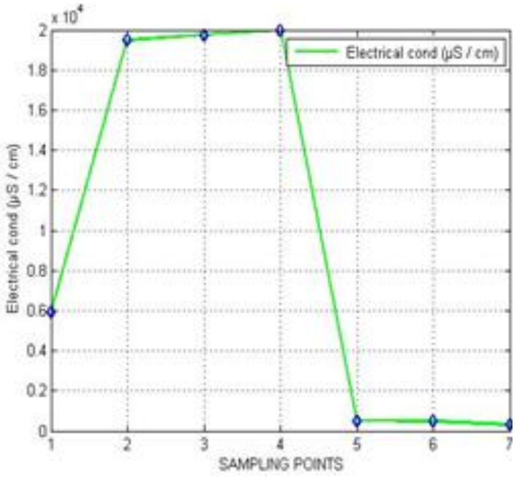

Fig. 6: Average electrical conductivity values of effluents.

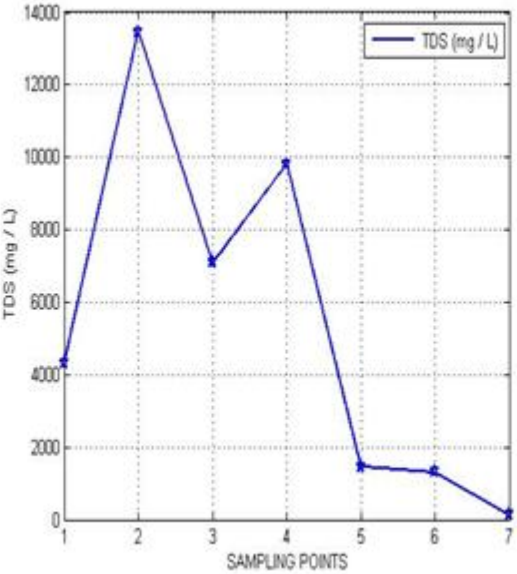

Fig. 7: Average values of TDS of effluents.

content of the SCS effluents varies from 4.96 to 21327.44 mg.L^{-1} with an average content of 5037.09 mg.L^{-1} (Fig. 7).

In surface water, Nitrate concentrations can vary rapidly due to uptake by phytoplankton, denitrification by bacteria, and surface runoff, but concentrations in groundwater generally show relatively slow changes. Some groundwater can also be contaminated with nitrates due to the leaching of natural vegetation (WHO 2008). The nitrate content ranged from 4.96 to 21327.44 mg.L^{-1}; this is probably due to the use of nitric acid as a chemical disinfectant for closed pipeline circuits (Hamdani et al. 2005), by the nitrification reaction of the organic nitrogen present in industrial effluents at the basin level. In reality, nitrification is a two-step reaction in which ammoniacal nitrogen is oxidized to nitrites (NO_2^-) and then to nitrates (NO_3^-) (Chachuat 2001).

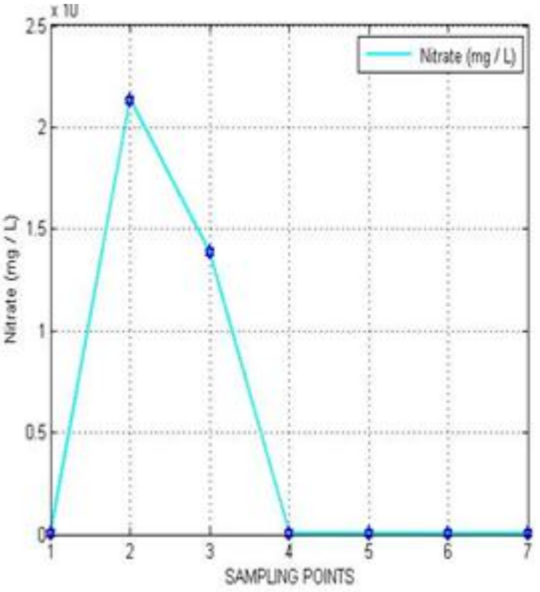

Fig. 8: Average values of nitrate of effluents.

Nitrite Content (NO_2^-)

The nitrite ion is considered to be the intermediate between ammoniacal nitrogen and nitrate, which justifies its low content in aquatic environments (Rodier et al. 1978). The nitrite contents were between 4.96 and 21327.44 mg.L^{-1}, with an average content of 3727.44 mg.L^{-1} (Table 3; Fig. 9).

The origin of the accumulation of nitrite may be linked to the inhibition of nitration, incomplete denitrification or even decoupling of the activities of the various reducing enzymes in the denitrification (Philips et al. 2002). The values obtained which ranged from 3.67 to 15782.3 mg.L^{-1} were 5,000 times higher than the prescribed standards (WHO 2008).

