



## Clinical Manifestations and Environmental Impact of Fish Smoking Based on Traditional and Improved Ovens in Marcory Anoumabo (Ivory Coast)

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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### **ABSTRACT**

The smoking of fish plays a very important role at the economic, social and nutritional levels. Despite its importance, smoking is still practiced through traditional techniques that have a considerable impact on the health of the processors. The objective of this work is to evaluate the environmental and health impact of traditional and modern fish smoking. The environmental assessment of the Marcory Anoumabo site equipped with an improved oven called FAO-Thiaroye Processing Technique (FTT oven) consisted in measuring the quality of the smoke on the smoking sites. It is a cross-sectional etiological study conducted from July to December 2018 on a sample of 135 women consisting of 40 women who use traditional ovens, 32 women who use FTT ovens and 63 control cases. The results showed that 87.50% and 37.50% of women practicing on traditional ovens versus 43.75% and 15.62% of women using FTT ovens as well as 39.68% and 14.29% of the case controls had respiratory and ophthalmological signs respectively. The gas levels measured at the smoking sites are often higher than the standard (50 mg/m<sup>3</sup>). This study highlights the deleterious effects of fish smoking.

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**Keywords:** Fish smoking; environmental impact; traditional oven; FTT oven; clinical manifestations; greenhouse gases; Marcory Anoumabo.

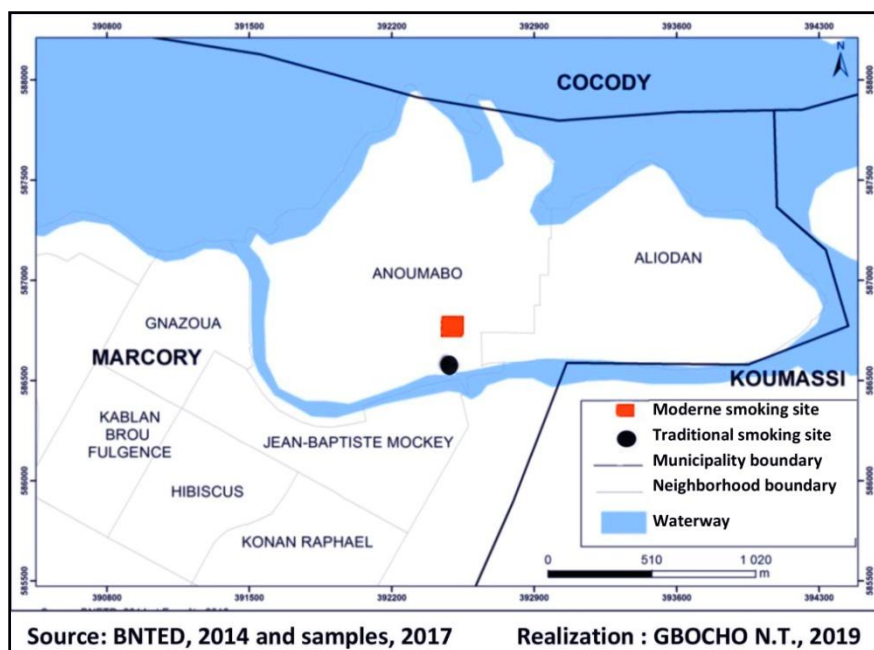
## 1. INTRODUCTION

Wood fires occupy an essential place for cooking food in Africa. These fires emit opaque smoke that certainly has health consequences [1]. One third of people living in rural communities in developing countries use biomass as their sole source of energy. This biomass has adverse health effects that are attributed to various respiratory irritants namely unburned hydrocarbon particles and carcinogens such as benzopyrene and other gaseous fumes (CO, NO<sub>2</sub>, SO<sub>2</sub> . . .) [2]. Indoor air pollution in the home during traditional cooking and/or heating activities is a respiratory risk factor in nonsmoking women from the age of 30 years [2]. According to WHO, mortality attributable, to exposure to indoor air pollution could be responsible for nearly 2 million excess deaths in developing countries, and about 4% of the global disease burden [3]. In Ivory Coast, women fish smokers are constantly exposed to the fumes and gases from wood burning. Indeed, the massive use of wood causes the release of hot air and large quantities of fumes, which are inhaled by smokers during the handling of fish. They handle the burning fish with their bare hands, in thick layers of hot smoke. This exposes them to respiratory and ocular problems [4]. The clinical manifestations related to the smoking

