Comparative study of the environmental and sanitary impacts of two fish smoking systems (traditional oven and FTT oven) used by the women of Guessabo (Ivory Coast)

Abstract

Women use traditional methods for smoking in Côte d'Ivoire. These methods have an impact on the environment and their health because of the emission of CO_2 which is a greenhouse gas and other gases (VOCs, PAHs...), carcinogenic and dangerous for the respiratory system. In 2013, an improved kiln, called FAO-Thiaroye Processing Technique (FTT) was introduced in Côte d'Ivoire in order to reduce the health and environmental impacts. The objective of this study is to compare the environmental and health impacts between traditional and improved ovens used by women in Guessabo. This study involved 45 fish smokers using traditional stoves, 34 smokers using FTT stoves and 50 controls. It was conducted from January to December 2017. The data collection methodology included questionnaire survey, interviews, observations, and medical prospection. Also, baseline spirometry and bronchial metacholine reversibility test in each woman were performed. Bronchial hyperreactivity was obserbed to be more frequent in women smokers who practice with traditional furnaces. Three measurement campaigns of Carbon dioxide (CO_2), carbon monoxide (CO), volatile organic compounds (VOC) and Nitric oxide (NO) were carried out. The level of CO measured at the traditional sites varies from 19 to 184 mg/m^3. It is often higher than the acceptable limit value ($50mg/m^3$).. However, these gas levels were very low with the use of FTT furnaces.

Key words: Fish smoking, environmental impact, health of women smokers, greenhouse gases, Guessabo.

INTRODUCTION

Post-harvest losses are a recognized problems in sub-Saharan Africa.,. 25% of fish are lost due to lack of effective means of conservation and processing. Smoking is one of the means used to conserve and improve the availability of fish [1]. Particularly in Ivory Coast, smoking is used to stabilize perishable foodstuffs before they are transported from catching or farming sites to consumption areas [2]. Smoking is one of the main income-generating activities for many people, the majority of whom are women [3]. However, this smoking activity is generally carried out in precarious and arduous conditions due to the rudimentary equipment used [4]. The use of traditional equipment is not without consequences for the environment and the health of women producers. Moreover, smoking operations are conducted in thick layers of smoke and female operators are exposed to respiratory, ocular and even cardiovascular problems [5]. The study of the impact of fish smoking on safety and health in fishing communities is part of the concern to identify environmental risks and diseases related to the exercise of an economic activity largely dominated by women of modest conditions [6]. Traditional smoking burns large quantities of wood, leads to rapid destruction of forest cover, including mangrove forests; the production of a huge volume of CO_2 responsible for increased greenhouse gas emissions [6]. To solve these problems mentioned, FAO in collaboration with the Ministry of Animal and Fisheries Resources, Ivory Coast, has set up in the fish smoking sites platforms in Attécoubé, Marcory Anoumabo, Guessabo and Braffèdon (Grand-Lahou) that were equipped with improved ovens, commonly known as FTT ovens (FAO-Thiaroye Processing Technique) [7]. The FTT oven has become widespread among fishing communities in Africa because of its ease of use and vast processing capacity. It requires little firewood, reduces smoking times, and produces high quality smoked fish [2]. Similarly, it reduces health risks, improves working conditions and reduces

post-catch losses [8]. In addition, it contributes to the safeguarding of the environment 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 compare environmental and health impacts between traditional ovens and FTT ovens used by female fish smokers in Guessabo (Ivory Coast). Specifically, the aim is to determine harmful gas levels at smoking sites according to the type of oven used, to assess their impact on the environment and on the health of female fish smokers.

I. MATERIAL AND METHODS

1. Study area

The study was carried out in Ivory Coast on the traditional and modern smoking sites of Guessabo. The sub-prefecture of Guessabo is located in the High Sassandra region, in the center-west of Ivory Coast. Administratively, it is part of the Department of Zoukougbeu. It is located between the parallels 6°44' North Latitude and 6°57' West Longitude and covers an area of 328 km². The sub-prefecture of Guessabo has a large and mostly rural population. Its population is estimated at 8,288 inhabitants [10]. The main economic activities of this population are agriculture and fishing. The activity of smoking fish is prominent in this artisanal fishing community and is largely dominated by women [11]. These smoking sites were chosen in view of the dynamism of the activity marked by the permanent occupation of the space, the large number of active women fish smokers and especially the establishment of FTT ovens.

