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Environmental and Health Impacts of Women Fish Processors Working on Traditional and Modern Fish Smoking Platforms in Braffèdon (Ivory Coast)

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Abstract

Smoked fish plays a significant role in food security and nutrition, represents 2/3 of the consumption of fishery products in Ivory Coast and is still obtained using outdated traditional smoking methods. These methods are not very concerned with the health of the populations and the preservation of the environment, despite the existence of improved ovens called FTT ovens (FAO-Thiaroye Processing Technique) introduced in the country. The objective of this study is to show the impact of traditional smoking on the health of fish smokers and the environment in comparison with smoking processes based on FTT ovens. It is a cross-sectional and descriptive study involving 36 female smokers who use traditional ovens, 24 female smokers who use FTT ovens, as well as 53 Braffèdon case controls. It was conducted from January 2017 to December 2018. The data collection methodology includes questionnaire surveys, interviews, and observations. For the purpose of the study, two samples were followed: these were women smokers and non-smokers of fish, all of whom volunteered at the clinical examinations conducted. The results showed that women who use traditional stoves are

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more affected by pathologies. Baseline spirometry did not detect a significant frequency of ventilatory disorders. Bronchial hyperreactivity was statistically more frequent in women smokers using traditional ovens. Three measurement campaigns for CO, VOC and NO were performed above the ovens, at the women's resting point and beyond the ovens. The CO levels found at the women's resting point in the traditional sites were higher and often exceeded the limit value (50 mg/m^3). This work has allowed us to identify the deleterious effects of the fish smoking activity on the health of the fish smokers and the environment.

0. Introduction

Fish occupies an important place in the human diet. Its worldwide consumption is constantly increasing. Fish is an important food in Africa for millions of people and is a major source of animal protein for low-income households [1]. However, it is a rapidly perishable commodity after capture [2]. This leads to huge post-catch losses and a deficit in fishermen's income [3]. In this context, processing becomes a necessity for the preservation of fish quality. Thus, various traditional type techniques such as frying, fermenting, salting, drying and smoking are adopted to preserve fish [4]. Smoking using traditional ovens is a processing operation that has been practiced for generations in many parts of the world [5]. However, these traditional smokehouses still suffer from many weaknesses especially in terms of energy and health efficiencies [6]. In addition to the health effects, other negative aspects of fish smoking have been identified, such as the fact that some smokers have lost their fingerprints from manually turning the fish in the oven and other smokers have mentioned having difficult relationships with their spouses who blame them for the lack of care given to their bodies and the persistent odor of smoked fish they give off [7]. To address the problems mentioned, FAO in partnership with the national training center for fisheries and aquaculture technicians of Senegal, has developed an improved oven called FAO-Thiaroye Processing Technique (FTT-Thiaroye) [8]. It was first tested and validated in Senegal. Then fisheries operators in other African countries have also experimented with the Thiaroye system, such as in Togo, Ivory Coast, Tanzania, and recently in Ghana [9]. Similarly, the FFT oven contributes to environmental conservation because the fuels used for fish smoking are generally made of heat retention stone, agricultural biomass, and very little coal [9]. The objective of this study is to show the impact of traditional smoking on the health of female fish smokers and the environment compared to smoking processes based on FTT ovens.

1. Materials and Methods

1.1. Study area

The study was conducted in Ivory Coast on traditional and modern smoking platforms in Braffèdon. Braffèdon is part of the department of Grand-Lahou and is located 18 km from the city of Grand-Lahou with an estimated population of 3,587 inhabitants [10]. Thus, it is surrounded by a lagoon complex, the Bandama River and the sea. Fishing is practiced there throughout the year. The natives (Avikam) prefer to fish in the lagoon and the river while the non-natives usually fish in the open sea [11]. Two types of fish smoking are practiced: modern smoking which is practiced by female fish smokers who operate on the modern platform and traditional smokers who most often operate individually in the open air on the traditional platform.