activity recorded among female fish processors are, among others, headaches, asthenia, dizziness and increased blood pressure [5]. Based on this observation, in 2013, an improved oven called the FAO-Thiaroye Processing Technique (FTT-Thiaroye) was introduced in Ivory Coast in fish processing communities in order to reduce health risks, increase food safety and quality, improve safety and food quality, improve working conditions and reduce post-capture losses [6]. The objective of this work is to evaluate the environmental and health impact of traditional and modern fish smoking.

### 1.1 Study Area

The study was conducted in Marcory Anoumabo which is a neighborhood in the commune of Marcory, located in the south of Abidjan, Ivory Coast (Fig. 1). The population of Marcory is estimated at 249,858 [7] spread over an area of 722 hectares. It encompasses former Ebriés fishing villages including the villages of Anoumabo, Old Koumassi and Bietry. Two fish processing sites were chosen for this study. The traditional fish smoking site, which is located a few meters from the market where the women work in a covered area. The other site is located near the market where women operate on a modern platform equipped with FTT ovens.



**Fig. 1. Location of the fish smoking sites in Marcory Anoumabo**

## 2. MATERIALS AND METHODS

### 2.1 Survey

#### 2.1.1 Study material

The technical equipment consisted of a GARMIN MAP GPS, a three-page paper questionnaire that obtained information on the identity of the fish smokers, their age, place of residence and the age, place of residence and type of oven used for smoking fish.

The technical equipment consisted of a GARMIN MAP GPS; a census form that provided information on the identity of the fish smokers, their age, their place of residence and the age, their place of residence and the type of oven used for smoking fish.

#### 2.1.2 Information collection methods and techniques

The data collection techniques were carried out through an observation phase, interviews with fish smokers and questionnaire surveys. The observation took place throughout the different surveys on the smoking sites. Thus, the daily experience of the processors was appreciated. Then, the interview with the fish smokers was conducted through a free exchange. This interview provided information on the problems encountered by the women in the course of their fish smoking activities. These are health problems and fish conservation problems. A questionnaire was developed based on the information collected, direct observations in the field and interviews.

#### 2.1.2.1 Description of practices related to fish smoking

This part highlights two (02) methods of smoking fish. These are traditional fish smoking, which is carried out on traditional platforms with traditional ovens, and modern smoking, which is carried out on modern platforms equipped with FTT ovens (Fig. 2).

#### 2.1.2.2 Survey by questionnaire

The survey was conducted among women processors in the communities of Grand-Lahou. This phase made it possible to determine the number of women smokers per study area, to collect information on the socio-demographic profile of the actors, the smoking activity, the fuels used, and the personal and family health history. Using a GPS, the coordinates of the different smoking points were geo-referenced. The study took into account all women present and fulfilling the inclusion criteria. All women aged 18 years and older who had been smoking fish products at least 5 days a week for at least 2 years were included. Women smokers with a history of active and/or passive smoking, respiratory manifestations prior to the smoking activity (asthma, tuberculosis, COPD, etc.) were excluded from the study. The study involved 135 women composed of 40 smokers who use traditional stoves, 32 smokers who use FTT stoves and 63 non-smokers (case-controls) engaged in other income-generating activities such as sewing, hairdressing and marketing of food crops.



**Fig. 2. Traditional (a) and modern (b) fish smoking sites in Marcory Anoumabo.**  
Source: Photo, OSSEHIN, 2018

## 2.2 Measurement of Smoke Quality

### 2.2.1 Measuring instruments

Three measuring instruments were used: a KIGAZ 300 pro, a MiniRAE 3000 and a MultiRae Lite. The KIGAZ 300 pro combustion analyzer allows direct analysis of O<sub>2</sub> and CO in the combustion chamber, measurement of CO<sub>2</sub>, SO<sub>2</sub>, air temperature, flue gas temperature, pressure and calculation of % CO<sub>2</sub> and NO<sub>x</sub> content. The MiniRAE 3000 portable monitor allows the detection of VOCs. The MultiRae Lite is an optimal monitoring solution for one to six gases (NO, NH<sub>3</sub>, H<sub>2</sub>S, CO and SO<sub>2</sub>).