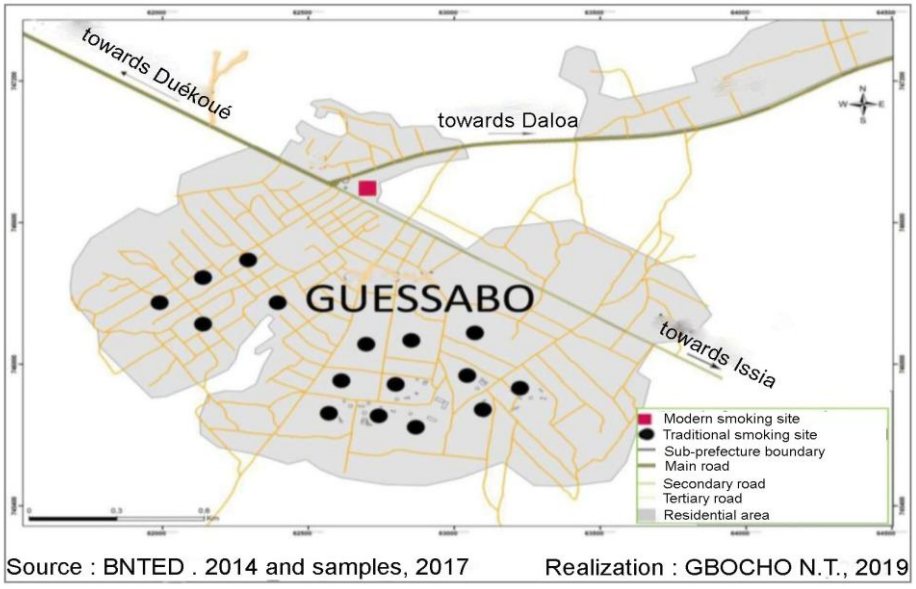


Figure 1: Location of the fish smoking sites in Guessabo

2. Survey

2.1. Study materials

The instruments used to carry out the survey were: survey forms, a camera and a GPS. The survey form was used to collect precise information on smoking activities, diseases developed and health history. The equipment used for the medical survey consisted of pharmacological substances, two spirometers, two dosimeters, two pneumatic nebulizers, a stethoscope, a fundus and a slit lamp.

2.2. Methods and techniques of information collection

This stage was conducted in three phases from January to December 2017. The first allowed for findings and observations. The second, led to interviews with the managers of the different sectors related to the smoking activity. The third involved the questionnaire survey.

2.2.1. Observation phase

Observation took place throughout the different surveys on the smoking sites. It was used to appreciate the daily experience of the women processors. In Guessabo, women smokers work individually, either in the open air or in concessions. The conditions under which these women carry out their activity, the type of equipment used and the immediate impact of this activity on the health of the producers were identified. Photographs were also taken to substantiate statements about the problems identified and their effects on the well-being of the women who process the fish into smoked products.

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

This is an open exchange with young professionals and the women fish smokers of the "AMAKPA" cooperative. Indeed, AMAKPA means in Gnaboua (an ethnic group of the Ivory Coast) unite us. This working session allowed to have information on the problems that women encounter in the framework of the exercise of the activity of fish smoking. These are health problems, problems of conservation of fishing products, insecurity and problems related to the associative life of women. A questionnaire was elaborated from this collected information.

2.2.3. Survey by questionnaire

The survey was conducted among women fish smokers in Guessabo. It allowed the determination of the number of women fish smokers per study area and to collect information on the socio-demographic profile of the women, their smoking activity, the fuels used and their personal and family health history. Using a GPS, the coordinates of the different smoking points were geo-referenced. The study included all women present and meeting the inclusion criteria. All women aged 18 years and older who had been smoking fish products at least 5 days per week for at least 2 years were included. Female fish smokers with a history of active and/or passive smoking, respiratory manifestations prior to smoking activity (asthma, tuberculosis, COPD, etc.) were excluded from the study. The study included 129 women consisting of 45 fish smokers using traditional ovens, 34 fish smokers using FTT oven, and 50 women who do not smoke fish (controls) engaged in other income-generating activities such as sewing, hairdressing, and marketing food crops.

3. Measuring Smoke Quality

3.1. Measuring instruments

Three measuring devices were used: KIGAZ 300 pro, MiniRAE 3000 and MultiRae Lite. The KIGAZ 300 pro combustion analyzer enables direct O_2 and CO analyzes in the combustion chamber to measure CO_2, SO_2, air temperature, fumes, pressure and to calculate the% CO_2 and the NO_x content. The

MiniRAE 3000 Portable Monitor can detect VOCs. The MultiRae Lite was used to determine the NO and CO.

3.2. Measurement methodology

Three measurement campaigns were carried out, from January to December 2017. The measurements were carried out on 2 modern ovens and 7 traditional ovens. Measurements were made over the ovens, at the women's resting point and beyond the ovens (4 to 12 meters from the ovens) according to the wind direction with a total of 126 measurements. Prior to the various gas measurements, the units were allowed to draw clean ambient air without smoke to establish the zero value of the sensors. To perform the gas measurements, the MiniRae 3000 and MultiRae Lite analyzers were held around the oven. However, the KIGAZ 300 Pro probe has been inserted into the oven.