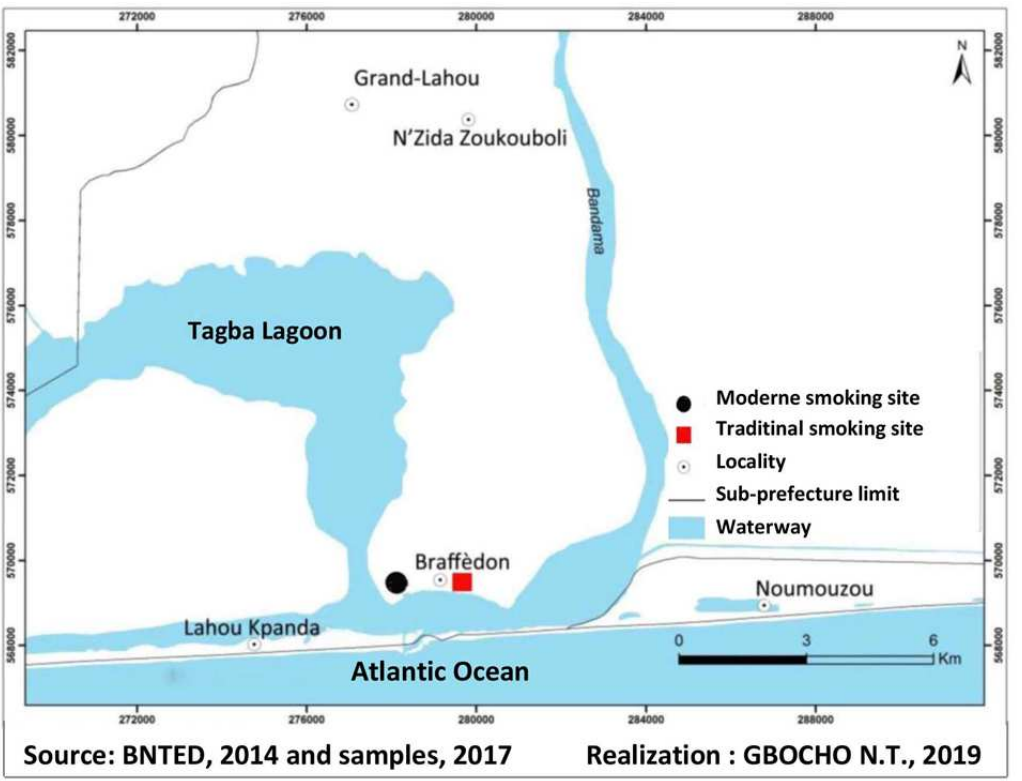


Figure 1. Location of the fish smoking sites in Braffèdon.

1.2. Survey

1.2.1. Study materials

The technical equipment consisted of a GARMIN MAP GPS; a census form that provided information on the identity of 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. For medical analysis, pharmacological substances, two spirometers, two dosimeters, two pneumatic nebulizers, a stethoscope, a fundus and a slit lamp were used.

1.2.2. Methods and techniques of information collection

This phase was conducted in three phases from January to April 2017. First, findings and observations were made. Then, interviews with the managers of the different sectors related to the smoking activity. Finally, the survey by questionnaire.

1.2.2.1. Observation phase

Smoking areas “in the front yard” are present in all Braffèdon processors. These workshops are equipped with a variety of smoking rooms protected by traditional buildings (raffia sheds). There are also smokehouses installed in the open air without any protection. Fish are smoked almost every day, except when there is a shortage of fish (Figure 2).

Figure 2. Traditional (a) and modern (b) fish smoking sites in Braffèdon.

Source : Cliche, OSSEHIN, 2017

1.2.2.2. Interviews with managers of sectors related to the smoking activity

It is a free exchange with the administrative authorities (the Departmental Direction of Resources of Grand-Lahou and the Aquaculture Directorate), the young professionals (FAO inspectors on the smoking sites) and the presidents of the selected cooperatives. The purpose of this interview is to present and explain the study project and to obtain authorization for the proper conduct of the survey. This working session with cooperative leaders, allowed us to obtain information on the problems that women. This working session with the leaders of the cooperatives allowed them to obtain information on the problems encountered by the women in the context of the fish smoking activity. These problems are health problems, product conservation problems, insecurity and problems related to the associative problems related to the women's associative life. A questionnaire was developed based on information gathered through documentary research, direct observations in the field and interviews.

