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Physico-Chemical Characterization of Industrial Liquid Discharges of Soap Factories in Abidjan, Côte D'Ivoire

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Abstract

This work deals with the efficient management of industrial liquid discharges from soap factories (ILDS) in the region of Abidjan. The aim of this work is to evaluate the physico-chemical quality of these discharges as well as the different types of pollution generated. Seventeen (17) industrial soap sources were studied through fourteen (14) global pollution parameters (T, pH, electrical conductivity EC, redox potential E_H, suspended matter SM, COD, BOD_5, biodegradability factor BF, NH_4^+, NO_2^-, NO_4^-, PO_4^3, total iron and SO_4^{2-}). A liquid waste collection campaign was done during six weeks from February to March 2016, corresponding to a period of intensive activity of these industries. The samples were analyzed according to the norms of the French Standardization Agency (AFNOR). Results were compared with the Ivorian guide values recommended by the Classified Installations Inspection Service (CIIS). Principal Component Analysis (PCA) is allowed to evaluate the pollution induced by these factories' rejection. In addition, Ascending Hierarchical Classification (AHC) method leads to classify soap factories into three groups according to the physico-chemical quality of their releases. Moreover, the estimation of the biodegradability factor is permitted to know the state of the biodegradability of these effluents.

Keywords

Biodegradability, ILDS, Pollution, Soap Industries

1. Introduction

Abidjan City gathers up to 85% of industries settled in Côte d'Ivoire, because of its lagoon and sea assets. These industries are localized in various areas of the different industrial zones [1]. Despite Ivorian government's efforts to protect the environment, very few industries do follow its recommendations [2]. The use of water in the production process generates a huge volume of rejected liquid heavily loaded with oxidable materials [3] [4]. The increase of soap industries is due to the increase of human beings needs in term of soap, detergent and cosmetic. And this soap factories growth participates to this ecological disaster. These soap factories, like the other industries, are mainly concentrated in the area of Abidjan. They contribute to the production of enormous volume of effluents in Abidjan area. The characterization of ILDS in Côte d'Ivoire remains less established to date. This fact confers a certain scientific interest on these discharges. That is why more complete physicochemical characterization constituted the first step to be taken into account in order to estimate the level of pollution of this type of industrial waste.

2. Experimentation Method

2.1. Area of Study and Location of Soap Factories

The area of Abidjan has a fluvial network of 89.81 km^2 of lagoon, which is equivalent to 16% of its area [5] with an estimated population of 4,693,912 [6]. The seventeen soap factories targeted are those which throw directly their rejection into the lagoon. The mapping of the studied area (**Figure 1**) shows the different industrial areas, the location of the studied soap factories and the river system of Abidjan's town.