4. Statistical analysis

Comparisons of respiratory symptoms were made using the Stata version 14 software. The statistical significance of the existence of a link between the different parameters was studied according to the case, by the Chi2 test or the Fisher exact test to the threshold of 5%. The comparison of the gas contents was carried out 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% level. All statistical calculations and graphs were done using the Statistica 7.1 software.

II.RESULTS AND DISCUSSION

1. Results

1.1 Results of pollutant measurements

Table I shows the minimum and maximum values of CO_2, CO, VOCs and NO measured in the traditional and FTT platforms. The gas values measured above the traditional furnaces range respectively from 126 to 1347 mg/m^3 for CO, 27.4 to 99 mg/m^3 for VOCs, 2.81 to 28.47 mg/m^3 for NO and 0.1 to 0.2% for CO_2. Regarding the gas contents carried out at the resting point of women in the traditional platform, they vary respectively from 50.54 to 183 mg/m^3 for CO, 5 to 52 mg/m^3 for VOCs and 0 to 1.58 mg/m^3 for NO. The gas levels beyond the traditional furnaces range from 1.87 to 19.2 mg/m^3 for CO and 0.3 to 6.47 mg/m^3 for VOCs. Gas measurements at FTT sites are not often detected, but the highest levels recorded above the FTT furnaces are around 130 mg/m^3 for CO and 10.25 mg/m^3 for VOCs respectively. Similarly, the highest values at the women's resting point are 21.3 mg/m^3 for CO and 1.3 mg/m^3 for VOCs respectively. However, all gas measurements beyond the FTT ovens are almost zero.

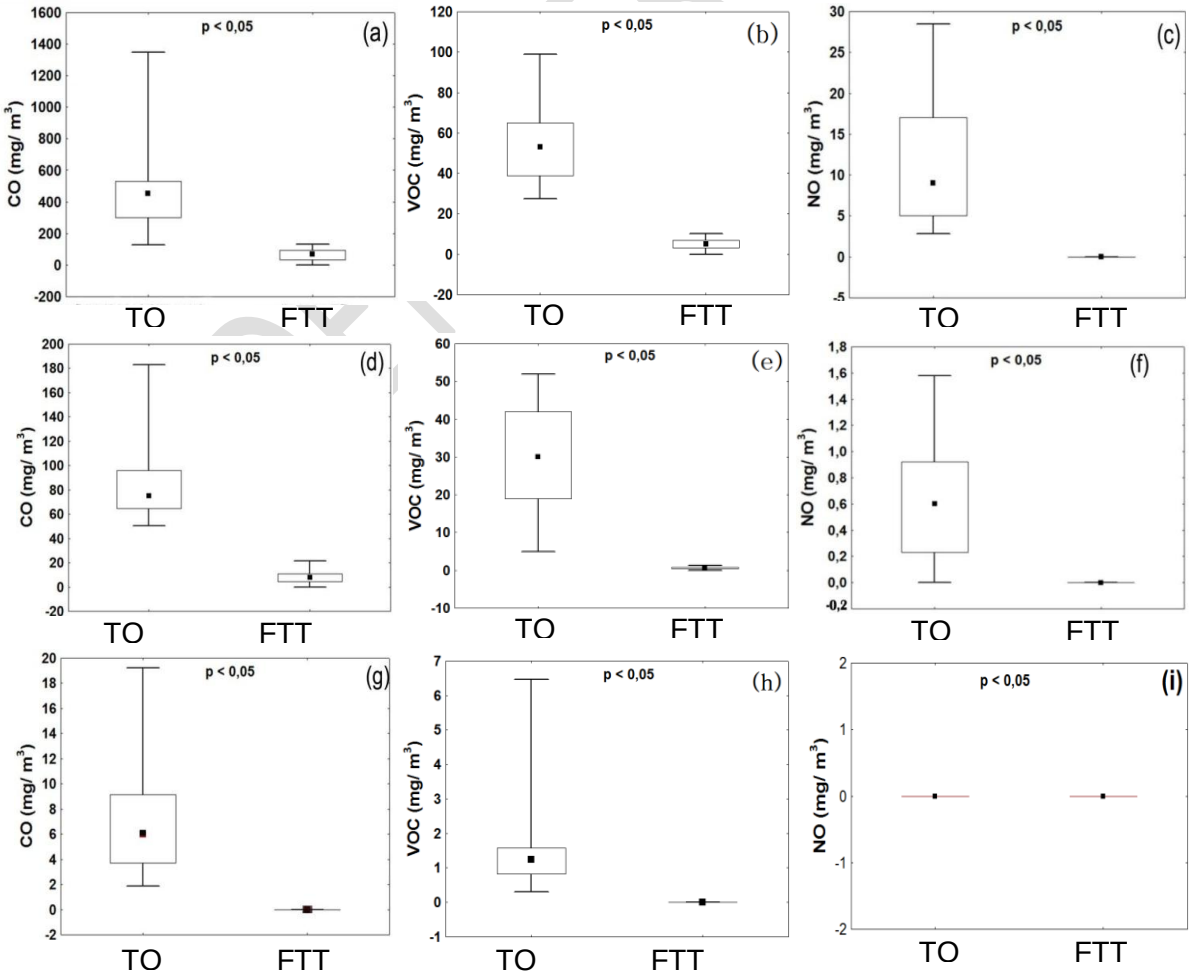
Table 1: Minimum and maximum values of gas contents (mg / m^3) measured above ovens, at the rest point of women and beyond ovens