1.2.2.3. 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 female 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 113 women composed of 36 smokers who use traditional stoves, 24 smokers who use FTT stoves and 53 non-smokers (controls) engaged in other income-generating activities such as sewing, hairdressing and marketing of food crops.

1.3. Measuring smoke quality

1.3.1. Measuring instruments

Three measuring instruments were used: KIGAZ 300 pro, MiniRAE 3000 and MultiRae Lite. The KIGAZ 300 pro combustion analyzer allows direct analysis of O_2 and CO in the combustion chamber, measurement of CO_2, SO_2, air temperature, flue gas temperature, pressure and calculation of % CO_2 and NO_X 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_3, H_2S, CO and SO_2).

1.3.2. Measurement methodology

Three measurement campaigns were conducted, ranging from January 2017 to December 2018. Measurements were performed on 2 modern ovens and 7 traditional ovens. The measurements were performed above the ovens, at the resting point of the women and beyond the ovens (from 4 to 12 meters from the ovens) depending on the wind direction with a total of 126 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.

1.4. 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.

2. Results and Discussion

2.1. Results

2.1.1. Results of pollutant measurements

The minimum and maximum values of CO_2, CO, VOC and NO measured in the traditional and modern platforms are recorded in Table I. The gas values measured above the traditional ovens range from 104 to 587 mg/m^3 for CO, from 28.5 to 168.5 mg/m^3 for VOC, from 0.98 to 10.12 mg/m^3 for NO and from 0.2 to 0.3 % for CO_2, respectively. Regarding the gas contents carried out at the resting point of women in the traditional platform, they vary respectively from 23 to 96.11 mg/m^3 for CO, from 0.31 to 61 mg/m^3 for VOC and 5.02 mg/m^3 for NO. The gas levels beyond the traditional furnaces range from 0.19 to 21.5 mg/m^3 for CO, 10.66 mg/m^3 for VOC and 3 mg/m^3 for NO, respectively. Gas measurements at modern sites are not often detected, but the highest

levels recorded above the FTT furnaces are around 38.61 mg/m^3 for CO, 8.14 mg/m^3 for VOC and 1.8 mg/m^3 for NO, respectively. Similarly, the highest values performed at the women's resting point reach 9.61 mg/m^3 for CO and 0.97 mg/m^3 for VOCs respectively. In addition, the highest values at the women's resting point are 8.9 mg/m^3 for CO and 1.02 mg/m^3 for VOCs, respectively.

2.1.2. Variation in gas measurements at the kilns

Figure 3 describes the variation in CO, VOC and NO levels above the ovens, at the women's resting point and beyond the ovens in the traditional and modern sites respectively. The Kruskal-Wallis test and the Man Withney test 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.

Table 1. Minimum and maximum values of gas contents (mg/m^3) measured above ovens, at the rest point of women and beyond ovens.

Different gases measured	**Traditional kiln of Braffèdon**			**FTT kiln of Braffèdon**		
	AOK	RPW	BOK	**AOK**	RPW	BOK
	Min-Max	**Min-Max**	**Min-Max**	**Min-Max**	**Min-Max**	**Min-Max**
CO (mg/ m^3)	104-587	23-96,11	0,19-21,5	0,07-38,61	nd -9,61	nd-8,9
VOC (mg/ m^3)	28,5-168,5	0,31-61	nd -10,66	nd-8,14	nd -0,97	nd-1,02
NO (mg/ m^3)	0,98-10,12	nd -5,02	nd -3	0,23-1,8	nd	nd
CO_2 (%)	0,2-0,3					

AOK: above ovens the kilns, RPW: rest point of women, BOK: beyond ovens the kiln, Min=minimum, Max = maximum, nd: not determined.