### 2.2.2 Measurement Methodology

Three measurement campaigns were conducted, ranging from July to December 2018. The measurements were performed on 2 modern and 7 traditional furnaces. The measurements were performed above the ovens, at the women's resting point and beyond the ovens (from 4 to 12 meters from the ovens) depending on the wind direction with a total of 198 measurements. Prior to the various gas measurements, the devices were allowed to draw in clean, smoke-free ambient air in order to establish the zero value of the sensors. For the gas measurements, the MiniRae 3000 and MultiRae Lite analyzers were kept in the vicinity of the furnace. On the other hand, the KIGAZ 300 Pro probe was inserted into the furnace. The research plan used to conduct the gaseous emissions tests was developed in two parts: the first is a comparison of measured gas concentrations between modern and traditional sites and the second is a comparison of measured gas concentrations at limit values. If the concentrations of pollutants are above the limit values, it can be concluded that the environment is polluted. Moreover, this air pollution has a considerable impact on health and the environment. The statistical test used is that of Kruskal-Wallis and that of Mann-Whitney.

## 2.3 Statistical Analysis

Comparisons of respiratory symptoms were made using Stata version 14 software. The statistical significance of the existence of an

association between the different parameters was studied, depending on the case, by the Chi2 test or Fisher's exact test at the 5% threshold. The comparison of gas contents was performed using the Kruskal-Wallis test at  $p < 0.05$ . Whenever this test revealed significant differences the comparison was continued with the Mann-Whitney test at the 5% threshold. All statistical calculations and graphs were made using Statistica 7.1 software.

## 3. RESULTS AND DISCUSSION

### 3.1 Results

#### 3.1.1 Sociodemographic aspect

##### 3.1.1.1 Age distribution of fish smokers

The distribution of the population according to age groups shows that the average age of female fish smokers is  $34.10 \pm 13.40$  years. The age group with the most fish smokers in the selected category of women is 33 to 42 years old with 41.66% of women. Note that nearly 15.28% of the target population is between 28 and 32 years old. The age of entry into activity is between 18 and 22 years old with 5.56% of the fish smokers. Women who smoke fish and are over 63 years old represent 5.56% of the total number of women surveyed (Table 1).

##### 3.1.1.2 Distribution of fish smokers by length of time in business

Fig. 3 shows the number of years of experience acquired by the women fish smokers. The study shows that more than 68.05% of the women have between 2 and 10 years of experience in fish smoking. Only 15.28 and 16.67% of the female fish smokers have between 11 and 20 years and more than 21 years of fish smoking experience respectively.

##### 3.1.1.3 Distribution of female fish smokers by nationality

The majority of women who smoke fish are from Burkina Faso (72%) and only 26% and 2% of women who smoke fish are from Ivory Coast and Togo respectively (Fig. 4).

**Table 1. Proportion of female fish smokers by age group**

<b>Ages (years)</b>	<b>18-22</b>	<b>23-27</b>	<b>28-32</b>	<b>33-37</b>	<b>38-42</b>	<b>43-47</b>	<b>48-52</b>	<b>53-57</b>	<b>58-62</b>	<b>63 et plus</b>
Proportion (%) of fish smoking women	5,56	12,50	15,28	19,44	22,22	6,94	5,56	2,78	4,17	5,56