Différent gases measure	Traditionnel oven			FTT ovens		
	AO	RPW	**BO**	**AO**	**RPW**	**BO**
	Min-Max	**Min-Max**	**Min-Max**	**Min-Max**	**Min-Max**	**Min-Max**
CO (mg/ m^3)	126-1347	50,54-183	1,87-19,2	nd-130	nd-21,3	nd
VOC (mg/ m^3)	27,4-99	5-52	0,3-6,47	nd-10,25	nd-1,3	nd
NO (mg/ m^3)	2,81-28,47	0-1,58	nd	nd	nd	nd
CO_2 (%)	0,1-0,2					

AO: above ovens, RPW: rest point of women, BO: beyond ovens, Min=minimum, Max = maximum, nd : not determined

1.1.2. Variation in gas measurements at the oven level

Figure 2 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 the Man Withney tests show that the median values of CO, VOC and NO found in traditional sites are higher compared to those measured in modern sites.

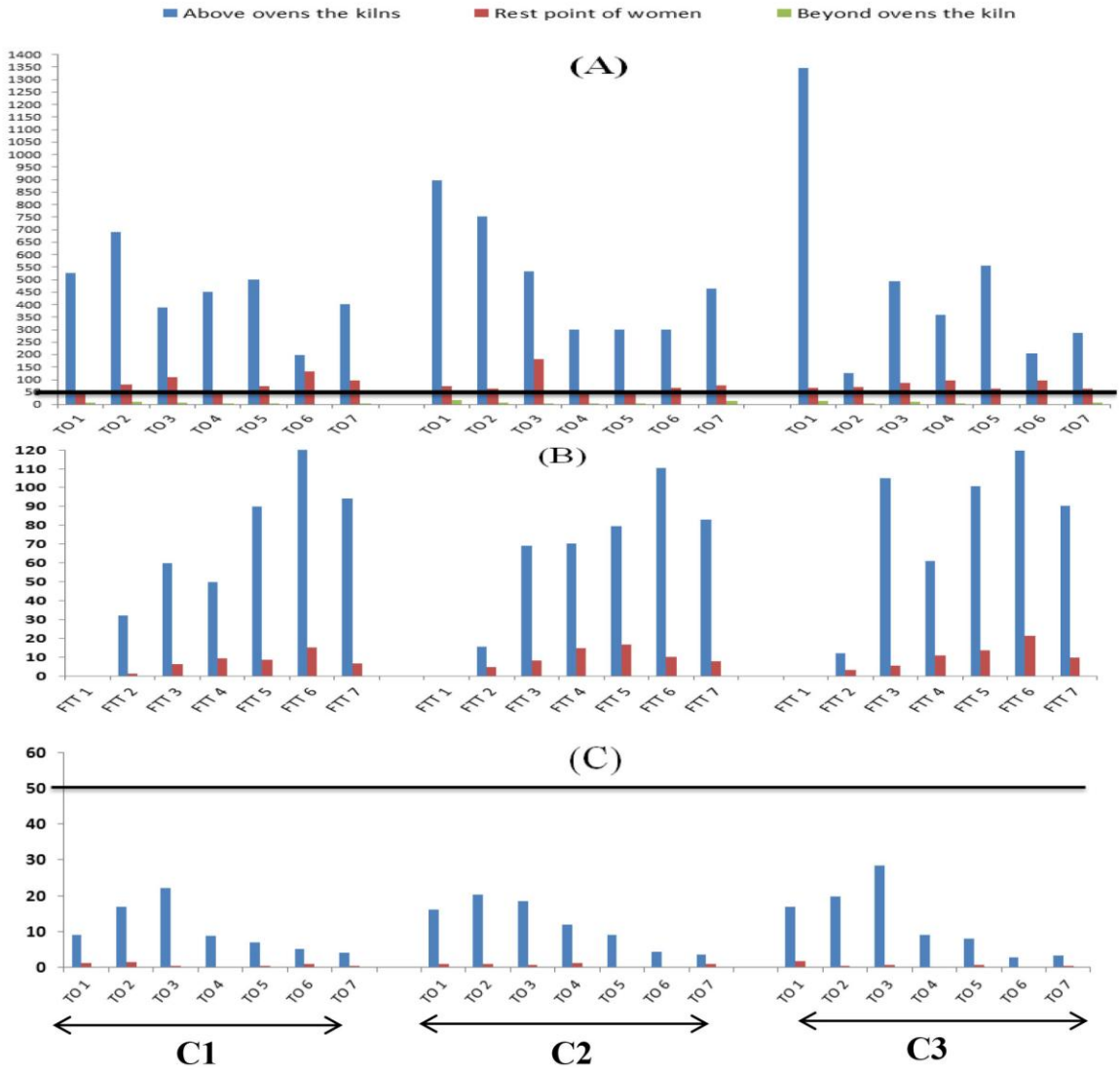


TO : traditional oven ; *FTT : FAO-Thiaroye Processing Technique*

Figure 2: 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

1.1.3. Comparison of gas levels to limit values

Figure 3 shows that all CO and NO levels measured above the traditional ovens were above the acceptable limit value of Decree N°. 2017-125 of February 22, 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, 11 were above the acceptable limit value. On the other hand, all the CO levels measured beyond the traditional ovens were below the acceptable limit value. Similarly, of 21 CO measurements made above the FTT furnaces, 14 were above the acceptable limit value. However, all CO levels measured at the women's resting point and beyond the ovens in the modern site were below the acceptable limit value.



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

Figure 3: Comparison of CO levels in the traditional site (A) and in the modern site (B) and NO

levels in the traditional site (C) with the limit value

1.2 Pathological events in women

1.2.1. Replace with 'Comparison of resting spirometric parameters in fish smokers women and non-fish smokers