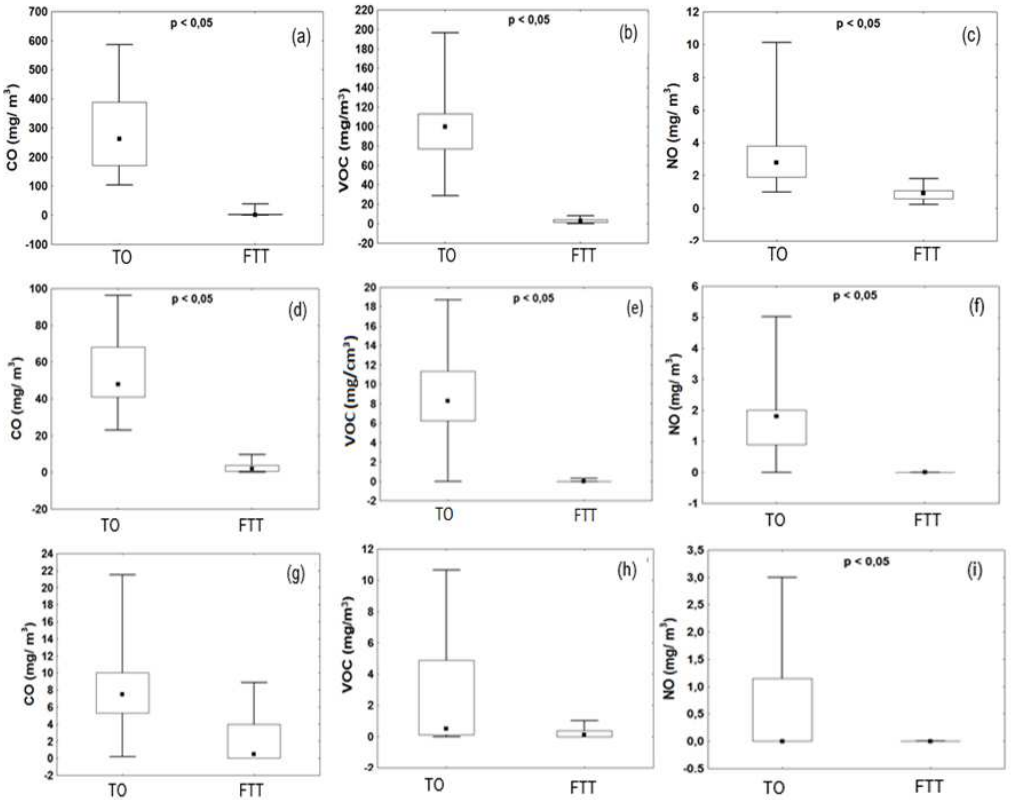
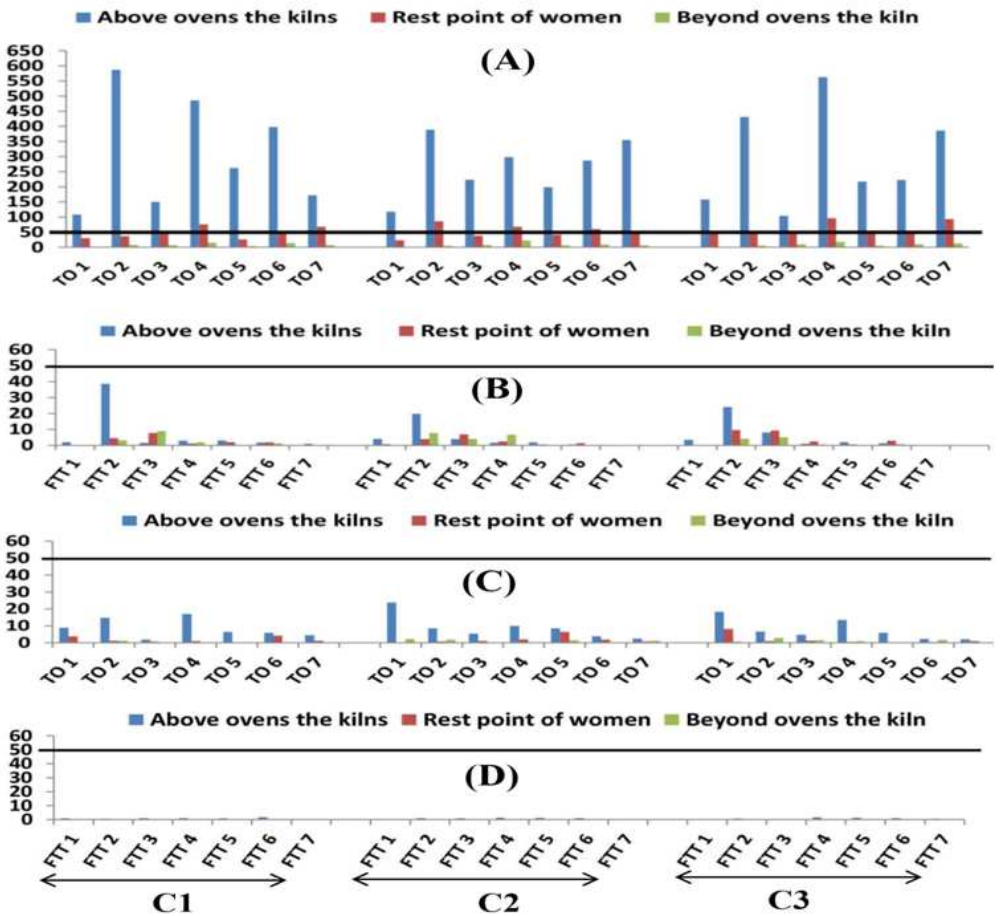