Sulfate Content (SO_4^{2-})

Sulfates occur naturally in many minerals and are used commercially, primarily in the chemical industry. They are released into the water in industrial wastes and by atmospheric

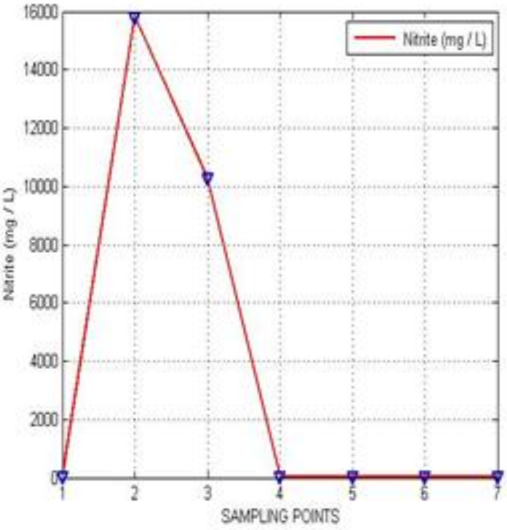

Fig. 9: Average nitrate values in effluents.

Table 3: variation of organic pollution indicators in the MEWOU river.

samples	Organic indicators		
	DO [mg.L^{-1}]	COD [mg.L^{-1}]	BOD5 [mg.L^{-1}]
P1	1.92	959	71
P2	1.28	555.3	99
P3	1.28	217.5	34
P4	1.28	333.5	55
P5	0.96	260.85	24
P6	0.64	452.52	23
P7	0.32	125.32	33

deposition (WHO 2008). The sulfate content of the industrial effluents analyzed varied from one sample to another (Fig. 10). The highest content is revealed for sample P3 (9725.2 mg.L^{-1}) and a minimum value for sample P7 (79.38 mg.L^{-1}), with an average value of all the samples, analyzed equally to 1049.6 mg.L^{-1} (Table 2).

The sulfate content of the discharged industrial effluents was between 1049.6 and 9725.2 mg.L^{-1}, these values are not tolerable because the WHO suggests that the sulfate content limit should not be higher than 1000-1200 mg.L^{-1} (WHO 2008).

Chemical Oxygen Demand (COD)

The chemical oxygen demand (COD) is an important parameter for determining the organic load in the water. In particular, for the operation of wastewater treatment plants, as well as for the characterization of water quality, this parameter is used worldwide and is one of the many directives relating to water quality. (Kolb et al. 2017). The COD values of the liquid effluents analyzed showed high concentrations ranging from 125.32 to 959 mg.L^{-1} (Fig. 11), with an average value of 414. mg.L^{-1}. These results exceed the recommendations of (OJAR n.26 2006).

The COD values ranged from 125.32 to 959 mg.L^{-1}, these values were much too high compared to the limits prescribed by the regulations (OJAR n.26 2006). These high concentrations were due to the high pollutant loads of organic matter released by the water since the production of soap involves the use of large quantities of palm oil (Félix et al. 2017). These results are similar to those reported by (Gouafo & Yerima 2013) 122-958 mg.L^{-1}. An industrial effluent with such a high COD can pose serious problems with reducing the oxygen concentration in waterways.

Biochemical Oxygen Demand (BOD5)

The need for the oxygenation factor of water is very clear as the presence of oxygen modulates the aerobic decomposition reaction of organic matter and more generally affects the biological balance of aquatic environments. The organic pollution values expressed in BOD5 show significant variations from one sample to another (Fig. 12). The recorded BOD5 values vary from 33 mg.L^{-1} (minimum value) to 99 mg.L^{-1} (maximum value) with an average value of 48.43 mg.L^{-1} (Table 2).

The BOD5 values obtained by the analysis of industrial effluents indicated an average value of 48.43 mg.L^{-1}. This result is close to that found by (Gouafo & Yerima 2013) which ranged from 34 to 71 mg.L^{-1} whose high BOD5 values could be explained by the abundance of organic matter. The chemical oxygen demand is the quantity of oxygen used by the materials present in the water which, under defined operating conditions, will oxidize. Indeed, its determination corresponds to an estimate of the oxidizable matter present in the water since its origin (Rodier 2005).

Organic Pollution Assessment

Biodegradability provides information on the ability of an effluent to be decomposed or oxidized by microorganisms involved in the biological process of water purification. It is expressed by the coefficient K.

- If (K <1.5): This means that the oxidizable materials are largely made up of highly biodegradable materials.