Table 2 shows the spirometric results recorded in female fish smokers who perform the activity of traditional fish smoking compared to those who do not. The measurements obtained from the spirometric database in the two categories of women surveyed are similar. The Tiffeneau ratio (FEV1/FVC) did not allow the detection of an obstructive or restrictive ventilator abnormality because it is higher than 80%. Its normal value is about 0.75 (or 75%). Generally speaking, any value is considered normal if it is greater than or equal to 80%. A clear drop in this ratio, below 0.65, indicates an obstructive type of respiratory disorder (due to a decrease in the caliber of the bronchi), such as asthma and chronic obstructive bronchitis.

Table 2: Comparison of resting spirometric parameters in women who smoke fish than in those who do not

Paramètres spirométriques	Fish Smoking Women	Non-Fish Smoking Women	Test de chi 2
FVC	2,48	2,61	0,19
FEV1	2,15	2,16	0,91
FEV1/VFC%	85,48	83,41	0,36
PEF	5,49	5,56	0,85
FEF25-75%	2,63	2,57	0,69
VC	2,67	2,52	0,13
MVVpre	75,22	75,22	0,93

FVC: Forced vital capacity; FEV1/FVC is the ratio of FEV1 to FVC; FEF25-75%: Forced inspiratory flow 25-75% ; PEF : Peak expiratory flow ; VC: Vital capacity ; MVV: Maximal Voluntary Ventilation.

1.2.2. Comparison of resting spirometric parameters in female fish smokers according to the type of oven used

Table 3 shows the spirometric results recorded from female fish smokers according to the type of oven used. The measurements obtained from the spirometric base in the two categories of smokers surveyed are similar. The Tiffeneau ratio (FEV1/FVC) did not detect an obstructive or restrictive ventilatory abnormality because it was above 80%.

Tiffeneau's ratio (FEV1/FVC), sometimes expressed as a percentage, of forced expiratory volume in one second (FEV1) to vital capacity (V.C., the maximum volume the subject can inhale after maximum exhalation), used to assess the degree of bronchial obstruction. Tiffeneau's ratio, which is very commonly used, is calculated from the results of spirometry (an examination that measures lung volumes and flows). Its normal value is about 0.75 (or 75%). Generally speaking, any value is considered normal if it is greater than or equal to 80%. A clear drop in this ratio, below 0.65, indicates