Figure 3. Comparison of CO (a), VOC (b) and NO (c) level above the ovens, CO (d) level, VOC(e) and NO (f) at the women's resting point and CO (g), VOC (h) and NO (i) level beyond the ovens.

TO : traditional oven ; FTT : FAO-Thiaroye Processing Technique

2.1.3. Comparison of gas levels to limit values

Figure 4 shows that all CO levels measured above the traditional ovens were above the limit value of Decree No. 2017-125 of 22 February 2017 on air quality in Ivory Coast (50 mg/m^3). Regarding CO levels measured at the women's resting point at the traditional sites, out of the 21 measurements taken, 6 were above the limit value. On the other hand, all the CO levels measured beyond the traditional ovens were below the limit value. However, all CO levels measured in the modern site were below the limit value regardless of the study area. Similarly, the NO measurements in the fish smoking sites were below the limit value (30 mg/m^3) for occupational exposure to chemical agents in France, regardless of the study area.



C1: 1st Campaign; C2: 2nd Campaign; C3: 3rd Campaign; TO: traditional oven; FTT: FAO-Thiaroye Processing Technique

Figure 4. Comparison of CO levels in the traditional site (A) and in the modern site (B) and NO levels in the traditional site (C) and in the modern site (D) with the limit value.

2.1.4. Pathological manifestations in women

2.1.4.1. Comparison of respiratory signs in fish smokers and non-fish smokers

Table 2 highlights the percentages of respiratory signs recorded in fish smokers and non-fish Smokers. The survey data show that apart from coughing and wheezing, there is no significant difference ($p>0.05$) in respiratory signs between fish smokers and non-smokers. Such cough represented the largest percentage. It was present in 50.00% of

female smokers versus 32.08% of non-smokers. Wheezing was found in a significant proportion and was present in 33.33% of exposed women against 9.43% of non-exposed women.

Table 2. Proportions of respiratory signs in fish smokers and non-fish smokers.

Respiratory Symptoms	Fish Smoking Women	Non-Fish Smoking Women	P
Cough	50,00	32,08	0,04
Chest pain	48,33	33,96	0,12
Dyspnea	35,00	26,42	0,33
Wheezing	33,33	9,43	0,00
Rhinitis	50,00	47,17	0,76
Sinusitis	6,67	1,89	0,37

2.1.4.2. Comparison of respiratory signs of fish smokers using traditional ovens and those who use FTT ovens

Table 3 presents the percentages of respiratory signs found in female fish smokers according to the type of oven used. Apart from rhinitis, dyspnea and wheezing, there was no significant difference ($p>0.05$) in the respiratory signs in female fish smokers using traditional ovens and those using FTT ovens. Among the respiratory symptoms observed, rhinitis was the most recurrent symptom and present in 63.89% of female fish smokers using traditional ovens versus 38.89% of those using FTT ovens. Dyspnea and wheezing were found in significant proportions. They were present respectively in 47.22% and 44.44% of female fish smokers using traditional ovens against 22.22% and 22.22% in those using FTT ovens.