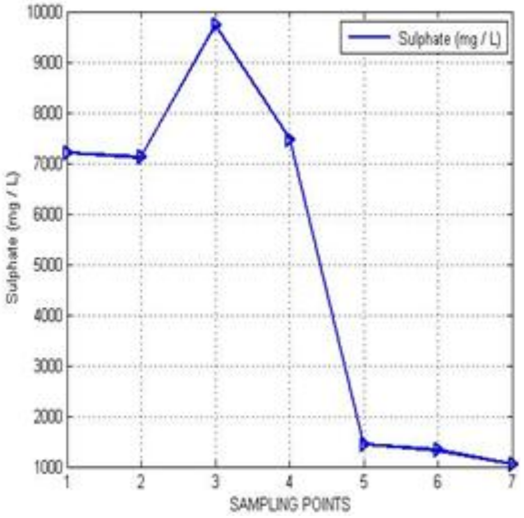

Fig. 10: Average sulfate values in effluents.

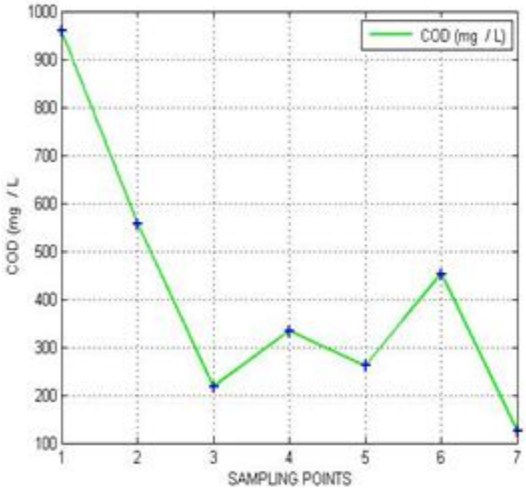

Fig. 11: Average COD values of effluents.

- If (1.5 <K <2.5): This means that oxidizable materials are moderately biodegradable.
- If (2.5 <K <3): This means that oxidizable materials are not very biodegradable.
- If K> 3: This indicates that oxidizable materials are not biodegradable. A very high K coefficient implies the presence of elements in the water that prevent bacterial growth, such as detergents, metal salts, hydrocarbons, phenols, etc. (Nabbou et al. 2020).

The industrial effluents studied have a K coefficient that varies from 3.79 to 19.67, which corresponds to that of industrial wastewater having a COD/BOD5 ratio greater than 3 (Rodier 1998). In addition, the average BOD5 / COD ratio of 0.14 reflects the low biodegradability of the substances contained in these effluents.

The COD / BOD5 ratio according to (Messrouk et al. 2014, Tardat-Henry & Beaudry 1992) Can make it possible to deduce whether the effluents are directly discharged into the receiving environment have the characteristics of domestic wastewater. this COD / BOD5 ratio is greater than 3 in our case, which means that the oxidizable materials thus released are not biodegradable. It can be deduced that the low biodegradability of this industrial wastewater from SCS may be associated with the presence of certain inhibitor products, such as palm oil heavily used for soap production, or with a high load of organic matter.

Metal Concentrations

The values of the metals in the sample stream varied as follows: chromium (35.76-1381.08 mg.L^{-1}), zinc (0.51-1.98 mg.L^{-1}), lead (0.21-2.49 mg.L^{-1}), potassium (13.31-26.53 mg.L^{-1}), iron (0.28-17.82 mg.L^{-1}), copper (0-0.04 mg.L^{-1}), and cadmium (0.03-0.19 mg.L^{-1}); the presence of lead is noted here with values greater than the WHO prescription, i.e. 0.01 mg.L^{-1} in drinking water. The health risks of an elevated lead concentration include kidney damage, anemia, and brain edema (WHO 2008). Only the values of copper and Zinc were within the admissible standards; other heavy metals were clearly and unequivocally above allowable standards; which allowed us to establish a definite link between the contamination of the Mewou River with heavy metals and the discharge of industrial effluents from the SCS.

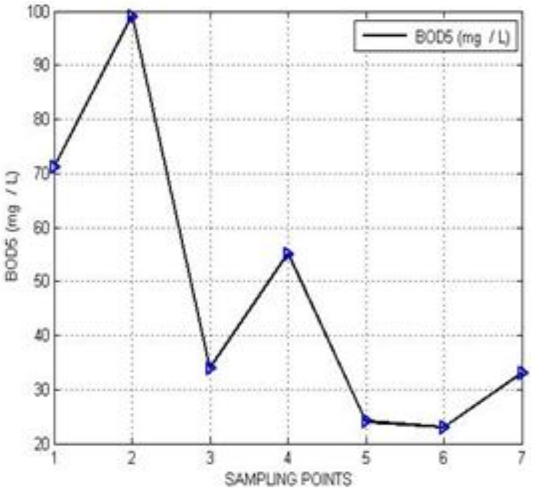

Fig. 12: Average values of BOD5 of effluents.