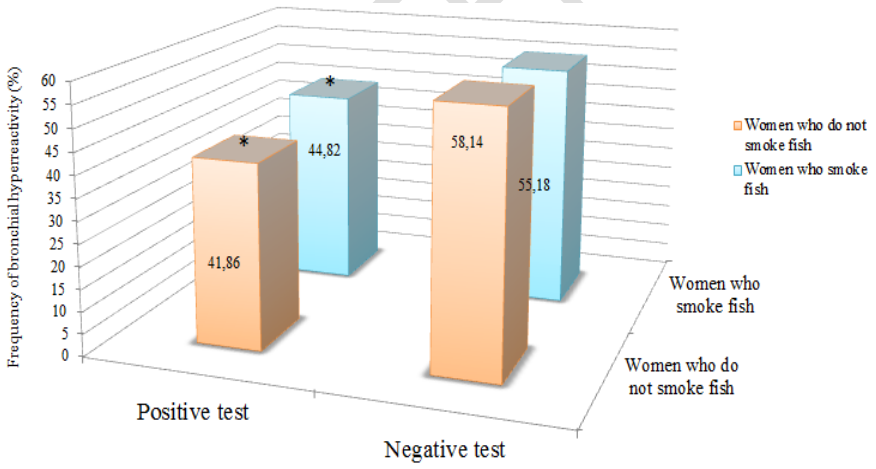
an obstructive type of respiratory disorder (due to a decrease in the caliber of the bronchi), such as asthma and chronic obstructive bronchitis.

Table 3: Comparison of resting spirometric parameters of fish smokers using traditional ovens and those who use FTT ovens

Paramètres spirométriques	Fish smokers using traditional ovens	Fish smokers using FTT ovens	**Test de chi 2**
FVC	2,43	2,40	0,89
FEV1	2,02	2,20	0,32
FEV1/VFC%	82,57	82,04	0,84
PEF	5,29	5,60	0,62
FEF25-75%	2,21	3,09	0,04
VC	2,54	2,62	0,72
MVVpre	70,60	76,94	0,32

1.2.3. Comparison of the methacholine bronchial challenge test in women who smoke fish than in non-fish smokers

Figure 3 shows the frequencies of bronchial hyperreactivity in female fish smokers compared to those who do not. The paraclinical analyses carried out in this artisanal fishing community showed that bronchial hyperreactivity in both categories of women is similar (44.82% versus 41.86%).

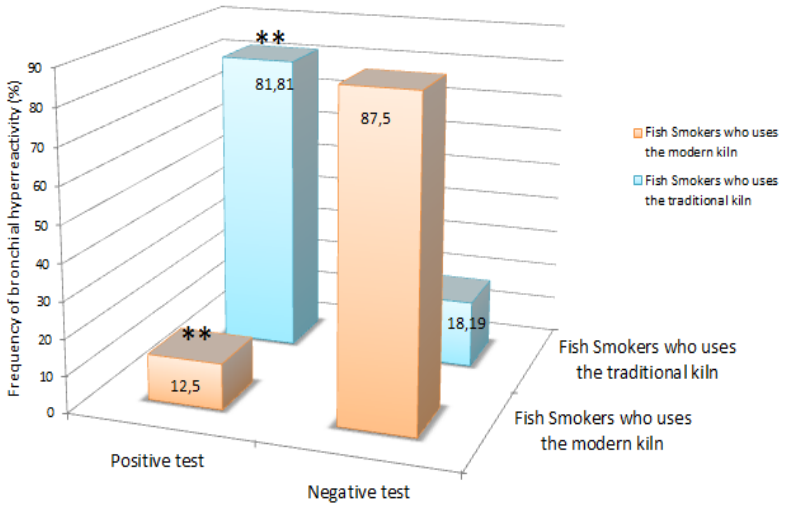


Legend: *= Not significant; Chi2 test: Significant p< 0.05.

Figure 3: Frequency of bronchial hyperreactivity in women who smoke fish than in those who do not

1.2.4. Comparison of the methacholine bronchial challenge test in female fish smokers according to the type of oven used

Figure 4 shows the frequencies of bronchial hyperreactivity in women smokers according to the type of oven used. The paraclinical analyses carried out in this artisanal fishing community showed that bronchial hyperreactivity is 6 times more frequent in women fish smokers who use traditional ovens than those who use FTT ovens with a significant difference (p<0.05).



Legend: **= Significant, Chi2 test: Significant p< 0.05.