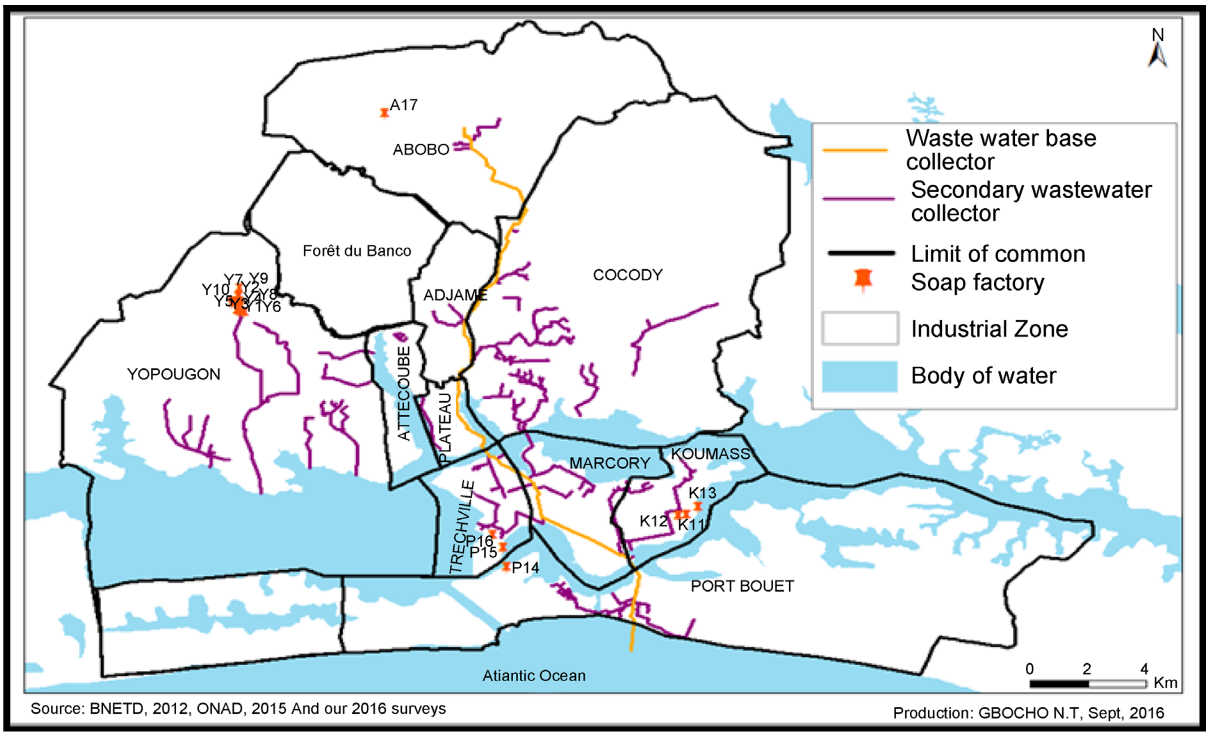

Figure 1. Mapping of the study area and location of soap factories.

2.2. Sampling Method

Samples have been collected in the seventeen factories at the level of the outlet before rejection of soap factories in polyethylene and put in glass bottles (for total iron parameter). Bottles are washed with distilled water before collecting process. Then collected samples are labelled, conserved at temperature of 4˚C and kept away from light in ice-box. Finally samples are analyzed the same day as soon as possible in order to avoid any bacterial activity. This sampling has been done during six (6) weeks from February to March, 2016. This period corresponds to the highest level of the production of soap factories.

2.3. Analysis Method

Physical parameters such as temperature, pH, redox potential and electrical conductivity were measured by electrometry in situ using a HACH HQ 40 D multiparameter probe. Ammonium, nitrite, nitrate, sulphate, ortho-phosphate, chemical oxygen demand (COD), and the total iron rate were measured through molecular absorption using a HACH/DR 6000 spectrometer. The Biochemical Oxygen Demand (BOD_5) was measured by oximetry using an Oxitop® WTW oximeter. Finally, the analysis of suspended matter (SM) was carried out through filtration/gravimetry with the WHATMAN filters. All these analyses were done according to the methods of the French Standardization Agency AFNOR [7]. The data collected were treated using statistical approaches such as the correlation coefficient, Principal Component Analysis (PCA) and Ascending Hierarchical Classification (AHC) [8]. Statistical treatments were carried out using the Statistica 7.1 software.

3. Results and Discussions

3.1. Physical Characterization of Industrial Liquid Discharges of Soap Factories (ILDS)

Table 1 presents the results of the characterization of the physical parameters of ILDS. Samples P16 and Y6 show the extreme temperature values of 25.4˚C and 39.0˚C respectively. All the measured values are lower than 40˚C, thus respecting CIIS recommended temperature in the case of discharge of effluents towards environment [9]. The highest and lowest pH values have been found in the soap effluent K13 and Y2, respectively. The high alkaline pH values recorded in 29.00% of the soap factories studied can be explained by the different activities related to the use of alkaline agents (caustic soda and potash) in soap formulation.

In fact, this essential raw material impacts, at several levels, the system of detergent's products formulation. First, the fatty acids are saponified by caustic soda or potash. In addition the lye (soda solution) is used for the operation of the hypo-lye. The rejections resulting from these operations, coupled with washing water of the soap, constitute effluents heavily loaded with hydroxide ions, which changes the pH of these discharges into alkaline. For soap factories with medium pH discharges, two explanations can be provided: The first is that

Table 1. Physical parameter values.

Stations	T (˚C)	pH	EC (μS/cm)	E_H (mV)	SM (mg/L)
Y1	29.9	7.32	441	−16.7	2060
Y2	31.1	5.13	40	115.1	214
Y3	29.7	7.16	741	−6.9	2040
Y4	30.4	12.37	17270	−319.4	25
Y5	30.5	6.62	495	24.5	26
Y6	39	7.75	682	−43.6	51125
Y7	28.3	7.42	1992	23.7	6200
Y8	27.5	10.31	1737	−193.9	220
Y9	28.2	12.58	14640	−330.6	1284
Y10	29.7	6.38	76.4	21.4	4
K11	31.5	9.74	957	−162.6	260
K12	30	5.27	645	106	2365
K13	32.1	13.47	138.4	−387.6	1570
P14	30.1	6.61	599	26.3	10384
P15	28	7.84	463	−47.5	80
P16	25.4	8.10	63	82	6.8
A17	32.3	6.12	570	55.5	588
VG*	**<40**	**5.5-9.5**	**-**	**-**	**150**