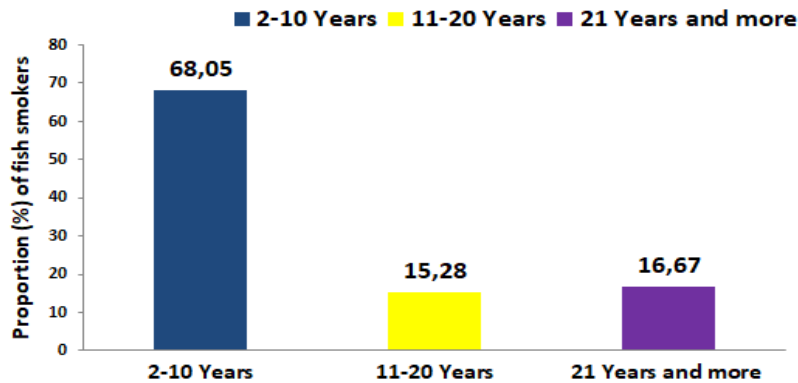


Fig. 3. Distribution of women fish smokers by length of time

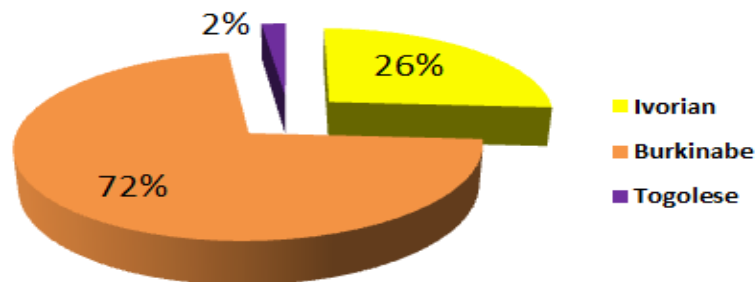


Fig. 4. Proportion of women who smoke fish by nationality

Table 2. Proportion of female fish smokers by level of education

Level of education	None	Koranic	Primary	Secondary	University
Proportion (%) of fish smoking women	57,50	2,50	25	12,50	2,50

3.1.1.4 Distribution of fish smokers by education level

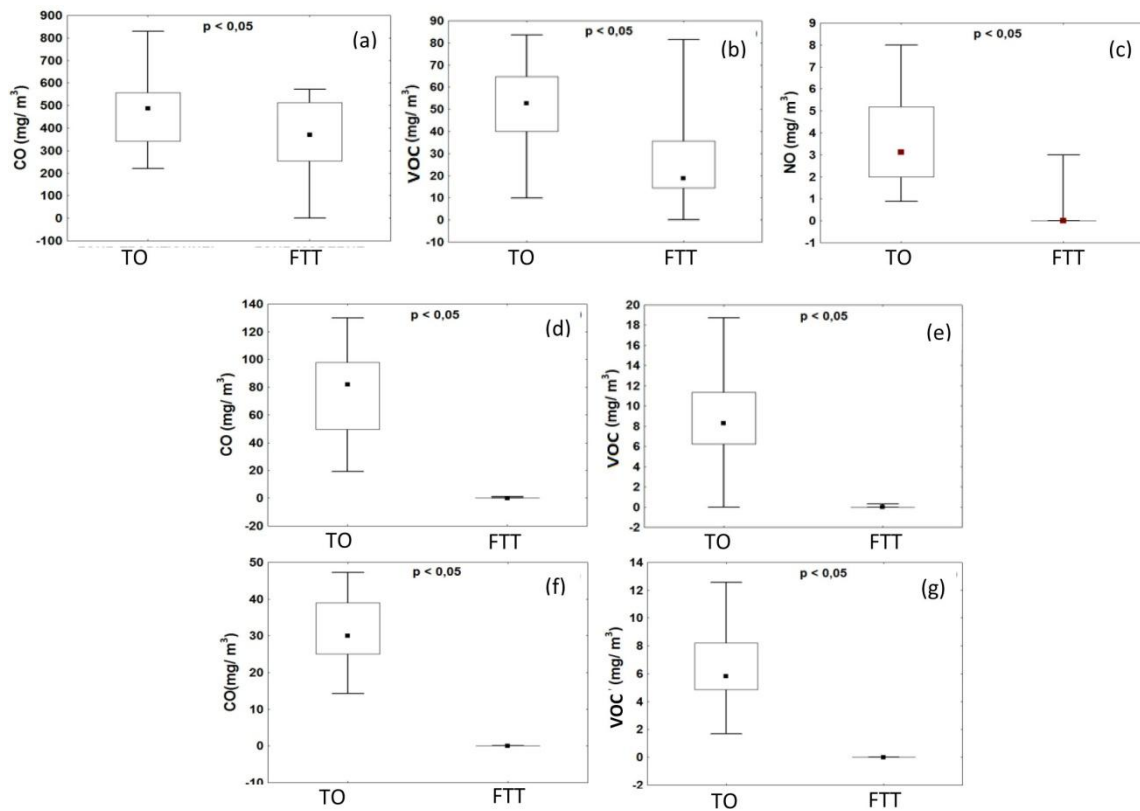
Table 2 presents the level of education attained by the women who smoke fish. Nearly 57.50% of the women had no schooling. 2.50% and 25% have reached the Koranic and primary levels respectively. Those who had reached secondary school level reached 12.50%. Finally, 2.50% of women who smoke have a university degree.