CONCLUSIONS AND RECOMMENDATIONS

In view of the results that we obtained, it is clear that the industrial effluents of the SCS analyzed were highly polluted,

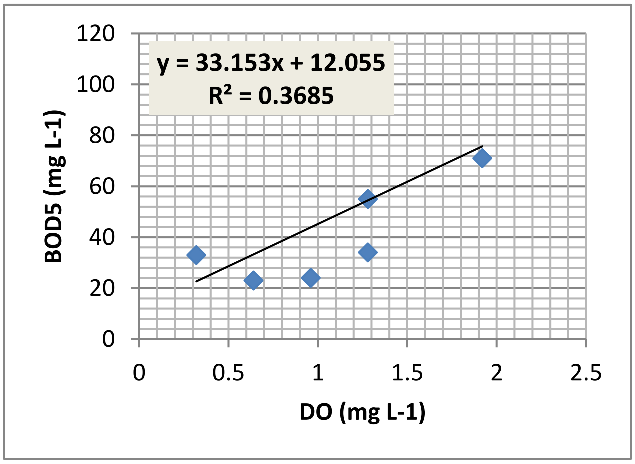

Fig.13: BOD against DO for River Mewou.

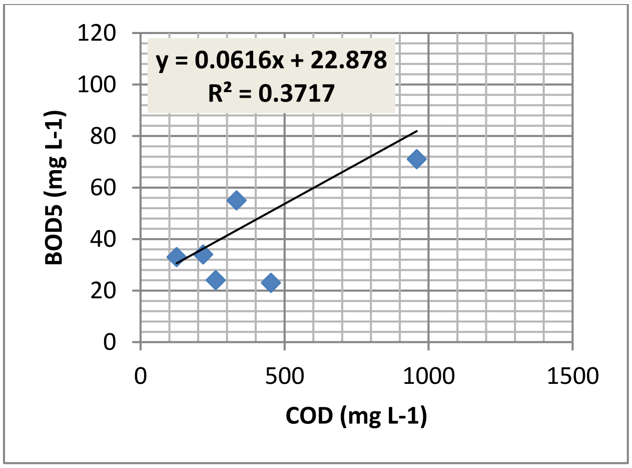

Fig.14: BOD5 against COD for River Mewou.

in particular in heavy metals (lead, chromium, and cadmium), and in organic matter, underlined in particular by high values of turbidity, COD and BOD_5. All these indicators, witnesses of undeniable pollution, indicate that these effluents constitute a source of contamination of the receiving environment and present a threat to the ecosystem and public health.

This situation is caused by the lack of an industrial effluent treatment procedure at the production site. Finally, the following practices are recommended to limit the volume as well as the polluting load of liquid effluents:

- Beyond its position as a major economic actor (employers and producers of goods) that the soap production company SCS plays in the city of Bafoussam, these managers must become aware of the social responsibility incumbent on them and set up an effluent treatment unit.
- Develop practices that will make it possible to minimize discharged effluents as much as possible, in an approach of "Cleaner production techniques", focused on the use of good practices to minimize water consumption;
- Set up anaerobic basins much more adapted to hot climates With relatively short retention times of only a few days, which can reduce the organic load by 40 to 70% (Shilton 2006).

REFERENCES

Awomeso, J.A, Taiwo, A.M, Gbadebo, A.M. and Adenowo, J.A. 2010. Studies on the pollution of a waterbody by textile industry effluents in Lagos, Nigeria. J. Appl. Sci. Environ. Sanit., 5(4): 353-359.

Chachuat, B. 2001. Optimal design and operation of activated sludge processes: State-of-the-art. Chem. Eng. J., 281: 900-920.

Félix, S., Araujo, J., Pires, A.M. and Sousa, A.C. 2017. Soap production: A green perspective. Waste Manag., 66: 190-195. https://doi.org/10.1016/J.Wasman, 2017.04.036

Ghazali, Z. 2013. Study of the physico-chemical and bacteriological quality of the waters of the Ain Salama-Jerri spring (Region of Meknes-Morocco). Larhyss, 12: 25-36.