VG*: Guide values referring to the lowest daily flow rates 01164 / MINEEF / CIAPOL / **CIIS** of 04 November 2008 [9].

these soap-making plants do not carry out saponification in their premises. They import soap paste bells for their productions. The second explanation comes from the fact that soap-making plants with weakly alkaline or neutral waste, the saponification is made with triethanolamine, which is a weak base organic alkaline agent. It should be noted that all these soaps produced by factories are used as toilet soaps with low pH value. In other way, it has been shown that 12.00% of the studied soap factories rejected water discharge with acid pH. These soap-making factories produce others commodities such as water of cleaning (bleach) and cosmetics products.

Analysis of the Electrical Conductivity (EC) of soap effluents reveals a fluctuation of the values of this parameter. The high values of this parameter are observed in effluents from the soap mills (Y4, Y9) in Yopougon area. The Y4 soap effluent recorded the highest value (17,270 μS/cm). The lowest value (40 μS/cm) was observed in the Y2 soap rejection (Table 1). Correlation's analysis between physico-chemical parameters (Table 2) reveals a strong positive correlation of conductivity with nitrates (0.90), ortho phosphates (0.69) and, to a lesser extent, with nitrites (0.62). This high mineralization is therefore due to the oxidation of these nutrients in the soap effluent. The oxidation-reduction potential value ranges from −387.6 mV (soap-making K13) to 115.1 mV (soap-making Y2) (Table 1). 76% of these releases have a reducing character with redox

Table 2. Correlation matrix of the physicochemical parameters of all the ILDS.

Variables	T	pH	EC	E_H	SM	COD	BOD_5	BF	T iron	NO_3^-	NO_2^-	NH_4^+	PO_4^{3-}	SO_4^{2-}
T	1.00													
pH	−0.07	1.00												
EC	−0.12	**0.63**	1.00											
E_H	−0.04	**−0.97**	**−0.63**	1.00										
SM	**0.77**	−0.09	−0.11	0.07	1.00									
COD	0.31	0.09	0.04	−0.13	0.41	1.00								
BOD_5	**0.81**	0.05	−0.04	−0.09	**0.93**	**0.61**	1.00							
BF	−0.14	0.11	0.16	−0.15	−0.13	**0.79**	0.04	1.00						
T iron	−0.13	0.14	−0.05	−0.17	−0.09	**0.65**	0.03	**0.81**	1.00					
NO_3^-	−0.04	**0.56**	**0.90**	**−0.57**	−0.13	0.03	−0.04	0.17	−0.08	1.00				
NO_2^-	0.01	0.26	**0.62**	−0.28	0.06	0.16	0.12	0.18	0.12	**0.62**	1.00			
NH_4^+	**0.50**	0.41	−0.10	−0.46	0.174	−0.05	0.26	−0.23	−0.03	−0.05	−0.11	1.00		
PO_4^{3-}	−0.24	**0.69**	**0.69**	**−0.70**	−0.20	0.44	−0.03	**0.62**	**0.62**	**0.59**	**0.53**	0.04	1.00	
SO_4^{2-}	−0.27	0.15	−0.00	−0.15	−0.11	**0.70**	−0.00	**0.83**	**0.87**	−0.02	0.14	−0.19	**0.60**	1.00

In bold, significant values at the alpha threshold = 0.050.

potentials negative or less than 40.0 mV [10]. These reductive soap discharges contain mainly aldehydes, organic compounds exhibiting reducing properties, resulting from the oxidation of compounds such as glycerols, polyphenols and polyalcohols used for the formulation of detergents and cosmetics [11]. The oxidation of the alcohol functions into aldehydes and the different oxidation-reduction reactions which result, use the oxygen of the receiving environment. Furthermore, the negative correlation of the oxidation-reduction potential with nitrates (**−0.57**), ortho-phosphates (**−0.70**) and conductivity (**−0.63**) explains the reverse evolution of these parameters with the redox potential. The reducing properties of soap effluents allow the oxidation of nitrates and ortho-phosphates. The mineralization is due to this oxidation. These oxidation reactions reduce oxygen concentrations in the receiving environment, so that affects aquatic life [12]. The analyzed concentrations of Suspended Matter (SM) are irregularly distributed (**Table 1**). Some soap factories have high SM concentrations that exceed **4** to **341** times the guide value (150 mg/L). The very high SM content of these discharges is due to mineral and organic raw materials used in the formulation of their products. These industries, specialized in the formulation of cosmetic products according to our investigation, use excipients and active ingredients (fatty acids, glycerol, surfactants, polyalcohols etc.) as raw materials. The strong positive correlation of suspended matter with BOD_5 (**0.93**) (**Table 2**) confirms the biodegradable organic origin of these SM in liquid soap discharges from soap industries. Moreover, this parameter is positively correlated with the temperature (**0.81**) (**Table 2**).