3.1.2 Variation in gas measurements at the ovens

Fig. 5 describes the variation in CO, VOC and NO levels measured above the ovens, at the women's resting point and beyond the ovens in the traditional and modern sites. The Kruskal-Wallis and Man Withney tests show that the median values of CO, VOC and NO in the traditional sites are higher than those in the modern sites, regardless of the study area.

3.1.3 Comparison of gas levels to limit values

Fig. 6 highlights the CO and NO levels measured at the traditional and modern fish smoking sites. Thus, all CO contents above the traditional ovens are above the limit value of Decree No. 2017-125 of 22 February 2017 on air quality in Ivory Coast (50 mg/m<sup>3</sup>). Concerning the levels of measured at the women's resting point of the traditional site, out of the 33 measurements 23 were above the limit value. On the other hand, all the CO measured beyond the traditional furnaces are lower than the limit value. Of 33 CO measurements taken above the FTT ovens, 30 were above the limit value. However, all CO levels measured at the women's resting point and beyond the FTT ovens were below the limit value. Similarly, all NO measurements taken at the fish smoking sites were below the limit value regardless of the type of oven used.



**Fig. 5. Comparison of CO (a), VOC (b) and NO (c) level above the ovens, CO (d) and VOC (e) at the women's resting point and CO (f) and VOC (g) level beyond the ovens**  
 TO: traditional oven; FTT: FAO-Thiaroye Processing Technique

**3.1.4 Results of carbon dioxide (CO<sub>2</sub>), oxygen (O<sub>2</sub>) and temperature (T) measurements performed above the traditional furnaces**

Table 3 shows the minimum and maximum values of carbon dioxide (CO<sub>2</sub>), oxygen (O<sub>2</sub>) and temperature (T) measured above the traditional ovens. The CO<sub>2</sub> contents measured above the traditional ovens range from 0.56 to 1.24%. The O<sub>2</sub> contents measured above the traditional furnaces oscillate between 19.75% and 20.42%, thus less than 21% of O<sub>2</sub> emanation from the combustion of the solid fuels used. The values of the temperatures taken above the traditional furnaces vary from 131°C to 275°C.

**3.1.5 Comparison of respiratory and ophthalmological signs in the women surveyed**

*3.1.5.1 Comparison of respiratory signs in the women surveyed*

Table 4 shows the percentages of respiratory symptoms identified in the women surveyed.

Apart from sinusitis, there is a significant difference ( $p < 0.05$ ) in respiratory signs between fish smokers and non-smokers, and between women who use traditional ovens and those who use FTT ovens. Among the respiratory symptoms observed, rhinitis represented the largest percentage. It was present in 52.78% of female smokers compared to 22.22% of non fish smokers. Cough was observed in a significant percentage in 41.67% of fish smokers against 3.17% of non-smokers. Dyspnea and wheezing were observed at low percentages and present in 19.44% and 12.94% of exposed women respectively compared to 6.35% and 0.00% of unexposed women. Similarly, rhinitis and cough were the most recurrent symptoms and present respectively in 82.50% and 52.50% of female smokers using traditional ovens versus 15.63% and 28.13% in those using FTT ovens. Chest pain and dyspnea were observed in significant percentages and present respectively in 45.00% and 35.00% of smokers using traditional ovens against 3.13% and 0.00% of those using FTT ovens. Wheezing was observed in 12.50% of women using traditional ovens while none was observed in those using FTT ovens.