Figure 4: Frequency of bronchial hyperreactivity of fish smokers using traditional ovens and those who use FTT ovens

2-DISCUSSION

The objective of this study is to highlight the deleterious effect of the fumes emanating from fish smoking on the health of the women fish smokers and the environment according to the type of oven used (traditional oven and FTT oven). The different gas measurements carried out above the ovens, at the women's resting point and beyond the ovens during the fish smoking activity in the traditional platforms, in contrast to those measured at the level of the modern platforms, showed a high emission of CO, which translates into incomplete combustion of the solid fuels used, and also the presence of other gases such as VOCs and NO_X. These results corroborate with those of *Anoh et al.* [6] who showed that the traditional ovens used by the Grand-Lahou processors emit more polluting gases compared to the FTT ovens. This is in line with the findings of Smith [12] on fuelwood use in developing countries who noted that small stoves do not properly burn fuelwood to become carbon dioxide. They emit gases such as carbon monoxide, benzene, butadiene, formaldehyde and many other harmful components. In addition to this, it is necessary to note the emission of carbon dioxide which reaches 0,2%, thus more than 0,04% of CO_2 emission (usual rate of CO_2 in the atmosphere). These gases emitted during the activity of fish smoking certainly have a considerable impact on the environment because CO_2 has the ability to absorb infrared radiation emitted by the earth system and contributes significantly to the natural greenhouse effect [13]. Similarly, CO, VOCs and NO_X that were emitted, through complex chemical reactions, lead, in the presence of solar radiation, to the formation of ozone (O_3) which is a greenhouse gas [14]. The results of the survey in the case of fish smoking activities in artisanal fishing communities showed that CO levels measured in the vicinity of women in traditional fish smoking sites (varies from 19 to 184 mg/m^3) were often above the acceptable limit value (50 mg/m^3). The duration of fish smoking in traditional sites often exceeds 2 hours. Yet, in 2016, WHO [15] has defined reference values for the whole population, including pregnant women and elderly people with heart or respiratory diseases (known or not), which are considered harmless

depending on the duration of exposure: 10 mg/m3 for 8 hours, 30 mg/m^3 for 1 hour, 60 mg/m^3 for 30 min, 100 mg/m3 for 15 min [16]. Processors are therefore exposed to high levels of CO (varies from 19 to 184 mg/m^3) over a long smoking period. The unawareness and lack of knowledge of the deleterious effects of smoke on human health by women smokers who work in traditional fish smoking sites without protective equipment possed negative effects on their health. Moreover, CO has a toxic effect even at very low volume concentrations, in prolonged exposure. Besides CO, which is more emitted, other toxic gases have been measured in traditional fish smoking sites. These are VOCs and NO. Thus, the VOC levels measured in the traditional fish smoking platforms were above the acceptable limit value. This could have impacts on their health because the study by Rouvière [17] showed that VOCs, in particular benzene, cause damage to the central nervous system, irritation of the respiratory tract, conjunctivitis, haematological toxicity and risks of leukaemia. In addition, the paraclinical examinations carried out in the women allowed the diagnosis of the pathological manifestations which appeared in the subjects. The results obtained showed that the basic spirometry performed in women did not allow to detect a significant frequency of obstructive ventilatory disorder because the value of Tiffeneau's ratio (FEV1/FVC) is higher than 80% of the volume. Its normal value is about 0.75 (or 75%). Generally speaking, any value is considered normal if it is greater than or equal to 80%. A clear drop in this ratio, below 0.65, indicates an obstructive type of respiratory disorder (due to a decrease in the caliber of the bronchi), such as asthma and chronic obstructive bronchitis. But there is a high frequency of pathological manifestations in women fish smokers who use traditional ovens. These observations could be explained by the fact that in Guessabo, women smokers who use traditional ovens, those who use FTT ovens and who do not smoke often use solid fuels such as cocoa and coffee wood during their cooking activities. These results are in agreement with those of Anoh *et al.* [6] who showed that there is no significant difference when comparing respiratory and ophthalmological abnormalities between female fish smokers using FTT ovens and those exercising on traditional ovens, as well as those who do not smoke. In addition, the bronchial hyperreactivity test showed that female fish smokers had a proportion of bronchial hyperreactivity approaching that of non-smokers. However, bronchial hyperreactivity was 6 times more frequent in fish smokers using traditional ovens than in fish smokers using FTT ovens with a significant difference ($p<0.05$). This observation highlights the deleterious effects of fish smoking activity on lung function. These results are in agreement with Bamba [18] who showed that bronchial hyperreactivity was twice as common in female fish smokers with a significant difference. Then, Kwas *et al* [19] showed that one third of people living in rural communities in developing countries use biomass as a sole source of energy which has adverse effects on their health.