The temperature favors the degradation of suspended organic matter in soap effluents. That damages the different receiving environments. Indeed, SM in a lagoon environment reduce the penetration of light into the water, consequently reduce the photosynthesis of phytoplankton under water, and dissolve oxygen in the aquatic environment. This causes faunal and aquatic floristic mortality by asphyxia [12]. In addition, SM conveys various chemical elements into the aquatic environment. The high concentrations of this parameter, generated by soap discharges, can be seen as a factor of pollution of the Ebrié lagoon [13].

3.2. Chemical Characterization of Industrial Liquid Discharges of Soap Factories (ILDS)

The analysis' results of chemical parameters are recorded in **Table 3** below.

The analyzed ammonium concentrations of the **ILDS** range from **1.40 mg/L** to **75.80 mg/L** The highest value corresponds to the soap factory K11 (**Table 3**). In general, these soap factories use nitrogenous compound such as anionic surfactants (ammonium dodecyl sulphate), cationic surfactants such as bactericides (cetyltrimethylammonium bromide) and azo derivatives dye (Naphtol Blue Black: NBB) as the colorant of detergents [14]. The ammonium ions come from the degradation of these azo dyes. This degradation generates NH_4^+ cations due to the conversion of the nitrogen of the azo bond and the thriazine cycle into ammoniums [14]. The degradation of cationic surfactants such as cetyltrimethylammonium bromide also justifies the presence of these ammonium ions. The nitrites concentrations have a minimum of **0.003 mg/L** and a maximum of

Table 3. Concentrations of the chemical parameters analyzed in **ILDS**.

Stations	Chemical parameter (mg/L)								
	COD	BOD_5	BF	NO_3^-	NO_2^-	NH_4^+	PO_4^{3-}	SO_4^{2-}	T iron
Y1	5760	900	6.4	21.8	0.03	12	0.7	22	0.5
Y2	34,000	1700	20	1.3	0.006	8.9	0.1	500	3.1
Y3	3700	800	4.6	21	0.9	17.2	13.2	30	6.2
Y4	13,800	1000	13.8	350	1.4	14.9	47.7	230	1.5
Y5	4030	750	5.4	0.9	0.012	12	1	36	0.13
Y6	37,900	8000	4.7	3	0.51	34.4	0.6	1.5	2.4
Y7	580	180	3.2	1.7	0.5	8.5	0.5	700	0.5
Y8	51,300	1500	34.2	14.2	0.6	8.27	62.5	2300	36.9
Y9	9170	1100	8.3	112	0.8	12.5	48.2	3.4	2.4
Y10	15	11.25	1.3	1.1	0.026	7.41	0.6	1.5	0.3
K11	3800	850	4.5	12.1	0.3	75.8	22.8	90	5.5
K12	7340	1000	7.3	11.2	1.33	6.11	0.4	16	1.2
K13	5510	1500	3.7	20	0.003	54	5.7	1.5	0.6
P14	8320	700	11.9	11	0.05	10.8	0.5	1.5	1.8
P15	3400	800	4.3	4	0.04	15	0.1	1.5	0.015
P16	119	42	2.8	0.024	0.003	1.4	2.28	1.5	0.015
A17	2690	280	9.6	0.002	0.06	21.7	0.9	1.5	12
VG*	**500**	**150**		**50**	-	-	-	-	**5**