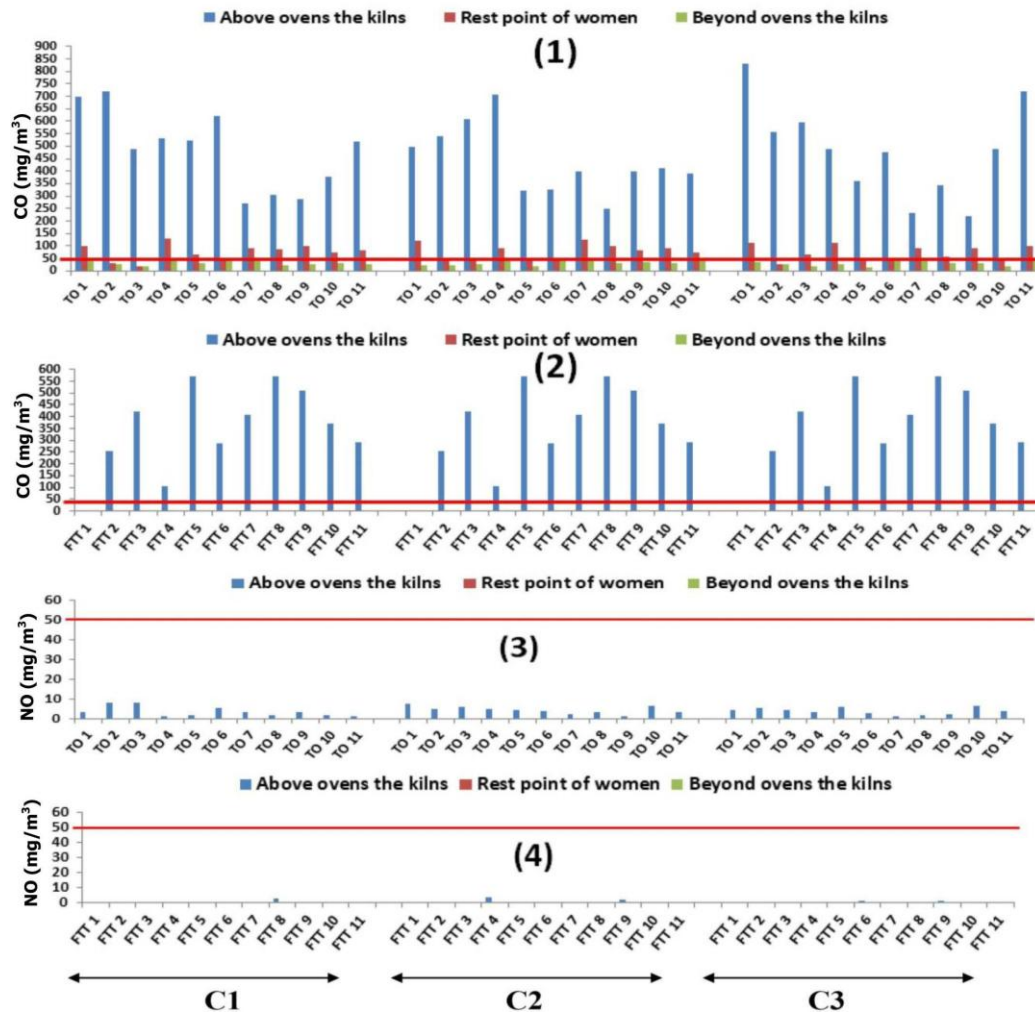


Fig. 6. Comparison of CO levels in the traditional site (1) and in the modern site (2) and NO levels in the traditional site (3) and in the modern site (4) with the limit value  
 C1: 1<sup>st</sup> Campaign; C2: 2<sup>nd</sup> Campaign; C3: 3<sup>rd</sup> Campaign