CONCLUSION

Traditional fish smoking techniques burn large quantities of solid fuels. The incomplete combustion of fuels emits toxic fumes with high concentrations of CO, VOCs, NO_X and CO_2. This practice leads on the one hand to an increase in greenhouse gas emissions and on the other hand to toxic gases, dangerous for the health of fish smokers. Moreover, the results obtained in the artisanal fishing

communities have highlighted the impact of traditional fish smoking on the health of women fish smokers. The baseline spirometry performed on fish smokers did not reveal a significant incidence of obstructive ventilatory disorder. However, the prevalence of bronchial hyperreactivity was significantly higher in fish smokers than non-fish smoke. Thus, this study confirmed the deleterious effects of fish smoking activity on the health of female fish smokers. The use of the FTT oven remains a hope to protect the health of women fish smokers and the environment because they emit less gas. Moreover, the Intergovernmental Panel on Climate Change (IPCC) has shown that the only real way to stop global warming is to reduce greenhouse gas emissions. The use of FTT furnaces is therefore one of the ways to fight climate change.

BIBLIOGRAPHIC REFERENCES

1-Abdoullahi O.H., Tapsoba F., Guira F., Zongo C., Abakar I.L., Tidjani A. & Savadogo A., 2018. Technologies, quality and socio-economic importance of dried fish in Africa Rev. Science. Technol., Synthesis, 37: 49-63.

2-Traoré O. D., 2016. Dosage of PAHs in smoked fish (tuna). Master's thesis, Nangui Abrogoua University, 33p.

3-Rivier M., Kebe F. & Goli T., 2009. Fish smoking in West Africa for local and export markets. Final report, AUF/CIRAD, Montpellier, France 19p.

4-Abotchi K., 2010. Evaluation of the microbiological quality of smoked fish artisanally in Togo. Master's thesis, EISMV of Dakar, 42p.

5-Ekomy S. A., Bruneau D., Mbega J. D. & Aregba W., 2013. New concept of drying and smoking artisanal fish food: application in the artisanal fishing environment in Gabon. Africa Science, 9(3): 45-55.

6-Anoh K. P., Ouattara S., Yapo O. B., Dembélé A. A., 2017. Health of women processors, product safety and environmental impact of fish smoking systems in artisanal fishing communities, study for sustainable food systems. FAO Fisheries and Aquaculture Report, Elmina, Ghana, 131-144

7-FAO, 2016. Information Bulletin. FAO Ivory Coast, (13) 12p.

8-Ndiaye O., Sodoke Komivi B., and Diei-Ouadi Y., 2014. The FAO-Thiaroye transformation technique (FTT-Thiaroye). Rome, FAO. 67p.

9-Ossehin A., Etchian AO, Gnagne AEJEY, Seka YJ and Yapo OB, 2019. Impact of fish smoking on the environment and the respiratory system of women exercising on the traditional and modern sites of Attécoubé (Abobo-doumé and Locodjro) and Braffedon. Journal of Chemical, Biological and Physical Sciences, 9(4): 333-346.

10-Institut National de Recherche et de Sécurité (INRS), 2016. Occupational exposure limit values for chemical agents in France. Technical aide-mémoire, 4th edition, 32p.

National Institute of Statistics (INS), 2014. General Population and Housing Census (RGPH), Overall Results: Districts, Region, Departments, Sub-prefectures. 26p.

11-Djessouho C., 2017. Health safety and marketing of smoked fish products hot and dried in Africa and Asia. FAO Fisheries and Aquaculture Report, Elmina, Ghana, 294-307.

12-Smith K.R., 2006. Health impacts of household fuelwood use in developing countries. Unasylva, 57: 41-44.

13-Intergovernmental Panel on Climate Change (IPCC), 2013. Summary at For Decision Makers: Climate Change 2013: The Science. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Tech. rep., Cambridge, United Kingdom and New York (State of New York), United States of America, 204p.

14-Mégie G., 1996. Ozone and oxidizing properties of the troposphere. Meteorology 8th series, 13: 18p.

15-World Health Organization (WHO), 2016. Indoor air pollution and health. Aide-mémoire N°292, Geneva, 5p.

16-French Food Safety Agency (AFSSA), 2003. Opinion of the Food Safety Agency relating to a request for an opinion on the assessment of the risks presented by benzo(a)pyrene (B[a]P) and by other polycyclic aromatic hydrocarbons (PAHs), present in various foodstuffs or in certain vegetable oils, as well as on the levels of PAH concentration in foodstuffs beyond which health problems are likely to arise. Request No. 2000-SA-005, 59p.

17-Rouvière A., 2006. Impact of the combustion of firewood on the atmospheres exterior and interior. Study of the degradation of a specific tracer in an enclosure of simulation: creosol. Doctoral dissertation, University Joseph Fourier-Grenoble I, France, 218p.

18-Bamba M., 2017. Prevalence of respiratory symptoms and hyperreactivity bronchial disease in female fish smokers in the Grand-Lahou region. Memory of doctoral thesis in medicine, Félix Houphouët Boigny University, Abidjan, 101p.

19-Kwas et al. (2016) Mégie G., 1996. Ozone and oxidative properties of the troposphere. Meteorology 8th series, 13: 18p.