1.400 mg/L (**Table 3**). It should be noted that 29.41% of the soap mills (Y3, Y4, Y8, Y9 and K12) have nitrites concentrations above the recommended guide values of 0.500 mg/L. These soap factories use nitrated and nitrosated dyes (X-C_6H_5-NO_2) which generate nitrates as a result of their degradation. As for nitrates, the contents fluctuate between **0.002 mg/L** and **350.000 mg/L**. Soap factories Y9 and Y4 show similarities in terms of nitrates with very high contents (**Table 3**). The presence of nitrates is due, in part, to the use of nitrogenous compound in the formulation of detergents and cosmetics. They are azo, nitrated and nitrosated dyes, nitrogen-containing surfactants, adjuvants such as nitrilotriacetic acid (NTA: $C_6H_9NO_6$), ethylene diamine tetraacetic acid (EDTA: $C_{10}H_{16}N_2O_8$), triethanolamine ($C_6H_{15}NO_3$). These compounds release nitrate ions, ammonium and nitrite ions [15]. Ammonium and nitrite ions can be oxidized into nitrates. In the light of the analyses, it can be said that the soap effluents are relatively rich in nitrogenous nutrients. The quantities of ortho-phosphates vary from **0.100 mg/L** to **62.500 mg/L** (**Table 3**). Soap factories with concentrations of ortho-phosphates higher than 2 mg/L use raw materials rich in phosphorus elements as adjuvants or bleaching agents (sodium tripolyphosphates: $Na_5P_3O_{10}$, sodium pyrophosphate: $Na_4P_2O_7$, trisodium phosphate: Na_3PO_4) for the formulation of detergents and cosmetics, especially. These compounds containing the soluble inorganic phosphorus in solution are transformed into orthophosphates which come from the hydrolysis of phosphoric acid. Even in very small quantity, orthophosphates are harmful for the environment due to the fact that they are easily absorbed by the soil, polluting thereby well water and the ground-water sheet [16]. Based on the recorded values, all the soap factories are potential polluters in terms of orthophosphates. Despite its usefulness, phosphorus is forbidden in the formulation of detergent and cosmetic products [17]. In sum, soap discharges are rich in nutrients that can impact environment. Indeed, concentration of nitrogen ammoniacal (NH_4^+) at about 1.2 mg/L in a hydro system, at pH 7.5˚C and 15˚C, is toxic for fish fauna [18]. In addition, nutrient concentrations can lead to an increase of algal blooms and consequently the appearance of eutrophication phenomena when the concentration of NO_4^- equals 0.03 mg/L and the concentration of phosphorus equals 0.01 mg/L [19]. The sulfate concentration contained in ILDS fluctuates between **1.5 mg/L** and **2300 mg/L**. Soap factory Y8 has the maximum concentration of sulphate ions (**Table 3**). The factories those rejections contain a lot of sulfate are specialized in the formulation of colored toilet soaps, cosmetics (shampoos, toothpaste, mouthwash products, etc.). These soap and cosmetics industries use anionic surfactants such as sodium dodecyl sulphate (SDS: $C_{12}H_{25}SO_4Na$) in the formulation of their products, sulfonated surfactants, especially sodium dodecylbenzene sulphonate (DBS: $C_{18}H_{29}SO_3Na$) and sulfated inorganic pigments or coloring agent, ferrous sulfate ($FeSO_4$, $7H_2O$), zinc sulfate ($ZnSO_4$) and organic sulfur dyes. These sulfate ions come essentially from both the dissolution of the sulfated salts and the oxidation of the sulfide groups of the aforementioned surfactants and dyes [20]. The total iron concentrations in the

ILDS range from **0.015 mg/L** to **36.900 mg/L** (**Table 3**). The total iron concentrations for some soap factories (Y3, Y8 and A17) are 1.24 to 7 times higher than the guide value (5 mg/L). These soap factories therefore use raw materials rich in iron ions. These soap factories use colored pigments such as iron oxide ($Fe(NH_4COO)_2$), the complex salt (ferric ferrocyanide or Prussian blue) and ferrous sulphate ($FeSO_4$, $7H_2O$) to color detergents and cosmetics. The iron ions in the liquid discharges of these soap mills therefore result from the dissolution of these inorganic dyes. Y8 soap effluent contains the highest concentration of sulfates and total iron. It mainly uses iron sulfate ($FeSO_4$, $7H_2O$) as a colorant for the formulation of their mostly cosmetic products. That can be explained by the strong positive correlation of sulfate ions with total iron (**0.83**) (**Table 2**). The Chemical Oxygen Demand (COD) concentrations in the soap discharges are considerably higher than the guide value (500 mg/L), except soap factories Y7, Y10 and P16. The soap factory Y8 has the maximum concentration (**51,300 mg/L**) which is **103** times the recommended guide value (**Table 3**). For 5-day biochemical oxygen demand (BOD_5), Y8 (1500 mg/L), Y2 (**1700 mg/L**) and Y6 (**8000 mg/L**) effluents have BOD_5 concentrations ranging from **10** to **53** times the limit value of 150 mg/L (**Table 3**). Liquid waste from most soap factories are heavily loaded with oxidable organic and mineral matter. These high COD values derive from the use of organic raw materials (fatty acids, surfactants, glycerin, phenolic compounds, polyalcohols, nitrogenous and phosphorus compounds, colorants, etc.) in the formulation of detergents and cosmetics. Y2, Y6 and Y8 effluents are identified by their high COD concentrations. This fact is worrying and can be explained by the nature of the products manufactured by these industries. Indeed, these soap factories are specialized in the intense production of toilet soaps and cosmetic products (cream, ointment, shampoos, hair products etc.). However, the formulation of these products requires oils and fat products such as surfactants (anionic, cationic, and nonionic), polyalcohols, etc., as basic raw materials. Organic or inorganic synthetic dyes, conservative and antioxidants must be added to the basic components. All these oxidable organic materials contribute to the high COD observed concentrations. The significant correlation of this parameter with sulfate ions (**0.70**), total iron (**0.65**) and BOD_5 (**0.61**) (**Table 2**) justifies this contribution to oxygen demand.