Table 3. Minimum and maximum values of carbon dioxide, temperature and oxygen measured above the oxygen measured above the traditional furnaces

Site traditionnel de fumage de poisson	CO <sub>2</sub> (%)	O <sub>2</sub> (%)	T (°C)
	Min-Max	Min-Max	Min-Max
Anoumabo	0,56-1,24	19,75-20,42	131-275

Table 4. Proportions of respiratory signs among women surveyed

Symptômes respiratoires	Toux	Douleur thoracique	Dyspnée	Sifflement	Rhinite	Sinusite
Fish smokers (%)	41,67	26,39	19,44	12,94	52,78	22,22
Non-smokers of fish (%)	3,17	17,46	6,35	0,00	22,22	0,00
P	0,00	0,30	0,04	0,04	0,00	0,50
Female smokers using traditional ovens (%)	52,50	45,00	35,00	12,50	82,50	5,00
Female smokers using FTT ovens (%)	28,13	3,13	0,00	0,00	15,63	0,00
P	0,03	0,00	0,00	0,04	0,00	0,50

**Table 5. Proportion of ophthalmological signs among the women surveyed**

Symptômes ophtalmologiques	Baisse d'acuité visuelle	Larmoiement	Conjonctivite
Fish smokers (%)	0,00	37,10	18,06
Non-smokers of fish (%)	0,00	4,26	2,10
P	-	0,00	0,03
Female smokers using traditional ovens (%)	0,00	31,71	12,20
Female smokers using FTT ovens (%)	0,00	11,11	0,00
P	-	0,04	0,04

**3.1.5.2 Comparison of ophthalmological signs among the women surveyed**

Table 5 shows the proportions of ophthalmological signs in the women surveyed. Apart from the decrease in visual acuity, there was a significant difference ( $p < 0.05$ ) in ophthalmological signs between fish smokers and non-smokers, as well as between smokers who use traditional ovens and those who use FTT ovens. Tearing was the most recurrent and present in 37.10% of the exposed women versus 4.26% of the unexposed. Conjunctivitis was observed in a small proportion of 18.06% of smokers against 2.10% of non-smokers. Similarly, apart from the decrease in visual acuity, there was a significant difference ( $p < 0.05$ ) when comparing ophthalmological abnormalities in women using traditional ovens and those using FTT ovens. Tearing presented the greatest proportion in 31.71% of the women fish smokers who practice on traditional ovens against 11.11% in those who use FTT ovens. Conjunctivitis was observed at a significant rate in 12.2% of the fish smokers who use traditional ovens while none was perceived in those who use FTT ovens.

**3.2 Discussion**

This study highlighted the practices related to fish smoking from traditional ovens and FTT ovens, the measurement of CO, VOC and NO contents from fish smoking platforms and the clinical manifestations recorded in female fish smokers. The socio-demographic surveys showed that the smokers surveyed were adults. Thus, the age of entry into activity is between 18 and 22 years. This is justified by the fact that girls do not go to school and do not attend school, which is still a reality on the African continent. Female fish smokers with an age range of 33 to 42 years and an experience of 2 to 10 years predominated. There is a small proportion of women over 63 years of age. This is justified by

the loss of physical capacity in the latter. These results are in agreement with those of Oulaï et al. [8], who noted that the mean age of female fish smokers ranged from 21 to 40 years. Similarly, the study showed that the majority of women who smoke fish are foreigners, with a rate of 74% compared to 26% of Ivorian women. These results corroborate those of Kakou [9], which showed that the population of the fishing sector is very cosmopolitan, with 2/3 coming from neighboring countries. This study found a low level of education among women fish smokers, with 57.50% being illiterate. These results are in agreement with those of Djessouho [5] who indicated that 89% of female fish smokers are illiterate. In addition, the CO, VOC and NO levels measured above the traditional ovens are higher than those measured above the FTT ovens in all the study areas. This high emission of toxic gases is due to the fact that with traditional stoves, large quantities of solid fuels such as rubberwood and painted and varnished wood are burned. These traditional stoves are poorly ventilated and do not have efficient chimneys to evacuate the fumes due to the lack of extractor, emit a high level of CO which is a sign of poor combustion of the biomasses used and also the emission of other toxic gases (VOC and NO) that can affect the health of smokers. On the other hand, there is a clear improvement in the working environment at the modern platform because all the CO levels measured at the women's resting point are very low, in contrast to those measured at the women's resting point at the traditional sites, where CO levels are almost above the limit value. These results are in agreement with those of Anoh et al. [10] who showed that traditional furnaces produce more toxic fumes with high concentrations of various compounds (CO, SO<sub>2</sub>, VOCs, PAHs...) compared to the FTT ovens where the gas emission is lower. The WHO [11] has defined reference values for the population that are considered harmless according to the standards 10 mg/m<sup>3</sup> for 8 hours, 35 mg/m<sup>3</sup> for 1