Table 3. Proportions of respiratory signs of fish smokers using traditional ovens and those who use FTT ovens.

Respiratory Symptoms	Fish smokers using traditional ovens	Fish smokers using FTT ovens %	P
Cough	52,78	44,44	0,47
Chest pain	61,11	38,89	0,06
Dyspnea	47,22	22,22	0,02
Wheezing	44,44	22,22	0,04
Rhinitis	63,89	38,89	0,03
Sinusitis	8,33	5,56	1

2.1.4.3. Comparison of resting spirometric parameters in fish smokers and non-fish smokers

Table 4 highlights the spirometric results identified in female smokers and non-smokers. The measurements obtained from the spirometric baseline in the two categories of smokers surveyed were similar. The Tiffeneau ratio (FEV1/FVC) did not identify an obstructive or restrictive ventilatory abnormality because it was above 80%.

Table 4. Proportions of spirometric parameters in fish smokers and non-fish smokers.

Spirometric parameters	**Fish Smoking Women**	**Non-Fish Smoking Women**	Chi 2 test
FVC	2,51	2,43	0,65
FEV1	2,08	2,05	0,82
FEV1/VFC %	81,70	81,70	-
PEF	5,48	5,33	0,56
PEF 25-75 %	2,50	2,47	0,90
VC	2,62	2,60	-
MVVpre	74,50	71,40	0,59

2.1.4.5. Comparison of bronchial hyperreactivity in fish smokers and non-fish smokers

Figure 5 shows the different results of bronchial hyperreactivity in relation to smoke exposure found in fish smokers and non-smokers. The statistical test shows that there is no significant difference ($p>0.05$) when comparing bronchial hyperreactivity in fish smokers and non-smokers.

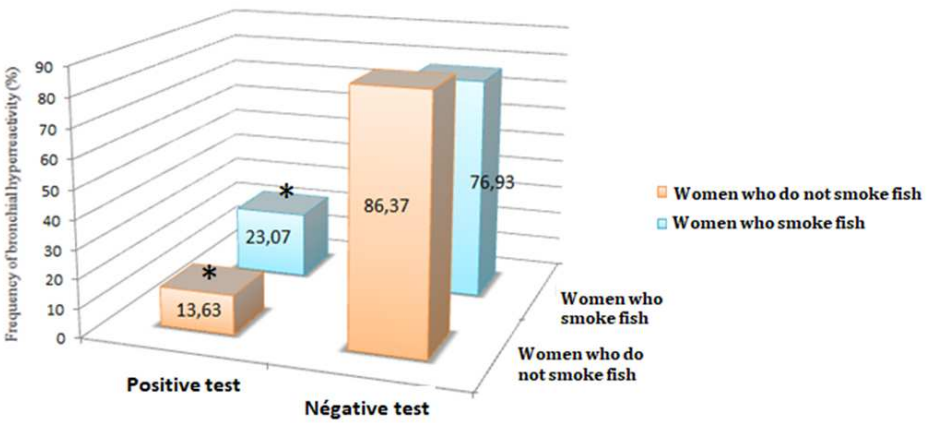


Figure 5. Frequency of bronchial hyperreactivity in fish smokers and non-fish smokers.