3.3. Biodegradability of Industrial Liquid Discharges of Soap Factories (ILDS)

Analysis of the biodegradability factors (COD/BOD_5) of the effluents reveals that soap discharges have a COD/BOD_5 ratio ranging between **1.3** and **34** (**Table 3**). Only one soap factory (Y10: $COD/BOD_5 = 1.3 < 2$) has a biodegradable effluent. Soap factory P16 has an average of biodegradable effluent ($COD/BOD_5 = 2.8$) between 2 and 3. Soap factories Y10 and P16 certainly have treatment station. Finally, **88.00%** of the soap factories show discharges that are difficult to biodegrade with chemical-dominant pollution ($COD/BOD_5 > 3$), which is characteristic of the chemical industries. The strong correlation of the biodegradability factor with sulfate ions (**0.83**), total iron (**0.81**), and orthophosphate ions (**0.62**) (**Table 2**) corroborates this chemical pollution, leading to the difficult biodegradability of soap effluents. The difficult biodegradability of these discharges is partly related to the specific use of surfactants as the main raw materials in the formulation of detergents and cosmetics. These effluents, which are mainly difficult to biodegrade, damage the environment. In order to propose an appropriate treatment method, it is necessary to group the soap industries studied according to the type of pollution induced by their releases through a multivariate statistical analysis.

3.4. Types of Pollution Generated by Industrial Soap Liquid Discharges

The application of the Principal Components Analysis (PCA) on the whole data allowed to highlight similarities or oppositions between variables, and to locate the most correlated variables between them in order to locate the various pollution generated by the liquid rejections of soap factories in the zone of Abidjan. **Table 4** reveals that the factorial design (F_1 - F_2) and (F_1 - F_3) respectively express **56.71%** and **55.66%** of the original variance of the groups of dots (**Table 4**). These three factors express **78.34%** of the explained variance thus releasing the maximum of information on the rejections of soap factories.

Correlation matrix between physicochemical parameters and the various factors reveals interesting correlations between these factors and some physicochemical parameters. Thus, the main component F_1 defines a strong positive correlation with pH (**0.71**), E_H (**0.72**) and strong negative correlation with EC (**−0.72**), nutrients NO_3^- (**−0.65**), NO_2^- (**−0.61**), PO_4^{3-} (**−0.92**), sulfates (−0.63), total iron (−0.69) and biodegradability factor BF (**−0.69**). This principal component characterizes ILDS alcalins, mineral-bearing with a nutritive and chemical pollution. Moreover, the factorial axis F_2 defines a significant correlation with the temperature T (**0.66**), the chemical oxygen demand COD (**0.77**), the biochemical oxygen demand of BOD_5 (**0.81**) and the suspended matter SM (**0.75**). This axis characterizes an organic pole of pollution. Finally the F_3 factor exhibits a fairly degree correlation with the ions ammonium (**−0.55**). This axis focuses a nutritive pollution caused by ammonium ion. It results from the analysis of the circle of community and the statistical units of factorial design F_1 - F_2 and F_1 - F_3 (**Figure 2(a)** and **Figure 2(b)**), four classes of effluents are rejected into the lagoon Ebrié and characterizing four groups of soap factories. Then Group 1 concerns ILDS rich in BOD_5 and in SM, such as soap factory Y6; Group

Table 4. Eigenvalues and percentages of the variances expressed by the factors.