hour and  $100 \text{ mg/m}^3$  for 15 minutes. The usual concentration of CO in ambient air is about 0.2 ppm [12]. However, the survey results showed that female fish smokers using traditional fireplaces are continuously exposed for more than 2 hours to high levels of CO. This explains the high proportion of pathologies reported in women smokers using traditional stoves. Comparing the respiratory and ophthalmological symptoms recorded in female smokers and non-smokers, there is an increasing proportion of pathologies recorded in those who use traditional stoves. The high rate of disease in this community is generally related to air pollution from smoke and constant exposure to the intense heat ( $275^\circ\text{C}$ ) generated during the burning of wood by the traditional stoves used. These results corroborate those of Mambo-Gnakalé *et al.* [13] who showed that female smokers using traditional ovens are exposed to clear health risks compared to non-smokers of fish and female smokers using FTT ovens. Wood is now the leading source of renewable energy. Thus, Sawerysyn [14] showed that the use of wood, without control and precaution in domestic heating appliances with insufficiently high combustion efficiencies, is responsible for environmental pollution because it releases three greenhouse gases: carbon dioxide ( $\text{CO}_2$ ), methane ( $\text{CH}_4$ ) and nitrous oxide ( $\text{N}_2\text{O}$ ) that have a negative and persistent effect on the climate. These gases from traditional fish smoking sites have an impact on the environment because the CO, VOCs and NO that are emitted, through complex chemical reactions, lead, in the presence of solar radiation, to the formation of ozone ( $\text{O}_3$ ) which is a greenhouse gas [15].  $\text{CO}_2$  levels measured above the ovens in traditional fish smoking sites vary from 0.56 to 1.24%, i.e. more than 0.04%  $\text{CO}_2$  emission (usual  $\text{CO}_2$  level in the atmosphere). The  $\text{CO}_2$  emitted during the fish smoking activity has an impact on the environment because it has the ability to absorb infrared radiation emitted by the earth system and contributes significantly to the natural greenhouse effect [16].

#### 4. CONCLUSION

In Ivory Coast, the fisheries resources sector is of undeniable economic contribution. The smoking of fish is one of the traditional means of reducing losses after capture. All categories of women are involved: educated and uneducated, Ivorian and non-Ivorian. Thus, in Marcory Anoumabo, women try to build their lives around this activity. However, the use of the

traditional oven is detrimental to the health of these fish smokers, who are seriously affected by the prolonged exposure to the smoke and heat from the combustion of the wood used. In addition, traditional smoking techniques cause the emission of toxic, carcinogenic gases that are dangerous for the women's respiratory system as well as the emission of greenhouse gases. Also, the women who use the FTT oven are less affected by pathologies than those who continue to use the traditional oven. The use of the FTT oven remains a hope to protect the health of women fish smokers.

#### CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

#### ACKNOWLEDGMENTS

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#### COMPETING INTERESTS

Being environmental chemists, we conducted a transdisciplinary study by associating the Tropical Geography team (IGT) of the Felix Houphouët-Boigny University, which evaluated the socio-demographic aspect, the Ivorian Anti-Pollution Center (CIAPOL), which ensured the environmental aspect, and the health agents of the Functional Explorations Service of the Yopougon University Hospital, which evaluated the health aspect.

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