Gouafo, C. and Yerima, B.P.K. 2013. Evaluation and mitigation of industrial wastewater pollutants from soap factories and breweries in the Bafoussam City Vicinity (Western Highlands of Cameroon). Res. J. Environ. Earth Sci., 5: 529-536. https://doi.org/10.19026/Rjees.5.5683

Gueddah, D. 2003Assessment of industrial and urban pollution in the eastern region of Algeria. Water Manag. Environ., 6: 1-25.

Hamdani, A., Moufti, A., Mountadar, M. and Assobhei, O. 2005. Evolution of the physico-chemical and bacteriological quality of a dairy effluent over an annual cycle. Waste Sci. Tech., 51: 414-425. https://doi.org/10.4267/Dechets-Sciences-Techniques,1880.

INS. 2004. Cameroon - Third Demographic and Health Survey, 2004, Cameroon.

Kankou, M.O.S.O. 2004. Vulnerability of Waters and Soils of the Right Bank of the Senegal River in Mauritania: Laboratory Study of the Behavior of Two Pesticides. Ph.D. Thesis, University of Limoges France, France.

Kolb, M., Bahadir, M. and Teichgräber, B. 2017. Determination of chemical oxygen demand (Cod) using an alternative wet chemical method free of mercury and dichromate. Water Res., 122: 645–654. https://doi.org/10.1016/J.Watres.2017.06.034

Mathurin, Z.G., Casimir, G., Kisito, T.P., 2022. Prediction of the compressive strength of concrete made with soap factory wastewater using machine learning. Model. Earth Syst. Environ. https://doi.org/10.1007/s40808-022-01445-z

Messrouk, H., Mahammed, M., Hadj, T.Y. and Amrane, A. 2014. Physico-chemical characterization of industrial effluents from the town of Ouargla (South East Algeria). Energy Proced., 50: 255-262. https://doi.org/10.1016/J.Egypro.2014.06.031

Nabbou, N., Benyagoub, E., Mellouk, A. and Benmoussa, Y. 2020. Risk assessment for chemical pollution of dairy effluents from a milk processing plant located in Bechar (Southwest Of Algeria). Appl. Water Sci., 10: 229. https://doi.org/10.1007/S13201-020-01309-W

Ojar, N.26. 2006. Executive Decree No. 2006-141 Of 20 Rabie El Aouel 1427 Corresponding To April 19, 2006, Defining The Limit Values Of Industrial Liquid Effluent Discharges.

ONU, 2006. World Urbanization Prospects, The 2005 Revision.

Philips, S., Laanbroek, H.J. and Verstraete, W. 2002. Origin, causes, and effects of increased nitrate concentrations in aquatic environments. Rev. Environ. Sci. Biotechnol., 1: 115-141. Https://Doi.Org/10.1023/A:1020892826575

Rice, E.W., Baird, R.B., Eaton, A.D. and Bridgewater, L.L. 2017. Standard Methods for the Examination of Water and Wastewater. 23rd Edition. Ed. American Public Health Association, Washington, DC.

Rodier, J. 2005. Water Analysis - Natural Water, Residual Water, Sea Water. Dunod, Paris, France

Rodier, J. 1998. Water Analysis: Natural Waters, Residual Waters, Sea Waters, Chemistry, Physicochemistry, Microbiology, Biology, Interpretation of Results. Eight Edition. Dunod, Paris, France.

Rodier, J., Geoffray, C. and Kovacsik, G. 2009. Water Analysis. Natural Waters, Residual Waters, Sea Water. Chemistry, Physico-Chemistry, Bacteriology, Biology. Dunod, Paris, France.

Rodier, J., Kovacsik, G. and Geoffray, C. 1978. Water Analysis. Natural Waters, Residual Waters, Sea Water. Chemistry, Physico-Chemistry, Bacteriology, Biology. Dunod, Paris, France.

Sayad, L. 2015. The Self-Purifying Power of the Seybouse Wadi on Discharges from the Edough Annaba Algeria Dairy and the Environmental Objectives of Discharges Universite Mokhtar Badji Annaba (Algeria), pp. 203.

Shilton, A.N. (Ed.) 2006. Pond Treatment Technology. Reprint. Ed. Integrated Environmental Technology Series, Iwa, London.

Shivsharan, V.S., Kulkarni, S.W. and Wani, M., 2013. Physicochemical characterization of dairy effluents. Pharm. Res., 12: 65.

Tardat-Henry, M. and Beaudry, J.P. 1992. Water Chemistry. Modulo, France.

WHO 2017. Water Quality And Health: Review Of Turbidity: Information For Regulators And Water Suppliers. Geneva, Switzerland.

WHO 2008. Guidelines For Drinking-Water Quality. Geneva, Switzerland.