Factors	Own values	% Total variance	Accumulation %
F_1	4.76	34.03	34.03
F_2	3.17	22.68	56.71
F_3	3.03	21.63	**78.34**

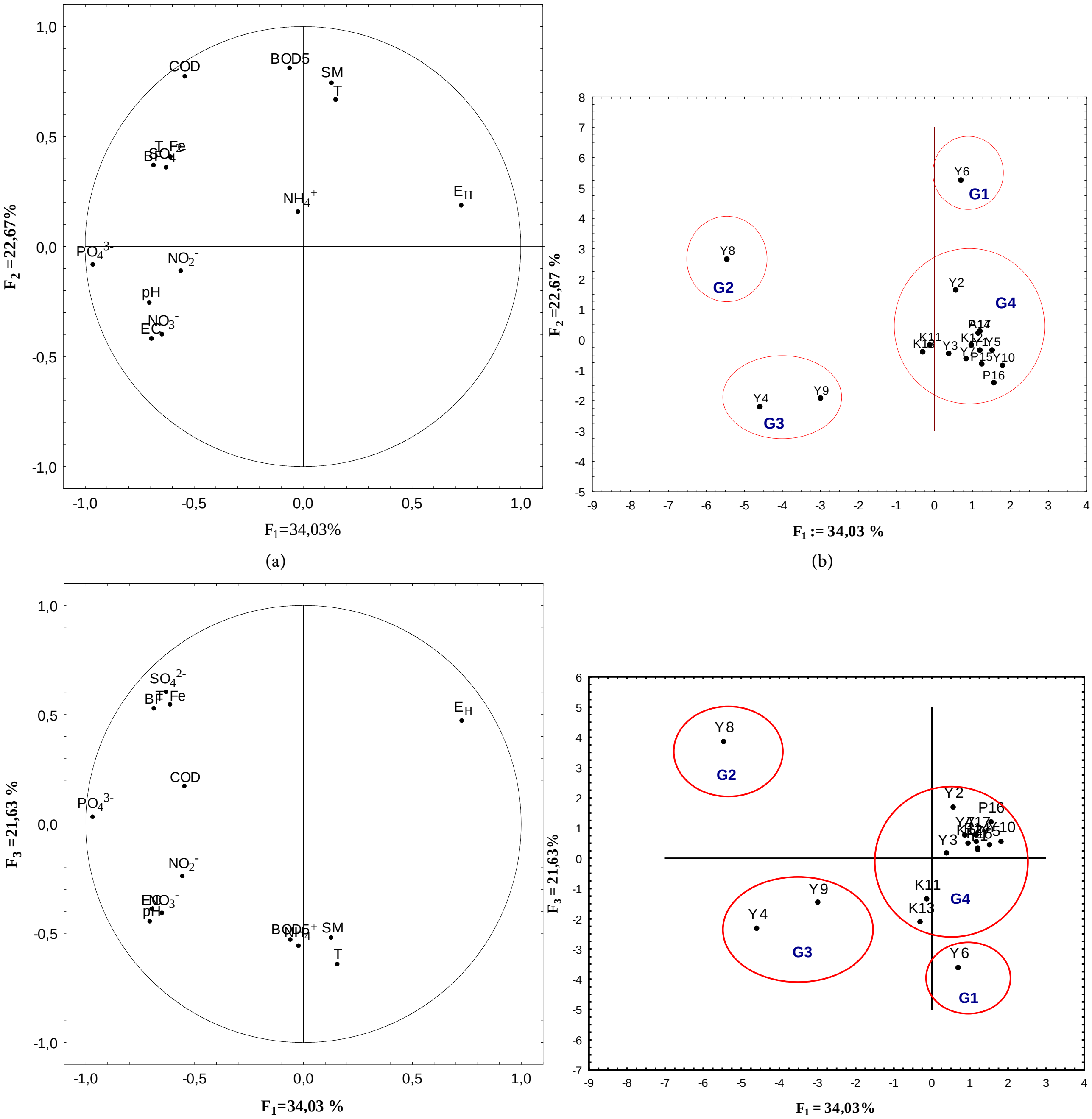

Figure 2. (a) Circle of community of the factorial design (F_1 - F_2); (b) Statistical units of the factorial design (F_1 - F_2); (c) Circle of community of the factorial design (F_1 - F_3); (d) Statistical units of the factorial design (F_1 - F_3).

2 relates to ILDS with high temperature, rich in COD, iron and in SO_4^{2-}, such as soap factory Y8; Group 3 corresponds to the alkaline, mineral-bearing ILDS and rich in PO_4^{3-}, NO_2^-, and NO_3 (soap factories Y4 and Y9); Group 4 concerns ILDS with low pollutants mentioned above, *i.e.* soap factories Y1, Y2, Y3, Y5, Y7, Y10, K11, K12, K13, P14, P15, P16 and A17.