2.2. Discussion

This study provided information on the gas levels (CO, VOC and NO) emitted during fish smoking and their impact on the environment and health of fish smokers according to the type of oven used (traditional oven and FTT oven). The gas levels measured in traditional fish smoking sites are higher than those measured in modern sites (sites equipped with FTT ovens) regardless of the study area. Compared to the limit value of Decree N° 2017-125 of 22 February 2017 on air quality in Ivory Coast (50 mg/m^3), all CO levels measured above the traditional ovens were above the emission limit value. However, those measured above the FTT kilns were below the limit value. These high gas levels on traditional platforms are due to the fact that traditional ovens are poorly ventilated and lack efficient chimneys to evacuate the fumes from the solid fuels used. However, FTT ovens with chimneys and grease trays emit less gaseous pollutants because the gas levels measured at the resting point of the women and beyond the FTT ovens are almost zero. These results corroborate those of Anoh *et al.* [12] who showed that traditional ovens used by women processors in Grand-Lahou emit more gas pollutants compared to FTT ovens. This is consistent with the findings of Smith [13] on fuelwood use in developing countries who noted that small stoves do not burn fuelwood properly. On the other hand, there is a clear improvement in the working environment at the modern kilns because all CO levels measured at the women's resting point at the modern sites are very low in contrast to those measured at the women's resting point at the traditional kilns where CO levels are often above the limit value. The smoking time varies from one hour to four hours for short smoking and from two to five days for long smoking. During the smoking of fish, large quantities of smoke are released and inhaled by the women during the handling of the fish to cook them but also when stoking the fire. This seriously jeopardizes their health. In addition, the unconsciousness and lack of knowledge of the deleterious effects of smoke on human health by women smokers who work on traditional fish smoking sites without protective equipment affects their health. In this regard, the study by Geronimi [14] showed that CO has a toxic effect even at very low volume concentrations, in prolonged exposure. Apart from CO which is more emitted, other toxic gases have been measured in traditional fish smoking sites. These are VOC and NO. Thus, the VOC levels measured in the traditional smoking platforms are significant. This could have impacts on their health because the study by Rouviere [15] showed that VOCs, particularly benzene, cause central nervous system damage, respiratory tract irritation, conjunctivitis, hematological toxicity, and leukemia risk. The results obtained showed that women who use traditional ovens, those who use FTT ovens

and non-smokers present similar anomalies. This similarity of pathological manifestations observed in the three categories of women surveyed is justified by the fact that Braffèdon is a village (rural area). Firewood is the main fuel for cooking. These fuels are used by both smokers and non-smokers of fish, whose main activities are smoking fish and producing attieke. However, there is a high frequency of pathological manifestations among women fish smokers who use traditional ovens. Also, in this artisanal fishing community, the activity of smoking fish is practiced at home, which exposes the population to smoke emissions. This exposure to biomass smoke has a negative impact on their health even when they are not fish smokers. These findings corroborate those of Umoh *et al*. [16] who showed the deleterious effect of exposure to smoke from wood burning during fish smoking and observed a high frequency of respiratory symptoms in the rural community of Obaka, Nigeria. Climate change is now recognized as a pressing global environmental issue. It is the result of an increase in average temperatures caused by the accumulation of greenhouse gases in the earth's atmosphere, the most important of which is carbon dioxide released during the combustion of fossil fuels [17]. Wood is now the leading source of renewable energy. It is used for construction, domestic and industrial heating. The safety of wood heating is controversial due to the emission of CO, VOCs and fine particles. In this regard, Sawerysyn [18] showed that the use of wood, without control and precaution in home heating appliances with insufficiently high combustion efficiencies, is responsible for environmental pollution because they release three greenhouse gases: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) which have a negative and persistent effect on the climate. Moreover, gas measurements carried out beyond the furnaces (from 4 to 12 meters radius around the furnaces) in the traditional sites of showed high levels of CO, VOC and NO. Similarly, CO_2 levels measured above the ovens in traditional fish smoking sites vary between 0.2% and 0.3%, thus more than 0.04% CO_2 emission (usual rate of CO_2 in the atmosphere). These gases emitted during the activity of fish smoking therefore certainly have a considerable impact on the environment because the usual rate of CO_2 in the atmosphere is about 0.04% [19].

3. Conclusion

Fish smoking is one of the traditional means of reducing post-harvest losses. The activity of smoking fish constitutes a source of income for women in Ivory Coast. In Braffèdon, women build their lives around this activity. In spite of its importance, traditional smoking has a considerable impact on health, as the results obtained revealed

its impact on the health of women fish smokers, unlike those who smoke on the modern platform, who are less affected by pathologies. This study has therefore confirmed the deleterious effects of the traditional fish smoking activity on the health of women smokers. Similarly, it appears in this work that the use of traditional ovens requires large quantities of wood, leads to the rapid destruction of forest cover, including mangrove forests and the production of a huge volume of CO_2 which is a greenhouse gas. However, the use of FTT stoves is one of the ways to fight against climate change because they emit less greenhouse gases.

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