Application of Ascending Hierarchical Classification (AHC) to the result of the PCA permits to specify clearly the above Groups. Thus three (03) groups were distinguished in the following way (**Figure 3**). Y2 and group 2 gather and form the main group II. Group 3 and Group 4 gathered to give only one main group, *i.e.* group III. Finally, three main Groups can be define as following: main Group I corresponds Y6 soap factory; main Group II includes soap factories Y8, Y2 and main Group III is made up from soap factories: Y1, Y3, Y4, Y5, Y7, Y9, Y10, K11, K12, K13, P14, P15, P16 and A17. This result is not enough different from those retrieved from PCA, which revealed four types of pollution generated by the liquid discharges of soap factories. Thus, the seventeen soap mills studied are grouped into three main groups according to the similar physicochemical quality of their releases.

4. Conclusion

The results of this work show the need to evaluate the level of pollution due to industrial rejection in Abidjan area. These results point out an alarming situation. Except the temperature, most of the other parameters of rejection have concentration which is beyond the national required level. Thus, fifteen (15) out of seventeen (17) selected soap and cosmetic industries (**88.00%**) discharge their effluents into the Ebrié lagoon without prior treatment. Those effluents are difficultly biodegradable. These soap industries do not have treatment stations or use powerless treatment processes. Moreover, they have very heterogeneous effluents due to both the specific raw materials used for the formulation and above all the non-respect of the laws that regulate their corporation. Moreover, these soap factories are classified into three groups according to the physicochemical quality of their releases: Group I (Y6), Group II (Y8, Y2) and Group III (Y1, Y3, Y5, Y7, Y9, Y10, K11, K12, K13, P14, P15, P16 and A17). Overall, the releases are sources of nutritive, organic and chemical pollution. Also, these discharges exhibit very high and non-biodegradable organic charges which are certainly linked to the use of surfactants that are difficult to biodegrade in the formulation of

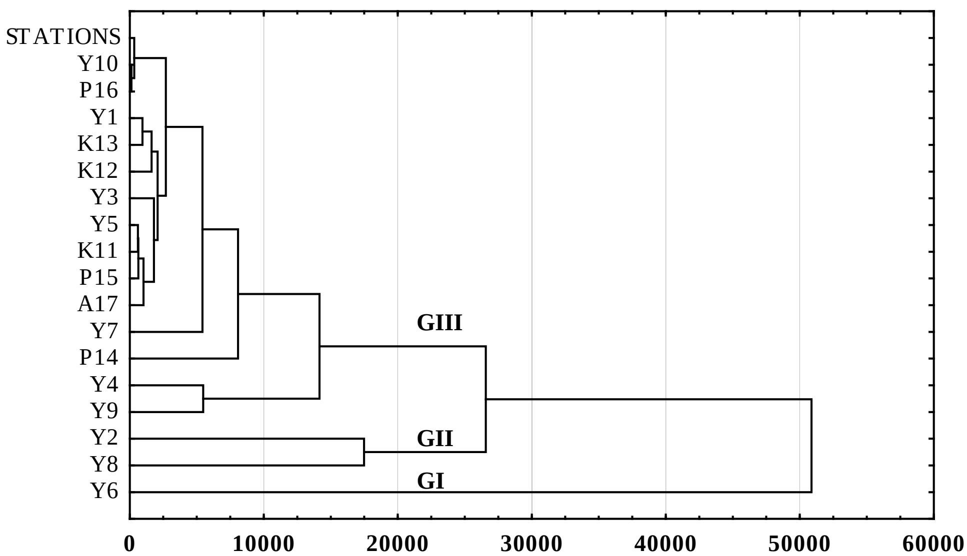

Figure 3. Ascending hierarchical classification of the studied soap factories.

detergents and cosmetics. The rejection of these micro pollutants without prior treatment affects the receiving environment. The ILDS, thus, highly contribute to the pollution of the Ebrié lagoon. In response to this sad remark induced by industrial soap liquid discharges, appropriate solutions must be found in terms of protection of the Ebrié lagoon and treatment process of these ILDS before the rejection of their waste. Republic of Côte d'Ivoire must make sure that industrial soap liquid waste is effectively well managed by soap factories. For us, a characterization of the anionic surfactants in ILDS is envisaged because of its wide use as an active ingredient in the formulation of any detergency product and cosmetics. A process for treating these anionic surfactants is envisaged in order to propose it to the soap industries who's ILDS are rich in these micro pollutants.

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